Pathways to inequalities in child mental health

Thesis submitted in accordance with the requirements of the University of Liverpool for the degree of Doctor in Philosophy by

Callum Rutherford

June 2022

Department of Public Health, Policy & Systems

University of Liverpool

Declaration

This thesis is my own work. The material contained in this thesis has not been presented, nor is currently being presented, either wholly or in part for any other degree or qualification.

I confirm that the work submitted is my own, except where work which has formed part of jointly authored publications has been included. My contribution and those of the other authors to this work have been explicitly indicated below. I confirm that appropriate credit has been given within this thesis where reference has been made to the work of others.

Chapter 6 contains results previously published in PLOS ONE as *How does perinatal maternal mental health explain early social inequalities in child behavioural and emotional problems? Findings from the Wirral Child Health and Development Study* by Callum Rutherford (student and first author), Jonathan Hill, Andrew Pickles, Helen Sharp (supervisor) and David Taylor-Robinson (supervisor). All authors contributed to the conception and design of the study. CR performed the analyses with guidance from HS and DTR. CR drafted the manuscript which was critically revised by all authors. All authors approved the final version of the manuscript.

Chapter 7 contains elements of an analysis previously published in the BMJ as *Wide variation in child mental health spend in England* by Callum Rutherford (student and first author) and David Taylor-Robinson (supervisor). All authors contributed to the conception and design of the analysis. CR performed the analyses with guidance from DTR. CR drafted the commentary which was critically revised by all authors. All authors approved the final version of the commentary.

Dedication

I would like to dedicate this thesis to my parents, Anthony and Clare, who have always supported and believed in me.

Acknowledgements

The research was funded by the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care North West Coast (NIHR CLAHRC NWC) at the University of Liverpool. The views expressed here are those of the author(s) and not necessarily those of the NHS, the NIHR, or the Department of Health and Social Care. I would like to express my gratitude to the NIHR CLAHRC NWC for providing the funding which made it possible for me to undertake this work and for the many development opportunities.

There are many people I would like to thank for their contributions to this research, and for supporting me during my studentship.

Firstly, I would like to thank my supervisors, David Taylor-Robinson and Helen Sharp. Thank you for your guidance, patience and encouragement throughout this process. I feel incredibly fortunate to have had the opportunity to learn from your experience and expertise. Thank you for inspiring me to join the fight in tackling health inequalities.

Undertaking this research would not have been possible without the support and friendship of colleagues past and present in the wider community of the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care North West Coast and the Department of Public Health, Policy and Systems at the University of Liverpool. There are too many to mention individually but I would like to thank in particular Sophie Wickham, Melisa Campbell, Viviane Schultz Straatmann, Eric Lai, Suzanne Rotheram, Tanith Rose and Davara Bennett.

I would like to thank everyone at the Wirral Child Health and Development Study for accepting me as a part of the team and for their work in making the studies in this thesis possible. I am particularly grateful to the people behind the numbers - all participating families whose lives are captured in this thesis.

A special thanks to my family and friends for all their love and support: To Niall, Danny, Ste and Tony who have shown me unwavering support, I am immensely grateful. To my parents, Anthony and Clare and to my brothers, Marc and Stuart, thank you for always being there. This would not have been possible without your support.

Abstract

Introduction: Increasingly, there is worldwide concern at the growing incidence of mental health problems in children and young people. Poorer childhood socioeconomic conditions (SECs) have been repeatedly linked with worse mental health outcomes in later life. Reducing inequalities in child mental health is a public health priority, yet in the UK and internationally, current policies are having limited success. Recently, more emphasis has been placed on the need for prevention and early intervention to reduce health inequalities, but there are gaps in the evidence base. This thesis aims to extend our current understanding by assessing when and how socioeconomic inequalities in child mental health outcomes develop, in order to inform more effective policies and timely intervention.

Methods: Study 1 is a systematic review of longitudinal studies assessing the relationship between childhood SECs around the time of birth and subsequent child mental health in the preschool period in high income countries. In subsequent studies, I analysed data from the Wirral Child Health and Development Study (WCHADS), a longitudinal cohort study of children's mental health following 1233 children born on the Wirral, in the North-West of England. For the first time, I analysed WCHADS data using a health equity perspective to explore the relationship between childhood socioeconomic conditions (SECs) and subsequent child mental health outcomes using a variety of analytical techniques. Study 2 assesses the impact of childhood socioeconomic conditions (SECs), as measured by household income, on early life longitudinal trajectories of mental health outcomes from ages 3.5 to 9 years in a birth cohort of 760 children, using linear mixed effects models. Study 3 presents results from an analysis exploring the role of perinatal maternal mental health problems in explaining early social inequalities in child mental health outcomes at five years of age using hierarchal regression models and mediation analysis.

Results: The systematic review identified that 82% of measures of childhood SECs utilised across 15 longitudinal studies were associated with mental health problems in preschool children, whereby the most disadvantaged children had poorer mental health outcomes. These findings build on current knowledge by showing that social inequalities are already established in a preschool aged population. Secondly, analysis of the WCHADS data in study two found that whilst scores for both externalising and internalising behaviour problems decreased from 3.5 to 9 years of age, indicating improving outcomes over this period, the rate of improvement was slower for disadvantaged children, with increasing inequalities observed up to age 9 years. Thirdly, analysis of WCHADS identified significant socioeconomic inequalities in externalising behaviour problems at age 5 years, measured on the basis of maternal income, whereby the most disadvantaged children scored 45 percentage points higher compared to the least disadvantaged children. This association was partially mediated by maternal mental health with pre- and post-natal maternal depressive symptomology attenuating the socioeconomic gap by 42%.

Conclusions: Disadvantaged children have poorer mental health outcomes compared to more advantaged children even in the preschool period. This thesis has demonstrated that the relationship between SECs at birth and child mental health outcomes is evident in the early years in high-income countries, and also in the Wirral population. For children in the WCHADS study, socioeconomic inequalities in mental health outcomes emerge after the age of three and increase up to the age of nine. Inequalities in early externalising problems are partially explained by perinatal maternal mental health problems. Polices to reduce inequalities should focus on improving SECs in the early years and support maternal mental health in the perinatal period. Additionally, the work presented highlights the need for further research to understand the pathways between SECs and mental health outcomes in children.

Contents

Figures

Tables

Abbreviations

ACEs	Adverse Childhood Experiences
AEDC	Australian Early Development Census
BITSEA	Brief Infant-Toddler Social and Emotional Assessment
CBCL	Child Behaviour Checklist
CCG	Clinical Commissioning Group
CES-D	Centre for Epidemiological Studies-Depression Scale
CRD	Centre for Reviews & Dissemination
DAG	Directed Acyclic Graph
DOH	Department of Health
DSM	Diagnostic & Statistical Manual of Mental Disorders
DWP	Department of Work & Pensions
EDI	Early Development Index
EPDS	Edinburgh Postnatal Depression Scale
GBD	Global Burden of Disease
GLM	Generalised Linear Model
IMD	Index of Multiple Deprivation
LSOA	Lower-Layer Super Output Area
MAR	Missing at Random
ML	Maximum Likelihood
NDE	Natural Direct Effect
NHS	National Health Service
NIE	Natural Indirect Effect
NIHR-CLAHRC	National Institute for Health Research Collaboration for Leadership, Applied Health Research & Care
NOS	Newcastle-Ottawa Scale
NS-SEC	National Statistics Socioeconomic Classification
OECD	Organisation for Economic Co-Operation & Development
OHCHR	Office of High Commissioner on Human Rights
OR	Odds Ratio
SDH	Social Determinants of Health
SDQ	Strengths & Difficulties Questionnaire
SEC	Socioeconomic Conditions
SEP	Socioeconomic Position
TE	Total Effect
UK	United Kingdom
UNICEF	United Nations Children's Fund
WCHADS	Wirral Child Health & Development Study
WHO	World Health Organisation

Chapter 1

Introduction

1.1 Relevance of the problem

This thesis explores socioeconomic inequalities in child mental health outcomes (characterised by externalising and internalising behaviour problems) in high income countries. Socioeconomic inequalities in health develop when there are systematic differences in health outcomes between groups occupying unequal social positions (Graham, 2007). Researchers have identified that health inequalities exist within and between countries, meaning there are many differences in individuals and social groups opportunities for a healthy life (Morgan, 2006). A multitude of studies have shown that individuals from socioeconomically disadvantaged backgrounds experience worse health outcomes compared to those from more socioeconomically advantaged positions across almost all outcomes studied. Furthermore, many health outcomes display a social gradient, whereby, the poorest in society experience greater levels of illness, morality and lower levels of wellbeing compared to those higher up the socioeconomic scale (Wilkinson & Marmot, 2003). In public health, these inequalities in health outcomes are considered unfair and unjust and are potentially modifiable by policy intervention (Whitehead, 1990).

Child and adolescent mental health problems constitute a substantial disease burden affecting one in eight globally (Barrican et al., 2022). Mental health problems are now the leading cause of childhood disability globally (Erskine et al., 2015). Mental health problems typically start in childhood and persist into adulthood (Kessler et al., 2007). In the UK, there is growing concern over the rising prevalence of mental health problems in children and young people (Collishaw et al., 2018). It is estimated that one in six children had a probable mental health disorder (NHS Digital, 2020). This represents an increase in rates since 2016, when one in eight children and young people were identified to have a probable mental health disorder (NHS Digital, 2017). Furthermore, the prevalence of mental health problems in preschool age (2-4 years) children was reported for the first time in 2016, with 5.5% of children having at least one mental health disorder (NHS Digital, 2017).

Reducing inequalities in child mental health outcomes is a public health priority (Pearce et al., 2020; Institute for Health Equity, 2020) There is strong evidence that children who are exposed to and experience low socioeconomic conditions are two- to three-times more likely to develop a mental health problem (Reiss, 2013). However, there is still little evidence on how and when early inequalities in child mental health are established.

There is a large and growing evidence base on risk and protective factors for child mental health. However, there is still much to learn about how they may influence change in inequalities in mental health outcomes over time. Studies suggest that there a complex interplay of genetic, biological, social, psychological, and environmental risk factors that operate over the life course.

Children follow different pathways in their mental health development. These pathways can vary in time, and across key developmental periods. These pathways are also likely to be influenced by wider biological and environmental factors. Having a clearer understanding of these pathways will help focus policy and interventions.

Furthermore, early identification can help quantify the level of need and ensure resources can be targeted to support families with young children most at risk of continuing difficulties. Intervening in the early years may be more effective as mental health problems are less entrenched and they may provide benefits across the life course (Webster-Stratton & Reid, 2010; Marmot et al., 2010; Institute of Health Equity, 2020).

There are several gaps in the literature in relation to inequalities in early child mental health problems. The work in this thesis endeavours to address some of the gaps and enhance the evidence base.

1.2 Rationale for this research

As outlined above, there is a high and growing prevalence of child mental health problems. These are associated with adverse outcomes across the lifecourse for the individual, the healthcare sector and society as a whole. There is evidence that there are inequalities in child mental health problems, however, little is known about when early inequalities develop. Furthermore, more evidence is needed to understand mechanisms that might explain these inequalities. Contributing factors may include social stratification, differential risk and susceptibility of risk, early years risk factors and unequal consequences across socioeconomic groups. Assessing and gaining a better understanding of the explanations and pathways is vital to informing the development of policies and interventions to tackle health inequalities. Research is required to address current gaps in the knowledge base that have been highlighted and to offer new insights. This thesis seeks to address some of these research gaps.

The theoretical basis of this thesis is informed by the Dahlgren & Whitehead's (2007) social determinants of health model and Diderichsen's model of the mechanisms of generating socioeconomic inequalities in health (Diderichsen et al., 2001). Both models highlight and inform potential pathways and mechanisms that can lead to health inequalities at the individual and population level, whereby, social position determines exposure and vulnerability to risk factors and the consequences they experience as a result. The studies in this thesis investigate mechanisms of health inequalities, in the context of child mental health. This thesis endeavours to enhance the current knowledge base on how and when early social inequalities in child mental health are established.

1.3 Aims and Objectives

The overarching aim of this thesis is to assess socioeconomic inequalities in child mental health outcomes, with a particular focus on testing when early inequalities are established, and to explore possible explanations for any inequalities identified.

The objectives of this thesis are to:

1. Systematically review literature on the relationship between socioeconomic conditions and preschool-aged children's mental health
2. Assess the impact of socioeconomic conditions (SECs) on longitudinal trajectories of child behavioural and emotional problems starting in the preschool period.
3. Assess the role of perinatal maternal mental health in explaining early social inequalities in child behavioural and emotional problems
4. Assess the policy implications of the above.

To address objectives 2 and 3, I utilise data collected as part of the Wirral Child Health and Development Study (WCHADS), a prospective epidemiological study of children and parents, situated in the North West of England. The objective of the WCHADS study is to identify early risk factors (biological, social and emotional) for the development of child conduct problems. The dataset has yet to be analysed from a health equity perspective.

1.4 Structure of this thesis

- Chapter 2 (Literature review) provides an introduction to health inequalities and their causes and an introduction to child mental health in the early years. A review of the current understanding of socioeconomic inequalities in child mental health is presented and key research gaps are highlighted.

- Chapter 3 (Methods) outlines the systematic review process and search protocol. The chapter also presents a description of the principal data source for the thesis, the Wirral Child Health and Development Study and provides an overview of the analytical methods used in the empirical research chapters.

- Chapter 4 (Study 1) reports the findings from a systematic review assessing the association between low SECs and mental health outcomes in preschool-aged children aged up to five years. This study addresses objective 1 of the thesis.

- Chapter 5 (Study 2) presents the results of a longitudinal analysis assessing the relationship between SECs and longitudinal trajectories of child mental health outcomes using the WCHADS dataset. This addresses objective 2.

- Chapter 6 (Study 3) presents the results of an observational study exploring the possible mediating role of perinatal maternal mental health problems in explaining early social inequalities in early child mental health using the WCHADS dataset. This addresses objectives 3 of this thesis.

- Chapter 7 (Discussion) draws together the key findings from studies 1 to 3 and sets them in the context of prior research. The strengths and limitations of the studies presented are discussed. This chapter also addresses objective 4 of this thesis by discussing the policy implications arising from the study findings. The chapter concludes with a description of on-going and proposed future research.

- There are additional appendices containing additional tables and plots to accompany the analysis chapter and publications arising from this thesis.

Chapter 2

Literature Review

2.1 Introduction

This chapter first defines and explores causes of health inequalities in high income settings. First, I highlight general theories pertaining to health inequalities which outline the different mechanisms that may be operating to cause socioeconomic inequalities in health. I cover some measurement issues and describe some relevant UK policy context. I then present an overview of issues pertaining to child mental health relevant to this thesis before focussing on key literature exploring socioeconomic inequalities in child mental health outcomes.

2.2 What are health inequalities?

There are many ways to define health inequalities. It is important to distinguish some of these differences at the outset of this thesis. In the Americas, health inequalities refer to differences in health outcomes between groups, for example, mortality rates across age groups. They do not necessarily refer to unfair outcomes, this would be most appropriately defined as health inequity (Arcaya et al., 2015; Krieger, 2001). However, in Europe, the term health inequalities is predominately used instead of health inequity (Krieger, 2011).

One of the first and clearest definitions of health inequalities was proposed by Margaret Whitehead in her seminal WHO report "The concepts and principles of equity and health". The report defined health inequalities as:

"*Systematic differences in health status between different socioeconomic groups. These inequities are socially produced (and therefore modifiable) and unfair." (Whitehead, 1990).*

The above definition emphasises that a key concept is the difference in health outcomes and, these differences between socioeconomic groups are not random, but rather systematic and should be understood at a population level (McCartney et al., 2019). Building on this definition, Krieger (2001) suggests that inequalities are a direct result of social structures and institutions which can be changed:

"*Health disparities within and between countries, that are judged to be unfair, unjust, avoidable, and unnecessary and that [health inequalities] systematically burden populations rendered vulnerable by underlying social structures and political, economic, and legal institutions."*

Furthermore, health inequalities can be referred to in terms of absolute and relative inequality. Absolute inequality refers to the simple difference in outcomes between ranked social groups (subtraction of one from another). Whereas, if the difference is expressed as a ratio (one divided by the other), this is considered to be relative inequality (McCartney et al., 2019). These distinctions are important as it has

been demonstrated that whilst absolute inequalities may decrease in health outcomes, relative inequalities can increase (Blakely et al., 2017).

Inequalities in health can also be observed in a stepwise, gradient function across the entire population. It is important to note that social gradients can only be measured where social groups can be ranked, for example, by income level. A social gradient approach to health inequalities is important because all social groups can be negatively affected. Additionally, if this is not captured, this can make the effect of inequalities less relevant for the majority of a population (Wilkinson & Pickett, 2009; McCartney et al., 2019). Furthermore, it has been shown there are differences in outcomes when comparing the most advantaged social groups across societies, this is more prominent in unequal societies (Wilkinson & Pickett, 2009).

These definitions make it clear that health inequalities are more than the unequal distribution of health outcomes of individuals or groups. They are widely considered to be unfair, unnecessary and avoidable. Health inequalities are in direct opposition of the right to the "highest attainable standard of physical and mental health" (WHO, 2004), or in the case of children, to the UN Convention on the Rights of the Child, which states that all children have a right to the best possible health (United Nations, 2008). The Declaration of the Rights of the Child, adopted unanimously in 1959 by the United Nations General Assembly, clearly states:

"The child will enjoy special protection and will have at its disposal opportunities and services, dispensed under the law and through other means, allowing physical, mental, moral, spiritual, and social development in a healthy and normal way, with liberty and dignity" (United Nations, 2008).

In the UK, health inequalities have tended to focus on the distribution of health outcomes by socioeconomic status (Smith, Bambra and Hill, 2016). Socioeconomic inequalities in health are, therefore, defined as systematic differences in health outcomes between groups occupying unequal socioeconomic positions (Graham, 2007). Generally speaking, inequalities in health outcomes exist due to exposure to different levels of exposure and, vulnerability to factors which damage health and access to resources that promote health, which are determined by an individual's social position (Graham, 2009).

Measuring socioeconomic position (SEP), an individuals or groups position held within society on the basis of social and economic factors, is essential for understanding health inequalities (Galobardes et al., 2007). For research on children, it is more appropriate to use the term socioeconomic circumstances / conditions (SEC) instead of SEP. Whilst both represent the socioeconomic environment, a child does not have control over their socioeconomic position, therefore, it is better to talk about the conditions

they are faced with. Children experience a multitude of SECs from their parents or caregiver which can be measured at an individual-level (e.g., parental education, occupation or income level) or at an area-level (e.g., area deprivation). Therefore, this thesis prefers to use the term socioeconomic conditions / circumstances (SECs) (Pearce et al., 2019).

Determinants of health and health inequalities

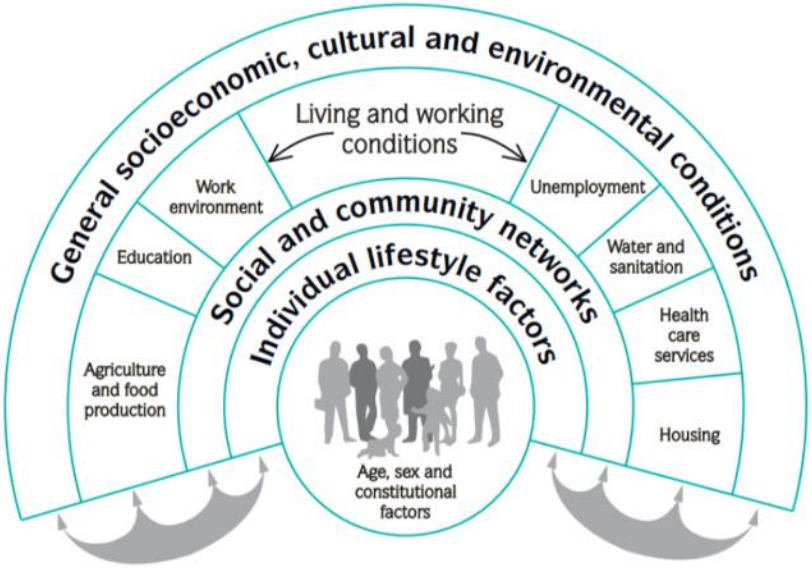
Owing to great progress in research on health inequities over the previous decade, our understanding of the drivers of health inequities has improved. Social factors are widely considered to be important drivers of health and thus inequalities:

"The social conditions in which people live powerfully influence their chances to be healthy. Indeed, factors such as poverty, social exclusion and discrimination, poor housing, unhealthy early childhood conditions and low occupational status are important determinants of most diseases, deaths and health inequalities between and within countries" (WHO, 2004b).

The social determinants of health (SDH) approach was first outlined by the World Health Organisation (WHO) Commission on Social Determinants of Health in 2008. The principal recommendation was that a country's quality of health should be judged on how fairly health is distributed across the whole of society (WHO, 2008). The social determinants are "the conditions in which we are born into, develop, live and work in" and are shaped by wider socioeconomic and political contexts (WHO, 2008). These social conditions have been shown to have powerful influence on a wide range of health outcomes across settings and populations (Braveman & Gottlieb, 2014; Kaplan et al., 1996; Lynch et al., 1997; Marmot et al., 1991).

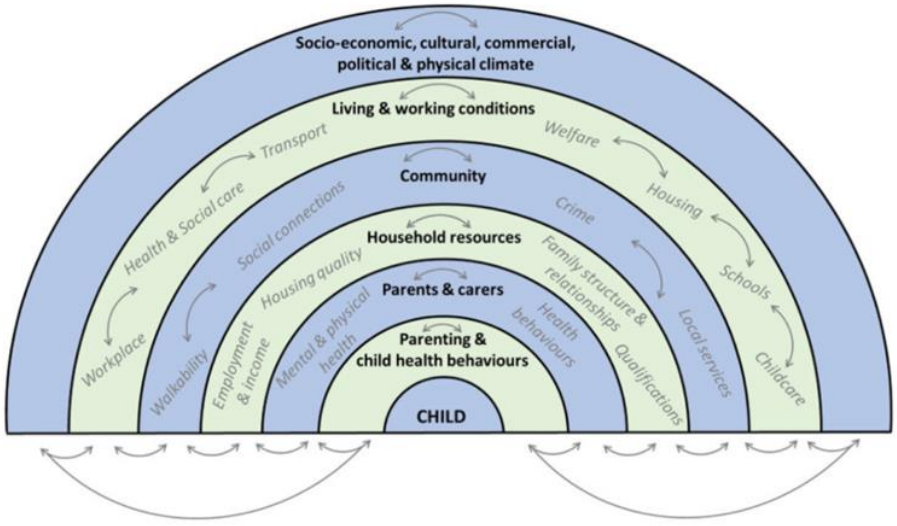
The 'rainbow' model proposed by Dahlgren and Whitehead (2007) (see Figure 2.1) places the individual at the centre. The main determinants of health are represented as a series of arcs that surround and exert influence over the individual. Health is determined by a wide range of factors across multiple ecological levels which are influenced by socioeconomic, cultural and environmental conditions. In the model, arrows point to the interaction between the determinants of health. For example, an individual's lifestyle is part of wider social practices such as living and working conditions, which are related to the wider socioeconomic environment (Dahlgren & Whitehead, 2007).

Figure (2.1) Dahlgren and Whitehead's rainbow model of the social determinants of health.



The social determinants of child health are more explicitly shown in Figure 2.2 which has been adapted to incorporate Bronfenbrenner's 'Ecological systems theory of child development' alongside the 'rainbow model' (Bronfenbrenner, 1979; Pearce et al., 2019).

Figure (2.2) Social determinants of child health.



In the rainbow model (figure 2.2), the individual (the child) is centrally located and there are fixed non-modifiable characteristics such as age and sex. The child is surrounded by concentric layers of influence which are potentially modifiable, these are the social determinants of health. The inner layer shows determinants that are proximal to individual health such as lifestyle factors. Specifically, for children, this includes interactions between the child and parent or care giver (e.g., parenting) which can influence child behaviours (Pearce et al., 2019). As the rainbow extends outwards, factors that may be influenced

by wider social networks are shown. For example, our immediate household networks, the communities we live in. Beyond these layers are macro-level social, economic and political conditions, the fundamental components of the social determinants of health approach, are represented. Whilst these layers of influence can have independent effects on the child, they are also inter-related (indicated by arrows) (Pearce et al., 2019; Dahlgren & Whitehead, 2007).

The SDH approach has provided a useful framework to health inequalities research by highlighting how structural influences (outer layers) affect the socioeconomic conditions in which people live and develop. Furthermore, the SDH approach has also been used to explain why differences in health outcomes exist between groups across the social strata. Additionally, it is important to understand that the SDH are themselves socially distributed, and the influence they have on the individual may vary depending on socioeconomic groups (Pearce et al., 2019).

Moving from the SDH, there are number of differing pathways in which SECs can influence child health outcomes and understanding these are essential to identifying health inequalities. The main pathways to inequalities in health outcomes were first set out in the Black Report (1980) and look at material, psychosocial, behavioural and structural pathways.

Material

The material living conditions in which a child is living and developing can lead to poor and unequal health outcomes. There are high levels of child poverty in the UK which means that families with low household incomes can find it challenging to access health promoting resources and provide basic materials for a healthy environment. For example, disadvantaged children are likely to find themselves living in poor quality housing, whilst parents struggle to purchase warm clothing and, quality healthy foods (Cooper & Stewart, 2013; Wickham et al., 2017).

Psychosocial

The psychosocial explanation for health inequalities posits that psychological and social stresses can lead to health inequalities. An individual in a lower social position may be more exposed to these stresses, for example, feelings of social isolation, social inferiority and low levels of control. In turn, these psychological factors may influence negative health outcomes (Wilkinson, 2005; Brunner, 2005). In relation to children, this pathway mainly manifests through their interactions with their parents and caregivers and their behaviours. This pathway may alter as the child ages as there will be greater awareness of their surrounding environments and their social status (Sweeting & Hunt, 2014). Furthermore, the psychosocial pathway can also refer to the subsequent stress of living and experiencing

social disadvantage. For example, economic hardship and poverty can lead to parental mental health problems which could then affect the child (Wickham et al., 2017).

Furthermore, more generally, the psychosocial approach has also offered an explanation for the social gradients in health outcomes, particularly those observed in high income countries. Studies have shown that countries with high levels of income inequality have higher mortality rates, lower levels of self-rated health and lower levels of well-being (Wilkinson & Pickett, 2009). The psychosocial approach is not limited to those in lower social positions, there is a relative effect, whereby, the psychological factors negatively affect the richest and poorest alike.

Behavioural

The behavioural pathway posits that health inequalities in later life are a result of unhealthy health behaviours such as alcohol consumption, physical inactivity and smoking (Pearce et al., 2019). Furthermore, there is a higher prevalence of unhealthy behaviours in the most disadvantaged groups. The behavioural pathways to health inequalities has been widely criticised as being simplistic and for not explaining the large differences in health outcomes between the most and least disadvantaged, which are in turn, heavily influenced by structural, material and psychosocial pathways (Dahlgren & Whitehead, 2007). Additionally, this pathway fails to acknowledge that children, in the early years, have little influence of the behaviours and environments in which they live (Pearce et al., 2019). As children age, they will then experience their own health protective and risk behaviours, but these are still influenced by their wider social environments (indicated in figure 2.2).

Structural

This pathway relates to the socioeconomic, political and environmental factors that are represented in the outer layers of figure 2.2. These structural pathways directly affect a child's health through the distribution and accessibility of health services (e.g., children's centres) across the population. The structural determinants of health can be viewed as the root causes of health inequalities (Dahlgren & Whitehead, 2007). Furthermore, it has been suggested that the influence of SECs on health outcomes are so strong that even if interventions are targeted to eliminate one of the material, psychosocial or behavioural pathways, SECs will still exert influence on another pathway (Link & Phelan, 1995).

The next section discusses the life course perspective, which emphasises the importance of considering the influence of the social determinants of health at different life stages when considering how health inequalities are generated.

Lifecourse approach to the generation of health inequalities

The social determinants of health, and the main influences on health outlined in the Dahlgren and Whitehead rainbow model discussed above have an influence across the lifecourse. A lifecourse epidemiological approach, discussed below, is an important theoretical concept underpinning the empirical studies of this thesis.

The lifecourse perspective has played a key role in shaping our understanding of how factors in early life can affect health and social trajectories through life, as outlined in the Marmot report for the UK which states:

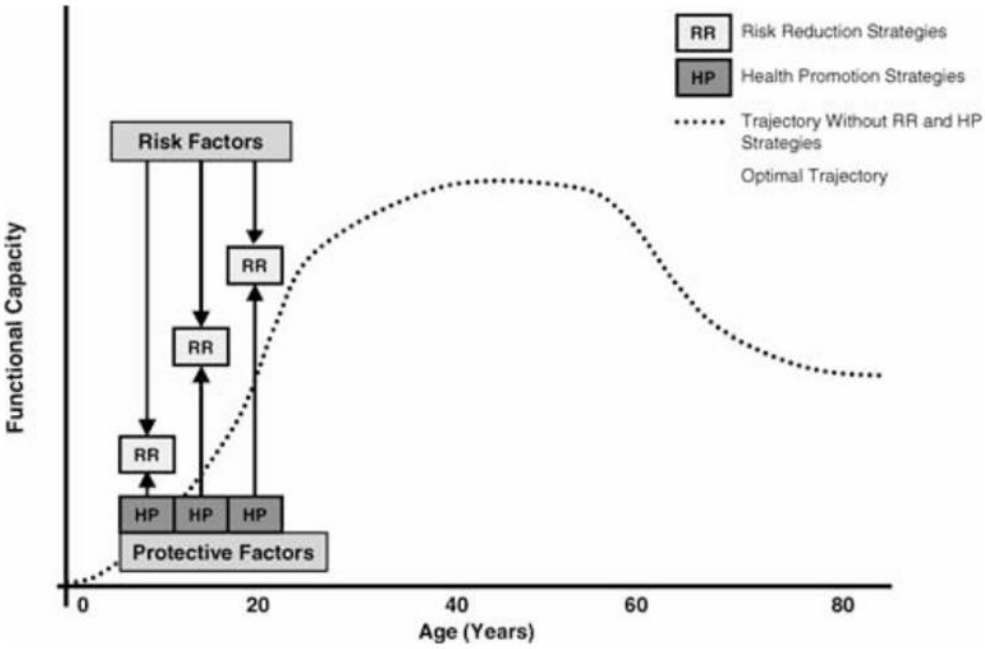
"Disadvantage starts before birth and accumulates throughout life. Action to reduce health inequalities must start before birth and followed through the life of the child. Only then can the close links between early disadvantage and poor outcomes throughout life be broken […] every child the best start in life is out highest priority recommendation (Marmot, 2010)."

The lifecourse perspective considers the timing and order of exposures and outcomes across an individual's life and across generations. These influences may have effects that accumulate and interact throughout the lifecourse. The life course perspective further highlights that risk and protective factors for health may be more or less important at varying points in life, for instance during particular developmental periods in childhood. For example, parental maternal mental health has widely been shown to have long-lasting effects on a child's cognitive and socio-emotional development (Cummings & Davies, 1994; Murray & Cooper, 1997). Furthermore, these influences may have effects that accumulate and interact over time. For example, exposure to persistent poverty has a detrimental effect on adolescent health (Cooper & Stewart, 2013).

Halfon (2003) proposed a life course health development model, in which there is an interaction between cumulative and programming mechanisms. Cumulative mechanisms are an accumulation of effects independent of a particular developmental stage in life and are dose or exposure dependent. Whereas programming mechanisms are independent effects of risks and exposures which occur during sensitive or crucial developmental periods (i.e., early years of a child's life) (Halfon & Hochstein, 2003). These mechanisms in turn influence the trajectory of healthy development, with exposure to risk factors in the early years contributing to decline in later life. Figure 2.3 shows how risk reduction strategies can mitigate the influence of risk factors on the developmental trajectory and that health promotion policies can aid healthy development. Without these strategies in place, development will be suboptimal (dotted line). Furthermore, this model of health development highlights that it is necessary

to invest in health promotion and risk reduction strategies in the early years as capacity greatly reduces later in the lifecourse.

Figure 2.3 Trajectory of health development (adapted from Halfon & Hochstein, 2003)



Taking the example of exposure to childhood adversity to illustrate some of these concepts, we know that children from more disadvantaged backgrounds are more likely to be exposed to adversity and adverse childhood experiences (ACEs) in childhood (Walsh et al., 2019). This early exposure has been associated with poor mental health outcomes by adolescence (Straatmann et al., 2019). ACEs have been found to account for approximately 30% of mental disorders (Kessler et al., 2010) and differential exposure to childhood adversity has been shown to account for up to half of the inequality in adult mortality in Denmark (Elsenburg et al., 2022). The impact of ACEs is likely to be cumulative, with exposure to a greater number of experiences associated with an increased likelihood of developing a mental health problem later in life (Hughes et al., 2017).

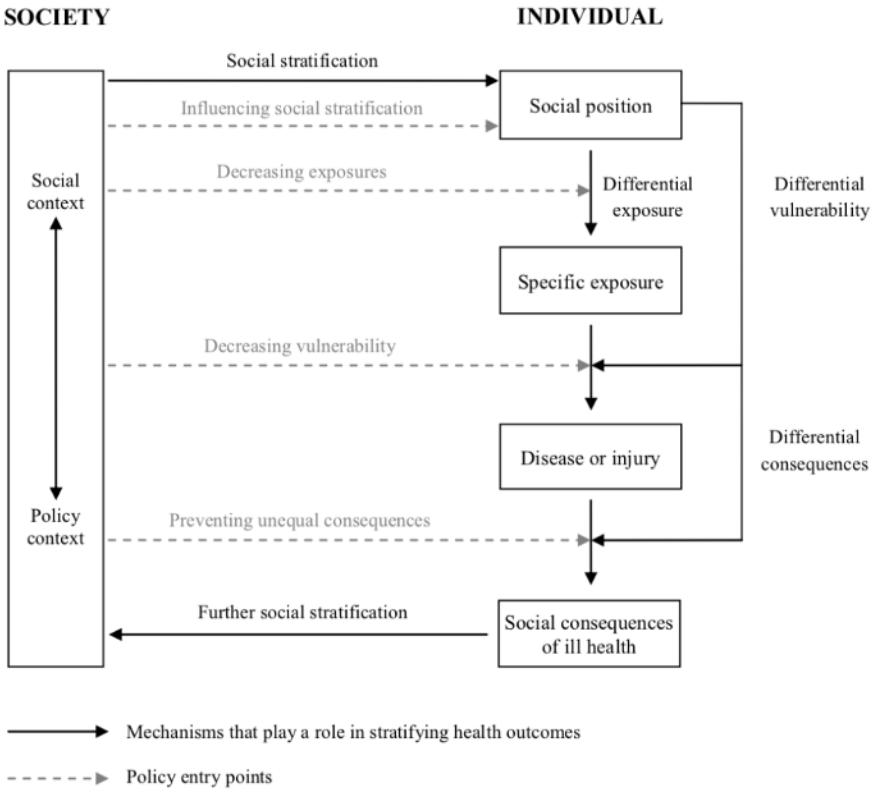
Diderichsen model

Diderichsen's model conceptualises how the social environment influences the stratification of individuals. The model shows how resources, such as wealth and power, are equally or unequally distributed amongst individuals of different social positions (Diderichsen et al., 2001). The model outlines the potential mechanism by which societal structures lead to social stratification, and how

social position then influences exposure, susceptibility and consequences of risk and protective factor exposure.

The model highlights that to understand how health inequalities are established and to determine points for policy intervention it is necessary to look ‘upstream’ to the social mechanisms and, ‘downstream’ to the mechanisms of human biology and psychology of coping mechanisms (Diderichsen, 2001). The theoretical framework that encompasses this approach is shown in figure 2.4. This model emphasises that any practical approach to address health inequalities must be contingent on highlighting the pathways through which social positions are linked to health outcomes. The four main mechanisms proposed are: social stratification, differential exposure, differential susceptibility and differential consequences. For each mechanism highlighted, there are possible policy entry points for intervention.

Figure (2.4): Diderichsen’s model of the mechanisms of health inequality



The model helps to highlight the pathways through which different socioeconomic circumstances can impact on exposure and vulnerability to risk factors for adverse mental health outcomes. Consequently, these outcomes can lead to differential social consequences in education, employment and health care utilisation. The model explicitly combines both social causation and selection mechanisms through differential social consequences pathways.

An individual's social position may also affect the consequences experienced following a period of ill-health. The social consequences of ill health affect every individual but with varying degrees of severity across the social stratum. The effects for an individual may include excessive healthcare costs and loss of work and/or income, which may have more damaging effects for those in lower social positions compared with individuals in more advantaged positions (Diderichsen et al., 2001). Therefore, ill health may result in further social stratification. Although, this may be moderated by larger social contexts, for example, the provision and scope of welfare systems and universal healthcare coverage.

A key strength of this framework is the social and policy focus that spans across the whole lifecourse for an individual. Policies that can influence social stratification, include strategies such as welfare policies designed to reduce the social gap between the least and most disadvantaged individuals in society. Policies to reduce differential exposures would cover public health interventions such as clean water, safer living and working conditions and, access to universal healthcare services. Whilst these policies may be targeted across the whole population, they are likely to have a greater effect on reducing exposure in the most disadvantaged groups.

Another strength of the model is that mechanisms within the model can be empirically tested, and for the development of logic models which outline pathways to inequalities in specific outcomes, such as child mental health. The model adapted from Diderichsen will be re-visited in the discussion chapter to explore how differential exposure to socioeconomic environments contributes to child mental health outcomes. Furthermore, I will explore policy entry points relating to key findings and conclusions drawn from the empirical studies.

In the next section, I will explore the policy context and history health inequalities in the UK.

2.3 Policy context and history of health inequalities in the UK

Historically, the UK has been at the forefront of research addressing health inequalities with the Black Report (Black et al., 1980), the Acheson Inquiry (DoH, 1998) and the Marmot reviews (Marmot et al., 2010, Institute for Health Equity, 2020) which are seminal works exploring health inequity. In 1980 the Black Report, published by the Department of Health and Social Security highlighted widening socioeconomic inequalities in health outcomes despite the establishment of a national health service in 1948. This report showed that the risk of mortality was almost twice as high for men in unskilled occupations compared to men in professional occupations (Black et al., 1980). The Black Report and the Whitehall study, a prospective cohort study of British civil servants, demonstrated the existence of a social gradient in health outcomes, whereby, the risk of mortality increases as an individual's social position decreases (Marmot 2005; Marmot, Shipley and Rose, 1984; Black et al., 1980). The Black

Report generated public attention to the issue of health inequalities and is regarded as an instrumental study in health inequalities research (Bambra and Hill, 2016).

A key theme that has emerged across all of these policies, from Black to Marmot, is the importance of investing in child health. The Commission on the Social Determinants of Health's overarching recommendation, for instance, relates to improving daily living conditions for all and mandates a renewed focus on child health, with major emphasis on early child development (WHO, 2008). This focus on the early years is echoed in the Marmot reviews of health inequalities (Marmot et al., 2010, Institute for Health Equity, 2020), which remains the blueprint for action on inequalities in child health in the UK, along with the Field (Field, 2010) and Allen reports (Allen, 2011), which focus on the importance of early child development.

To address the issues of health inequalities a wide range of social policies were introduced as part of a health inequalities strategy for England between 2000-2010. For example, a national minimum wage, and increased spending on education and health care were implemented. The 'Health Action Zone' was designed and introduced to improve health in deprived neighbourhoods (DoH, 1999). Policies that targeted children explicitly, include the 'Every Child Matters' agenda (Department for Education and Skills, 2003) which combined a number of strategies to help increase immunisation rates, improve access and provision of early antenatal care and reduce parental smoking (DoH, 1998). Most notably, there was an intensive policy focus during the New Labour government (2003-2010) on reducing and eventually ending child poverty. These policies targeted the core blocks of the SDH approach with changes to the tax and benefits system. An emphasis was also placed on improving parental employment with increased preschool care provision at the local authority level. Furthermore, policies specifically targeted children's life chances with the establishment of Sure Start centres to address child poverty though education and support to parents in the early years (Judge, 2012).

As shown above, there was a period of commitment to address the wider social and environmental determinants of health, however, progress later stalled and declined. The initial Marmot review highlighted that the policies had done little to address the root social causes of health inequalities and that policies had not been efficiently co-ordinated across all sectors (Marmot et al., 2010). Another issue identified was that the initial focus of policies was often lost after their implementation. For example, policies that were initially created and implemented with a focus on the social determinants of health ended up targeting, the behavioural pathway and individual lifestyle factors. Consequently, policies have a behavioural approach and the initial focus on wider social factors is lost (Whitehead and Popay, 2010).

Furthermore, the previous strategies highlighted above changed with the Coalition government in 2010 with the introduction of austerity measures. Austerity measures and welfare reforms hit children hardest. Spending on children's centres fell by 28% and 580 centres were closed by 2014. There have been significant changes in investment in Sure Start children centres from 2010-17, with a reduction in funding of approximately 40%, and the largest cuts occurring in the most disadvantaged local authorities (Mason et al., 2021).

This issue was first recognised by the Social Mobility and Child Poverty Commission which believed that policies to substantially reduce child poverty were ineffective and that more radical approaches were needed. Whilst earlier policies had committed to tackle the root causes of the social determinants of health, the commitment had fallen flat. With the introduction of the 'End Child Poverty Campaign' set forward by Tony Blair and New Labour and later reiterated by David Cameron in the Coalition government there was a call for a cross-party approach to tackling child poverty. With the introduction of the Child Poverty Act (2010) there was a legal commitment to the monitoring, reporting and eradication of child poverty. However, it became evident early on that this target was to be missed.

By 2014, the number of children living in absolute poverty had increased by 300,000. This figure equated to around 20% higher than the target levels for the same period. As a result, the Social Mobility and Child Poverty Commission offered a bleak assessment believing only implausible policy measures, such as, vast increases in employment rates for households with children could make any headway. Consequently, they surmised that previous public policy approaches had failed, and that the government would have to pursue a radical agenda for necessary change (Social Mobility & Child Poverty Commission, 2014).

A component of the Child Poverty Act was the establishment of the Social Mobility & Child Poverty Commission. The commission was to act as advisory, non-departmental, body of the Department of Education. The initial roles were to monitor the UK government's approach and strategies to improving social mobility and ending child poverty, providing advice to ministers when requested (Child Poverty Act, 2010). A publicly available report was required to update poverty figures and highlight if relevant targets were being met each year. Since its inception the commission has undergone several changes. Most prominently and controversial was the decision to remove Child Poverty from the title under the Welfare Reform and Work Act 2016. Initially, the decision was made to evaluate how child poverty is measured in the UK, as the relative index of poverty measure was deemed unsuitable. Initially, a move away from an income-based measure was pursued but this was later abandoned.

Since 2010, the UK has witnessed a "great leap backwards" in health (Taylor-Robinson et al., 2014; Stuckler et al., 2017; Picket et al., 2021). There have been increasing health inequalities as a result of

rising poverty levels, welfare reform and cuts to local government budgets and services. In 2016-17, 30% of children were living in poverty in the UK. This was approximately a 30% increase in rates since 2010-11 (DWP, 2018). The proportion of children living in poverty was further expected to increase with 5.2 million children projected to be living in poverty in 2021-22 (Hood & Waters, 2017). These increases are leading to poorer health outcomes and inequalities. For example, since 2010, infant mortality has increased for the first time in over a decade (Taylor-Robinson & Barr, 2017; Taylor-Robinson et al., 2018).

The policies to reduce health inequalities (pre-2010) explored in this section have supported families, improved prevention and treatments and attempted to tackle the underlying social determinants of health. In order to reverse the trends over the last ten years, policies need to tackle child poverty and address the root causes of health inequalities. Furthermore, addressing health inequalities makes economic sense.

Health inequalities have a substantial economic cost to society. In the European Union an estimated 20% of health care and 15% of social security costs are attributable to health inequalities (Mackenbach et al., 2011). Consequently, it has been identified that addressing social disadvantage in the early years, through prevention policies, is crucial to reducing spending on later health and social problems such as unemployment, lifelong conditions and mental health problems (Field, 2010; Marmot et al., 2010, Institute for Health Equity, 2020).

The New Economic Foundation (2008) estimated the cost of addressing social problems, as a result of disadvantage in childhood, as £4 trillion over 20 years to the UK economy. This expenditure is approximately four times the annual NHS budget. The report suggested that increased investment in a combination of early years interventions, universal childcare and paid parental leave could help address almost half of this cost. Consequently, this would place the UK on similar levels of child wellbeing expenditure as Scandinavian countries (Aked et al., 2009). Furthermore, socioeconomic inequality was estimated to cost NHS England £4.8 billion a year (one-fifth of total budget), with hospital costs 50% higher for the most disadvantaged individual compared to the least disadvantaged individual (Asaria et al., 2016).

In the next sections, I will give an introduction to child mental health in the early-years and explore inequalities in child mental health outcomes.

2.4 Introduction to child mental health in the early years

In recent years there has been increased attention given to identifying determinants of children and young people's mental health, as researchers and clinicians increasingly support the principle of parity of esteem between physical and mental health. If mental health is as important as physical health, then we need to improve our understanding of the potential pathways from early risk factors and early symptomology to later outcomes to inform the nature and timing of prevention strategies across the lifecourse.

Definition of mental health

The mental health charity Mind defines mental health as an individual's cognitive, behavioural and emotional wellbeing (Mind, 2020). For children, being mentally healthy means reaching key developmental and emotional milestones and learning how to healthily regulate responses to problems and challenges (CDC, 2022). Whilst the terms 'mental health problem' or 'mental disorder' suggest a clinically diagnosable illness, this thesis utilises the notion of mental health as a continuum of symptom severity and not simply the presence or absence of a diagnosable disorder since considerable functional impairment can be present at sub-diagnostic thresholds (Angold & Costello, 1996).

Emergence of emotional and behavioural symptoms in the early years is considered part of a normative development (Tremblay et al., 1999), however, it is important that these behaviours are normative and regulated. The understanding of the nosology of emotional and behavioural disorders in the preschool period is acknowledged to be less well developed than for disorders in older children (Angold & Egger, 2006). In young children, mental health can manifest as socio-emotional difficulties. A distinction is made between internalising disorders (e.g., anxiety, depression) and externalising disorders (e.g., attention problems, aggressive behaviours and conduct problems). Furthermore, with the development of reliable and validated measures of child mental health, it is widely accepted that there is often comorbidity between behavioural and emotional problems. Angold (2006) found that the risk of comorbidity increased with each additional year of age (from ages 2 to 5 years).

How is mental health measured?

Child mental health can be measured at a diagnostic level or at a dimensional level (symptomology, traits) (Egger & Angold, 2006; Rutter, 2011). Whether child mental health should be measured by one approach or another has been widely debated (Markon et al., 2011) and is often given research attention when changes are made to the widely used classification system, the Diagnostic and Statistical Manual of Mental Disorders (DSM) (American Psychiatric Association, 2000). The DSM is based upon a medical model, which conceptualises mental health constructs as located within the individual that are represented as disease or illness (Rutter, 2011). Following this approach, it is possible to make clinical-level diagnoses informed by sets of criteria and symptomology. Adopting a categorical diagnosis has

clinical utility, as this can aid communication about treatments and services. Additionally, for researchers, a diagnostic approach allows for comparisons between cases in clinical and non-clinical settings (Maughan, 2005).

A dimensional approach to psychopathology is also recognised, with levels of symptomology that are below clinical and diagnostic thresholds being taken into consideration (Gotlib et al., 1995). It is vital to also investigate and establish subthreshold levels of symptoms in populations as they can cause distress and impairment in life and are often 'impaired but undiagnosed' (Angold et al., 1999).

This thesis focuses on dimensional approaches to child mental health, which are predominantly assessed through checklist measures assessing symptomology and traits and are most commonly selected for use in longitudinal studies of child development due to their reliability, validity, comparative brevity and consequent low participant burden. Dimensional approaches have become the most widely used method of measuring mother and child factors (Pickles & Angold, 2003).

Widely used, and well-validated, checklists for measuring child mental health in the early-years include the Child Behaviour Checklist (CBCL) (Achenbach & Rescorla, 2000), the Brief Infant-Toddler Social and Emotional Assessment (BITSEA) (Briggs-Gowan & Carter, 2002), the Strengths and Difficulties Questionnaire (SDQ) (Goodman, 1997) which can be completed by the child's parents, caregiver or teacher and can be reliably used to assess child mental health in children from as young as 12-18 months of age (Mantymaa et al., 2012). However, these measures often do not account for social context or severity of impairment that may be associated with the constructs of interest (Hill et al., 1989).

Measures of child behaviours often rely on reports being undertaken by different informants who interact with the child across environments, for example, at home or at school (Achenbach et al., 1987). Whilst dimensional measures have been constructed to minimise subjectivity and how the reporter may focus on particular behaviours, scores will be based upon an informant's perception (Lederberg Stone et al., 2014). Studies have found that differences between teacher- and mother reported scores are associated with maternal age, socioeconomic status, depression, child's sex and age (Hartman et al., 2007; Kerr et al., 2007). Strong rater reliability and agreement have been found for children who have moderate to severe psychopathology, however, discrepancies are much larger in at-risk samples (Achenbach et al, 1987; Konold et al., 2004).

Ratings may also be independently influenced by SES, with discrepancies between teacher- and parent-reports more frequent in lower SES families (Lederberg Stone et al., 2014). Furthermore, Lederberg Stone et al., (2014) found that mothers often reported higher internalising and externalising behaviour problems in both girls and boys compared to teachers. Despite the above limitations and challenges

with a dimensional approach to child psychopathology, these measures are still widely used in child mental health studies, particularly, large cohort studies.

Mental health can also be measured as part of an investigator-based approach. This approach is usually administered by trained interviewers using a set of standardised semi-structured interviews, whereby respondents provide very detailed accounts about their behaviours. These descriptions are then rated by researchers trained to reliability in coding practices (Hill et al., 2000). This approach to measuring child mental health is often very timely and expensive, thus, are often not employed in large cohort studies.

Global burden and prevalence of mental health problems

In high income countries there has been an epidemiological transition, whereby, mental health problems have overtaken infectious diseases as the leading contributor to disability adjusted life-years lost (DALYs) in the Global Burden of Disease (GBD) index (Baranne & Falissard, 2018). A systematic analysis of the global burden of mental disorders found that from between 1990 and 2019 the number of DALYs due to mental disorders increased from 80.8 million to 125.3 million (GBD, 2019). The analysis also found that depressive disorders ranked highest for DALYs across all age groups, with the exception of ages 0-14 years, where conduct disorders were the leading cause of burden (GBD, 2019).

In the UK there is growing concern over the rising prevalence of mental health problems in children and young people (Collishaw et al., 2018; Institute of Health Equity, 2020). The most recent official survey of mental health in children and young people found that one in six children (16%) had a probable mental health disorder (NHS Digital, 2020). This represents an increase in rates since 2016, when one in eight children and young people were identified to have a probable mental health disorder. (NHS Digital, 2017). Furthermore, the prevalence of mental health problems in preschool age (2-4 years) children was reported for the first time in 2016, with 5.5% of children having at least one mental health disorder (NHS Digital, 2017).

Prevalence of mental health problems also vary across the lifecourse. In preschool aged children behavioural disorders are most common, and there is little difference in the prevalence of emotional disorders in boys (4.6%) and girls (3.6%) (NHS Digital, 2017). With the transition into adolescence, the prevalence of emotional disorders increases with girls more likely to be diagnosed with an emotional problem (Green et al., 2005). Strikingly, a survey in England found that this is further exacerbated by early adulthood (17-19 years), with 1 in 4 girls having a probable mental disorder compared to 1 in 10 boys (NHS Digital, 2017).

It is important to understand the prevalence of mental health in early years but also subsequent trajectories of mental health across the lifecourse as this will provide vital information about optimal

timing for interventions and policies. For example, the inclusion of the prevalence of emotional and behaviour disorders in 2-4-year olds for the first time in the NHS Digital Survey 2017 is much welcomed. Early identification can help quantify the level of need and ensure resources can be targeted to support families with young children most at risk of continuing difficulties. Intervening in the early years may be more effective as mental health problems are less entrenched and they may provide benefits across the life course (Webster-Stratton & Reid, 2010; Marmot et al., 2010; Institute of Health Equity, 2020).

Child mental health trajectories

Children follow different pathways in their mental health development. These pathways can vary in time and across key developmental periods. These pathways are also likely to be influenced by wider biological and environmental factors. Having a clearer understanding of these pathways will help focus policy and interventions. For example, understanding mental health trajectories of children exposed to social disadvantage, may help identify when children are particularly vulnerable and where policy change is needed to tackle inequalities.

In the developmental psychopathology literature, one of the main theoretical approaches to understanding the developmental taxonomy of antisocial behaviour was offered by Moffitt (1993). The 'life course persistent trajectory' where antisocial behaviour develops in early childhood and continues through adolescence and also into adulthood. The 'adolescent-limited' trajectory, where antisocial behaviour develops in adolescence and declines in adulthood. Moffit (1993) put forward two theories to explain the different trajectories. For the life-course persistent group, social, familial and neurodevelopmental deficits contribute to the development of child behavioural problems in the early years and over time, the accumulation of exposure to risks lead to difficulties in later life which are linked with adult mental health problems (Moffitt, 1993). A subsequent examination of data gathered in the Dunedin longitudinal study supported the life-course persistent trajectory (seen in 7.5% females and 8.2 % males) and the adolescent-limited trajectory (seen in 17.4% females and 12.3 % males) and led to further identification of two other developmental trajectories. A 'childhood-limited' trajectory (seen in 20.0% females and 23.6 % males) whereby, externalising problems are evident in early childhood but reduce through late childhood and early adolescence (Odgers et al., 2008) and a low trajectory group (seen in 55.1% females and 55.9 % males).

These distinct trajectories of behaviour problems from the early years to adolescence have now been well established across populations using different measures of child mental health problems (Thompson et al., 2011; Flouri et al., 2018). For example, a study of Belgian children (aged 4-17) found that both childhood-limited, and life course persistent groups showed high levels of behavioural

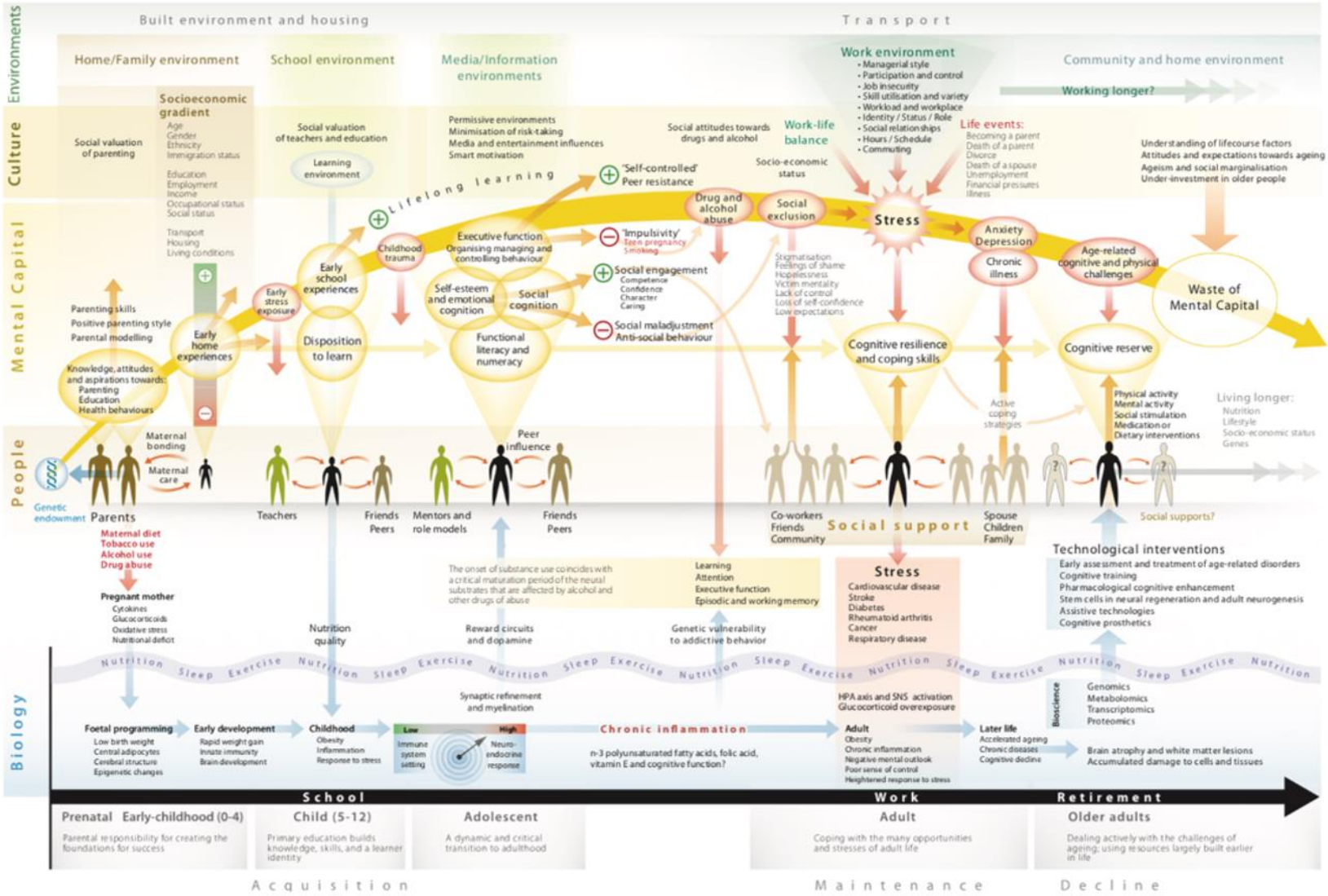
problems across the early years, with an improvement in problems scores for the childhood limited group (Sentse et al., 2017). Furthermore, studies have also tried to identify differing developmental pathways for internalising problems. A longitudinal study of Australian children (aged 4-12) identified that approximately 75% of children experienced a low difficulty trajectory between 4-12 years of age for internalising problems, with only 2% following a stable, high difficulty trajectory (Vella et al., 2019).

In summary, there are multiple developmental trajectories evident for mental health problems in children and these can vary for internalising and externalising problems. Identifying children most at risk of sub-optimal pathways will help target and focus interventions intended to reduce child mental health problems. Developmental trajectories are also likely to be influenced by wider environmental factors. For example, disadvantaged children are less likely to follow a normative and healthy development trajectory compared to more advantaged children (Flouri et al., 2018). In the next section, I explore some of the main risk and protective factors that may play a role in trajectories of mental health.

Risk and Protective factors of child mental health

There is a large and growing evidence base on risk and protective factors for child mental health. However, there is still much to learn about how they may influence change in mental health outcomes over time. Studies suggest a complex interplay of genetic, biological, social, psychological, and environmental risk factors that operate over the life course. This section will highlight some of the main risk factors for child mental health recognised in the literature. Figure (2.5) summarises the range of risk and protective factors for mental health identified in the literature that an individual is exposed to across the lifecourse. Risk and protective factors in pre-natal and early-childhood period are the focus of this thesis.

Figure 2.5: Risk and protective factors affecting the trajectory of mental health across the lifecourse (Foresight Mental Capital and Wellbeing Project, 2008).


Environments
Culture
Mental Capital
People
Biology
Built environment and housing
Transport
Home/Family environment
School environment
Media/Information environments
Work environment
Community and home environment
Socioeconomic gradient
Social valuation of parenting
Social valuation of teachers and education
Learning environment
Permissive environments
Minimisation of risk-taking
Media and entertainment influences
Smart motivation
Social attitudes towards drugs and alcohol
Work-life balance
Socio-economic status
Life events:
Becoming a parent
Death of a parent
Divorce
Death of a spouse
Unemployment
Financial pressures
Illness
Working longer?
Understanding of lifecourse factors
Attitudes and expectations towards ageing
Ageism and social marginalisation
Under-investment in older people
Lifelong learning
'Self-controlled' Peer resistance
Drug and alcohol abuse
Social exclusion
Stress
Anxiety Depression
Chronic illness
Age-related cognitive and physical challenges
Waste of Mental Capital
Executive function
Organising managing and controlling behaviour
'Impulsivity'
Childhood trauma
Early school experiences
Early stress exposure
Self-esteem and emotional cognition
Social cognition
Social engagement
Competence
Confidence
Character
Caring
Social maladjustment
Anti-social behaviour
Stigmatisation
Feelings of shame
Hopelessness
Victim mentality
Lack of control
Loss of self-confidence
Low expectations
Parenting skills
Positive parenting style
Parental modelling
Early home experiences
Disposition to learn
Functional literacy and numeracy
Cognitive resilience and coping skills
Cognitive reserve
Knowledge, attitudes and aspirations towards:
Parenting
Education
Health behaviours
Active coping strategies
Physical activity
Mental activity
Social stimulation
Medication or
Dietary interventions
Living longer:
Nutrition
Lifestyle
Socio-economic status
Genes
Maternal bonding
Maternal care
Peer influence
Genetic endowment
Parents
Teachers
Friends
Peers
Mentors and role models
Co-workers
Friends
Community
Social support
Spouse
Children
Family
Social supports?
Maternal diet
Tobacco use
Alcohol use
Drug abuse
Pregnant mother
Cytokines
Glucocorticoids
Oxidative stress
Nutritional deficit
The onset of substance use coincides with a critical maturation period of the neural substrates that are affected by alcohol and other drugs of abuse
Learning
Attention
Executive function
Episodic and working memory
Stress
Cardiovascular disease
Stroke
Diabetes
Rheumatoid arthritis
Cancer
Respiratory disease
Technological interventions
Early assessment and treatment of age-related disorders
Cognitive training
Pharmacological cognitive enhancement
Stem cells in neural regeneration and adult neurogenesis
Assistive technologies
Cognitive prosthetics
Nutrition quality
Reward circuits and dopamine
Genetic vulnerability to addictive behavior
Nutrition Sleep Exercise
Synaptic refinement and myelination
HPA axis and SNS activation
Glucocorticoid overexposure
Bioscience
Genomics
Metabolomics
Transcriptomics
Proteomics
Foetal programming
Low birth weight
Central adipocytes
Cerebral structure
Epigenetic changes
Early development
Rapid weight gain
Innate immunity
Brain development
Childhood
Obesity
Inflammation
Response to stress
Low
High
Immune system setting
Neuro-endocrine response
Chronic inflammation
n-3 polyunsaturated fatty acids, folic acid, vitamin E and cognitive function?
Adult
Obesity
Chronic inflammation
Negative mental outlook
Poor sense of control
Heightened response to stress
Later life
Accelerated ageing
Chronic diseases
Cognitive decline
Brain atrophy and white matter lesions
Accumulated damage to cells and tissues
School
Work
Retirement
Prenatal
Early-childhood (0-4)
Parental responsibility for creating the foundations for success
Child (5-12)
Primary education builds knowledge, skills, and a learner identity
Adolescent
A dynamic and critical transition to adulthood
Adult
Coping with the many opportunities and stresses of adult life
Older adults
Dealing actively with the challenges of ageing; using resources largely built earlier in life
Acquisition
Maintenance
Decline

Adopting a life course approach to mental health helps researchers to understand how social and biological factors interplay in the development and subsequent consequences of mental health problems over the entire life span (Karestan et al., 2013) (Figure 2.5). The lifecourse approach utilises two perspectives, the psychological life span and the developmental psychopathology perspective to understanding the development of mental health problems.

In developmental psychopathology, it is important to understand how risk and protective factors independently influence child outcomes. This will enable further examination of possible mechanisms, pathways and any interactional processes (Rutter, 2011). The many mechanisms at play can make it difficult to separate out specific causal effects of an individual factor on an outcome, such as child mental health. Consequently, this can lead to difficulties in attempting to address risk factors which contribute to the onset and maintain problems in childhood and, that may also establish and exacerbate social inequalities (Hill, 2002).

As shown in Figure 2.5, there is a wide range of influential factors in the prenatal and early-childhood period that contribute to development of mental health across the lifecourse. Understanding developmental psychopathology requires attention of both proximal and distal factors present in the wider environment. Bronfenbrenner (2004) proposed that factors can have a proximal or distal influence. Distal influences refer to the wider socioeconomic, environmental or genetic factors. Whereas proximal influences refer to influences on children such as parental mental health or parenting quality. Furthermore, distal and proximal factors are not exclusive in their influence. Wider environmental factors are likely to lead to proximal factors and associated inequalities (Kumsta et al., 2010). Additionally, individuals may differ in their susceptibility to wider social and environmental factors, with some more vulnerable to risk factors, contributing to inequalities in outcomes (Belsky et al., 2007).

Furthermore, it is important to understand any temporal relationships between factors in order to provide information on the developmental processes that are most pertinent in child mental health outcomes (Rutter et al., 2001). Assessing the timing of relationships between factors and outcomes (temporal relationships) is important in developmental psychopathology (Rutter et al., 2001). Prospective, epidemiological study designs (i.e., birth-cohorts) can help researchers understand the role of risk and protective factors across the lifecourse and how they may be receptive to policy and intervention in critical or sensitive periods (Barker et al., 2011). Timing of effects can be difficult to isolate and often require study over many years. For example, prenatal risks are often associated with postnatal risks, which can lead to a continuum of influence (Hill, 2002). Furthermore, differential susceptibility to effects in critical or sensitive periods may help to establish or widen inequalities in externalising or internalising behaviour problems.

Life course approaches to mental health have increased as a result of the availability of biological measures in cohort studies allowing for the examination of gene-environment interplay in the development of mental health problems (Karestan et al., 2013). Previous research had been limited to examining a number of candidate genes for increasing susceptibility and vulnerability, however, large scale genomics studies have begun to open up opportunities to investigate the role of gene-environment across the lifecourse (Karestan et al., 2013).

Wider environmental factors may also co-occur with genetic influences. Genetic influences may be direct whereby variations of behaviours are transmitted from parent to child (Jaffee et al., 2012). Genetic influences may also be indirect, through gene-environment interactions, meaning there is an interplay between genetic influences and wider environmental risk factors. This may affect an individual's responsiveness to their own environment (Caspi et al., 2010). Behavioural genetic studies have shown that genetic effects are strengthened on risk factors such as parent-child relationships and stressful life events on symptoms of externalising disorders (Hicks et al., 2009). Furthermore, in the context of antisocial behaviour, genetic variants of the monoamine oxidase A (MAOA) gene can moderate the effect of environmental adversity (i.e., childhood maltreatment) on later antisocial outcomes (Caspi et al., 2002; Kim-Cohen et al., 2006). Therefore, the prenatal and early-years environment is vital to healthy development and vulnerability to wider social factors can contribute to the emergence of inequalities. These biosocial risks are likely to continue throughout the lifecourse, for example, through the interaction of characteristics such as hormone levels, stress reactivity and pubertal status (Rowe et al., 2004).

Additionally, studies have consistently found associations between prenatal risks such as maternal anxiety, depression, life events and levels of stress hormone with later emotional and behaviour problems in children (Davis et al., 2007; Van den Bergh et al., 2008). There is strong evidence (human and animal) for sex differences in vulnerability to foetal risks and the different effects of stress on male and female foetuses (Weinstock, 2007). These differences have been linked to differences in the Hypothalmo-Pituitary-Adrenal (HPA) axis mechanisms (Aiken & Ozanne, 2013). Risks associated with maternal HPA variations may have different effects on male and female foetuses with prenatal risks associated with lower levels of emotional reactivity in boys but higher reactivity in girls (Tibu et al., 2014; Braithwaite et al., 2017). This suggests that there may be a biological explanation for differences in risk in males and females or that are their different vulnerabilities and susceptibilities which may be further influenced by the wider socioeconomic environment.

Further showing the effects of gene-environments interactions, studies have shown that the prevalence of depression is higher among immediate family members of individuals with depression compared to

the general population (Mitjans & Arias, 2012). Twin studies have also shown that whilst genes are important, they are not an independent risk factor. There is likely to be further interplay with the wider environment (Sullivan et al., 2000). For example, adverse life events were found to be stronger predictors of depression in individuals with a genetic risk for developing depression than individuals not predisposed to risk (Kendler et al., 1995).

Understanding the role of genetic influences is often complex and relies on study designs explicitly capturing genetic and biological data to test for interactions and comparisons (i.e., twin samples). Whilst genetic effects are not the focus of the studies in this thesis, there may be associations that are partially explained by unmeasured genetic effects. This section has explored how the emergence of differences in externalising and internalising behavioural problems may be as a result of genetics and foetal programming, however, these effects are likely to work alongside wider environmental factors. In the next section, I will explore some of these factors that may contribute to the development of inequalities in mental health outcomes.

The familial and social environment are important risk factors that may be targeted for intervention to reduce the risk of the emergence of child mental health problems (Bayer et al., 2005; Marmot et al., 2010; Mantymaa et al., 2012). Parental psychopathology has widely been acknowledged as a determinant of child mental health, with parental depression shown to have long-lasting effects on a child's cognitive and socio-emotional development (Cummings & Davies, 1994; Murray & Cooper, 1997). Parental mental health impacts from very early in life with prenatal and postnatal depression associated with children experiencing more externalising and internalising symptomology (Gelfand & Teti, 1990; Dean et al., 2010; Kingston et al., 2012). Parents who experience chronic mental health problems are also at further subsequent risk due in part to the impact on their own lives. Individuals may experience a loss of income from work absence or loss of employment which can further increase stresses in the family environment, which in turn may lead to poorer child mental health outcomes (Chen, 2017).

Parental mental health can also negatively affect parenting quality and subsequently contribute to poorer mental health outcomes for children. For instance, maternal depression has been associated with more negative parent-child interactions. Maternal depression has been associated with less sensitivity to children's emotions and behaviours. For example, a depressed parent may become more withdrawn and disengaged with their child and may engage less in positive social interactions such as playing (Lovejoy et al., 2000; McLearn et al., 2006).

A potential pathway between SECs and mental health outcomes in later life is the familial environment (Repetti et al., 2002). Early parent-child relationships have long been recognised as important,

potentially protective factors, for healthy development with social and emotional consequences for children (Bowlby, 1988). Positive early mother-infant interactions are important in the development of attachment security, as a parent's ability to help their child regulate distress is likely to aid the child's development of emotion regulatory capacities (Goldberg et al., 1999).

Positive parenting and involvement in a child's development are particularly important in crucial periods, such as the early years (Whittle et al., 2014). Parental warmth and parenting quality have been shown to mediate the effects of family stressors on children socio-emotional behaviours (Kawabata et al., 2011; Beijersbergen et al., 2012; Reuben et al., 2016). Providing emotional support, bonding and active engagement in a child's life can encourage resilience and help with children's emotion regulation capacity in response to stressors (Badri et al., 2014; Hernandez & Popli, 2017).

Furthermore, parenting that lacks warmth and receptiveness may pose a serious risk to children's mental health (Davies & Windle, 1997). Harsh or erratic disciplinary practices have been associated with both externalising and internalising symptomology in both children and adolescents (Gershoff 2002; Patterson & Stouthamer-Loeber, 1984). Studies have also shown that socioeconomic status may influence parent's attitude to their children and their subsequent approaches to parenting practices (Hoff et al., 2002).

Parental, child and family risks are thought likely to work in a 'transactional, reciprocal manner.' (Mantymaa et al., 2012). For example, early externalising symptoms might contribute to the stability or continuity of parenting stress (Williford et al., 2007) which in turn may influence parenting. It is likely that these mechanisms form 'risk clusters' and do not act independently (Mantymaa et al., 2012). Influences are also likely to be bi-directional between mothers and their children (Kochanska, et al., 2004). Children are also likely to influence their mothers, with child attributes such as temperament affecting and contributing to the parent-child dynamic (Belsky, 1984). Studies have found that high levels of infant irritability predict the onset of depression in mothers already identified as at risk of postnatal depression (Murray et al., 1996).

Furthermore, non-compliant behaviour in boys, aged 1.5 years, predicted higher levels of maternal depressive symptomology, after adjusting for socio-demographic factors (Gross et al., 2009). Additionally, higher levels of depressive symptomology were associated with both teacher and adolescent reported externalising problems, even after controlling for initial levels of non-compliance (Gross et al., 2009). This highlights that influences are likely to be bi-directional in the parent-child dynamic and have effects across the early-years and into adolescence.

In summary, it is clear that there is a complex interplay of factors in the prenatal and early childhood period that can contribute to children's mental health. As stated by Bowlby (1973) "Development turns at each and every stage of the journey on an interaction between the organism as it has developed up to that moment and the environment in which it finds itself." Therefore, adopting a lifecourse approach is a useful framework when examining how and when inequalities in mental health problems develop.

Genetic, social and wider environmental factors (figure 2.5) do not operate exclusively and can lead to increased susceptibility or further exposure to risk factors. Conger's (1992) family stress model helps to illustrate this issue. Conger (1992) posits a consequential model in explaining the role of family stress on child mental health. The model highlights how social disadvantage (distal factors) can cause economic pressures, which in turn contributes to parents' mental health (proximal factors), which affects parenting style or quality of parenting, which in consequence leads to negative behavioural adjustment in children. Whilst this model can be adapted and utilised across the lifecourse, as mentioned above, there are genetic, socioeconomic and wider environmental factors in the prenatal and early-years that are vital to a child's healthy development and can be targeted to address social inequalities.

Furthermore, psychosocial environment theory offers a possible explanation for the increased risk of mental health problems for the most disadvantaged individuals in society. People's perceptions of their standing and place within the socioeconomic sphere can affect health via psycho-neuro-endocrine processes (Lynch et al., 2001). Furthermore, the accumulation of stress associated with low socioeconomic status may lead to higher rates of depression (Lynch et al., 2001). Whilst, inequalities are often measured in adult populations, similar effects have been identified in children (Lupien et al., 2000).

This thesis primarily explores risks and protective factors (socioeconomic conditions and parental mental health) in the perinatal period as these are amenable to change through policy and intervention.

2.5 Inequalities in child mental health

Primarily research on child mental health has been conducted from a psychological and/or psychiatric perspective. Whilst there has been an increase in child mental health research from a health inequalities perspective, a focus on early child mental health is still in its early stages. Socioeconomic disadvantage is a well-established risk factor for developing mental health problems. Disadvantaged children are more likely to be exposed to psychological and biological risk factors that lead to the early development of mental health problems (Pickett & Wilkinson, 2015; Ravens-Sieber et al., 2008; Essex et al., 2006; Tennant et al., 2007).

Previously, a systematic review exploring socioeconomic inequalities in child and adolescent mental health (5-18 years) in high-income countries found that the most disadvantaged children were up to three times more likely to have a mental health problem compared to less disadvantaged children (Reiss, 2013). This association was identified in 52 out of the included 55 studies. Whilst there is strong evidence of the association of social disadvantage and the risk of subsequent mental health problem in children aged 5-18, this relationship remains unclear in preschool aged children.

Furthermore, there is evidence that social inequalities in child mental health are worsening. A recent study explored child mental health inequalities across three UK population cohorts of 11-year-old children (British Child and Adolescent Mental Health Surveys and the Millennium Cohort Study) assessed in 1999, 2004 and 2012 (Collishaw et al., 2018). The study found that there were substantial socioeconomic inequalities in child mental health within each cohort. Additionally, when comparing mental health scores between the most and least disadvantaged children, scores increased by 50% across the study period (1999-2012) (Collishaw et al., 2018).

There has been a growth in literature assessing the relationship between socioeconomic disadvantage and child mental health outcomes over the lifecourse, however, few studies explore social inequalities in trajectories of mental health across the early years. Predominantly, research on child and adolescent mental health trajectories have explored changes in behavioural and emotional profiles through key development phases (i.e., childhood into adolescence) and whether trajectories vary by sex (Odgers et al., 2008; Murray et al., 2022; de Lijster et al., 2019).

Social inequalities in child mental health may also vary by the domain of mental health measured. Vanderblit & Gleason (2011) found that that disadvantage led to an increase in the risk of both internalising and externalising behaviours. Whereas studies have found that SECs was associated with increased risk for internalising behaviours only (Paterson et al., 2013; Ciciolla et al., 2014).

Social inequalities in child mental health have been shown to track through into adulthood (Viner et al., 2012; Arango et al., 2018). However, there is limited and mixed evidence as to when early inequalities in child mental health are established and whether inequalities widen or narrow across childhood. Bayer et al., (2008) in a population-based study of 585 children in Australia found that household income (measured at 7 months postnatal) was not associated with changes in externalising or internalising behaviour scores from 1.5 to 3 years of age. Contrastingly, D'Souza (2019) found in a sample of 5896 New Zealand children, that the most disadvantaged children (defined by low maternal education) were more likely to have persistent mental health problems between 2 and 4.5 years of age, compared to the least disadvantaged children.

Mazza et al., (2016) demonstrated in a sample of 2045 Canadian children that exposure to poverty influenced longitudinal trajectories for hyperactivity, opposition and physical aggression behaviour profiles. Furthermore, the accumulation of experiencing social disadvantage was particularly important. Children that were exposed to persistent poverty had higher levels of these symptom profiles from age 1.5 to 5 years of age, before experiencing a much slower rate of decline through to eight years of age compared to children who were not exposed to poverty (Mazza et al., 2016).

2.6 Gaps in the literature

The following points highlight several gaps in the evidence based in relation to inequalities in child mental health outcomes in high income countries. The work in this thesis aims to address the gaps identified, to enhance current understanding of inequalities in child mental health outcomes.

- Firstly, there is a growing body of evidence that there are social inequalities in child mental health outcomes across the early years. The studies in this thesis will seek to enhance the current evidence based.

- The association between SECs and the risk of child mental health problems has been demonstrated in children and adolescents aged 5-18 years. However, it remains unclear if these inequalities are already established in the early years of a child's life. A systematic review is warranted to pool together and summarise the current evidence on this issue. Study 1 of this thesis seeks to enhance understanding of early social inequalities via longitudinal studies, capturing SECs in the perinatal period and validated measures of early child behaviours through a systematic literature review.

- Little is known about the trajectories of inequalities in child mental health, particularly, in the early years. Furthermore, there is mixed evidence as to whether trajectories differ for internalising and externalising behaviours and whether these differ by sex. Study 2 of this thesis seeks to address this gap in the evidence base by exploring trajectories of child mental health from early- to late-childhood, using data from a longitudinal birth cohort study conducted in the Wirral, UK.

- Parental mental health is a widely known risk factor for the development of child mental health problems. However, there is a small evidence base exploring the role of maternal mental health in explaining any early social inequalities in child mental health. Study 3 of this thesis seeks to enhance our current understanding of this issue through analysis of multiple perinatal mental health measures.

2.7 Policies to tackle inequalities in child mental health

In this section, I will give a brief introduction to policies in the UK to tackle the burden of child mental health problems.

The prevalence of child mental health problems is increasing across high-income countries and socioeconomic inequalities in child mental health are an important public health concern. As discussed in section 2.3, prior to 2010 there was a comprehensive strategy and policy focus on addressing the wider social determinants of health, which helped to reduce rates of child poverty and improve child health outcomes.

The UK government set out its intention to improve mental health outcomes across the population with the introduction of the 'No Health without Mental Health' strategy with the aim of:

"Promoting good mental health and intervening early, particularly in the crucial childhood and teenage years, we can help prevent mental illness from developing and mitigate the effects when it does" (DoH, 2011).

In order to achieve this aim, focus was given to collaborative work across schools, workplaces and local authorities to promote children and young people's mental health and wellbeing (DoH, 2011). Subsequent action to address the issues of child mental health was issued with the 'Closing the Gap: priorities for essential change in mental health' strategy (DoH, 2014). This strategy identified areas that needed immediate change and improvement. The key commitments were aligned to early detection of mental health improvements and access to services. For example, there was recognition that access to psychological therapies for children and young people was not adequate and should be expanded to cover all children of England by 2018 (DoH, 2014; Garratt et al., 2022). Extending on the need to improve access to services and treatment the government announced that targets to reduce waiting times (treatment within 6 weeks for 75% of referrals) for Improving Access to Psychological Therapies (IAPT). Additionally, £150 million of funding over five years was announced to tackle this issue (DoH, 2014; Garrat et al., 2022).

The government has stated that it is committed to reducing mental health problems in children and young people. In 2015, £1.25 billion investment in children's mental health services was announced for the next five years, with a significant proportion of this budget to improve standards and roll out of IAPT programmes across England (DoH, 2015). With continued issues with access to services, the

government announced that there should be better mental health provisions in educational settings, as well as funding new support teams to target early intervention (DoH, 2017).

The NHS Long Term Plan (2019) designed to set out priorities for the NHS England for the next ten years included a commitment to reduce waiting times and provide services to 70,000 more children and young people (Garrat et al., 2022). Noting that funding for services still remained an issue, a key commitment was set out, whereby, funding for children and young people's mental health services would grow faster than the overall NHS funding (DOH, 2019). Furthermore, the plan projected that 345,000 children and young people would be able to access services provided by the NHS by 2023/24 (DoH, 2019).

The updated Marmot review (2020) highlights that there are worrying indications that there are widening social inequalities in mental wellbeing in the UK and that current policies to address these issues are not adequate. There needs to be a strong commitment to a 'mental health in all policies' approach, alongside policies that target the wider social determinants of health. A more detailed discussion on policies to target inequalities in child mental health is provided in Chapter 7.

Chapter 3

Methods

3.1 Introduction

This chapter provides a description of the data source and analytical methods used in the analyses presented in Chapters 4-6 of this thesis. In this chapter I will outline the methods utilised on a study-by-study basis. Firstly, I describe systematic review methodology, outlining some general principles about their utility before moving on to the specific protocol for the systematic review in order to address objective 1. Next, I describe the Wirral Child Health and Development Study, the data source used for the analyses in Chapters 5-6. Then I present the methods used in Chapters 5-6 to address objectives 2 and 3, including details of ethical approvals, study design, inclusion and exclusion criteria, primary exposure and outcome variables and data analysis. Finally, I present a summary to outline how the approach I have proposed, when triangulated, addresses my research questions.

As described in Chapter 1, the objectives of this thesis are to:

1. Systematically review the literature on the relationship between childhood socioeconomic conditions (SECs) and preschool-aged children's mental health
2. Assess the impact of socioeconomic conditions on longitudinal trajectories of child behavioural and emotional problems
3. Assess the role of perinatal maternal mental health in explaining early social inequalities in child behavioural and emotional problems
4. Consider policy implications of the above

The methods described in the following sections were chosen to address the objectives in the most effective way.

3.2 Study 1: Relationship between socioeconomic conditions and preschool-aged children's mental health: a systematic review

Study 1 is a systematic literature review, which aims to assess the association between SECs and preschool-aged children's mental health in high income countries. The following section describes the rationale for undertaking a systematic review and the development of the review protocol.

3.2.1 Systematic Reviews

The purpose of systematic reviews is to identify, summarise, analyse and critically evaluate all relevant studies to answer focused research questions (Blaxter et al., 2010). A systematic review is designed to compare and synthesise evidence from several studies to establish consistency and patterns of an effect (Greenhalgh, 2010).

Systematic reviews can address relationship, correlation and causal questions and can be shaped for a particular audience, for example, clinicians (Boland et al., 2013). The results of a systematic review should provide an unbiased summary of findings from a large body of available evidence thus enabling greater reliability in informing policy and practice decision making (Greenhalgh, 2010).

A systematic review follows a strict set of predefined guidelines, systematic and reproducible methods to increase validity of conclusions drawn (Khan et al., 2003; CRD, 2008). Before undertaking a systematic review, it is necessary to establish if there are completed or ongoing reviews. If a review has previously been undertaken on the research question, then the review should be assessed to determine its quality and suitability.

The first step in conducting a systematic review is to develop a well-structured and clear research question. A poorly framed research question will lead to ill-formed search terms and strategies. There are many tools available for constructing a review question depending on the subject focus (CRD, 2008; Boland et al., 2013). The review question in this study was developed utilising the PICO framework. The PICO framework is widely used in health research to construct focused and precise questions. PICO uses four key elements to design research questions: the population under investigation; exposure or intervention of interest; the comparison exposure and, the outcome of interest (Richardson et al., 1995).

To ensure greater transparency in the review process, researchers are encouraged to develop and register a protocol. A systematic review protocol outlines the proposed methods to be used in the review. Decisions about the review question, inclusion criteria, search strategy, study selection, data extraction, quality assessment, data synthesis and plans for dissemination of results should be reported. The protocol is an iterative process that requires a transparent approach at all times. (CRD, 2008).

PROSPERO is an international prospective database for registering systematic reviews in health-related outcomes. The database is funded by the National Institute for Health Research. Pre-registration of review protocols is on the rise as it ensures greater transparency in the review process. A database of review protocols helps to identify any reviews that have already been undertaken on the topic of interest, thus, limiting publication bias. A protocol was developed and registered with the PROSPERO database as show in section 3.2.2.

3.2.2 Relationship between socioeconomic conditions and preschool-aged children's (up to five years of age) mental health: a systematic review protocol

Background

A social gradient in health outcomes, whereby the most disadvantaged in society experience less favourable health outcomes, has been well established across multiple conditions, including mental health (Graham, 2004; Pickett & Wilkinson, 2015). Mental health is poor in the United Kingdom (UK), and there are concerning indications from UK and international studies that the prevalence of affective disorders in adolescents is rising (Gunnell et al., 2018). Furthermore, there is increasing recognition that there are growing inequalities in health outcomes in the UK (WHO, 2014). These inequalities in health outcomes are preventable and amenable to policy intervention.

In early childhood, mental health predominantly refers to behavioural and social-emotional development, including externalising (aggression, conduct) and internalising (anxiety, depression) problems. In the UK, one in ten children and adolescents (5-16 years) have a clinically diagnosed mental health problem (behavioural 6% and emotional 4%) (Green et al., 2004). The prevalence of mental health problems is a growing concern, with 24% of girls and 9% of boys aged 14 years self-reporting high levels of depression in the UK (Patalay & Fitzsimons, 2018). It is also well established that adverse child mental health is associated with poor educational and health outcomes, lower adult socioeconomic status, and poorer health in adulthood (Brooks-Gunn & Duncan, 1997; Taylor-Robinson et al., 2016).

Following a life course framework in the study of health inequalities allows for a temporal understanding of how factors may shape later mental health trajectories (Galobardes et al., 2010). A recent systematic review showed that by school age, inequalities in child mental health are already evident. Children and young people growing up in the most disadvantaged circumstances were found to be two-to-three times more likely to develop mental health problems compared to children from less disadvantaged backgrounds (Reiss, 2013). Reducing these inequalities in mental health outcomes earlier in life is therefore a public health priority (Marmot, 2010). However, it is not yet known how early these inequalities manifest and develop.

Despite increasing recognition that the early years of a child's life are critical periods in which inequalities in health outcomes may well develop, it is still unknown how early in life inequalities develop (Marmot, 2010). This review aims to identify when early inequalities in child mental health are generated in order to identify clear targets for intervention.

Gaps in the literature: why a systematic review is warranted

A preliminary search of PROSPERO (a database of registered review protocols) indicated that there were no completed or ongoing reviews exploring social inequalities in preschool child/infant/toddler mental health at the time of the search. A previous systematic review has been carried out exploring socioeconomic inequalities in child and adolescent mental health. Reiss (2013) found that 52 out of the

included 55 studies reported an association between at least one measure of socioeconomic conditions and mental health problems. The review concluded that the most disadvantaged children were up to three time more likely to have a mental health problem compared to less disadvantaged children (Reiss, 2013). I will now outline the key strengths and weaknesses of the previous review and state how the present study will build upon this.

The Reiss review focused on children and adolescents (5-18 years), including only four studies with a preschool-age population. Many of the identified studies used preschool-age mental health as a baseline measure for mental health later in the life course. The present review aims to address the issue of assessing how early in the lifecourse, social inequalities in mental health outcomes are established.

The Reiss review was conducted in six electronic databases and used limited search terms for both the outcome and exposure measures. Searches for mental health problems were restricted to "mental health" or "mental disorder". Exposure terms were limited to "socioeconomic" or "poverty" or "social inequality" or "income". (Reiss, 2013). From searching the titles and/or abstracts in preliminary searches, it was difficult to discern whether the outcome measures used were available at the target population age for the current review. Many of the studies identified in scoping searches used the early years as a baseline measurement either for comparison to later developmental stages or in longitudinal methods such as growth curve modelling.

Scoping searches for the current review indicated a growth in published early-years studies and that studies with a preschool-age population were predominantly cohort studies. Searches indicated that multiple studies were drawn from a core group of international cohorts. These included international cohort studies with socioeconomic measures and child health outcomes such as the Copenhagen Child Cohort, Danish National Birth Cohort, Generation-R (Netherlands), BELLA (Germany) and the Longitudinal Study of Australian Children. To ensure relevant search terms were used in the review, terms used in titles and abstracts of these studies informed the search terms used in the review.

The previous review and scoping searches indicated that search terms could be expanded to better capture the review question and that a well-defined population should be specified and reflected in the terms. For example, searching "preschool" and "infant" as key words would potentially identify more relevant studies. These terms were deemed likely to identify studies focusing on early manifestations of child behaviour problems that would not necessarily have been identified with the previous review search criteria.

Scoping searches indicated potential issues with searching for a preschool-age population. The starting age for schooling (compulsory or voluntary) varies worldwide, with children starting as early as four

years of age and as late at seven years of age. The variation in age in which the outcome is assessed has implications for interpretation of results included in the review due to the levels of child development in these years. Therefore, it was necessary to have a well-defined population age in the review.

Development of the systematic review protocol

Research Question

Is exposure to lower socioeconomic conditions (SECs) compared to higher SECs associated with the emergence/development of mental health problems in children up to five years of age?

Population

Any preschool-aged child aged 5 and under from a high-income country defined as being a member of the Organisation for Economic Co-operation and Development (OECD). The OECD aims to monitor economic development of member countries and provides policy recommendations to tackle poverty. (OECD, 2020).

Exposure

The exposure of interest was lower SECs compared to higher SECs, commonly, measured at the individual or aggregate level by income, education, occupation, employment, or area deprivation in the perinatal period.

Outcome

The primary outcome of interest was any validated measure of mental health in preschool-aged children. For example, internalising and externalising behaviour problems as measured by the Child Behaviour Checklist (CBCL) or the Strength and Difficulties Questionnaire (SDQ).

Inclusion and exclusion criteria

Using a clearly defined inclusion/exclusion criteria during the screening process adds rigour to a review and reduces the possibility of selection bias (CRD, 2009). The inclusion and exclusion criteria were developed to systematically screen search results and ensure only relevant articles were included in the final review.

Longitudinal observational studies (prospective, cohort and case-control) that were written or translated into English, reporting quantitative results assessing the association of SECs in the perinatal period and subsequent preschool mental health outcomes were included. Socioeconomic conditions could be measured at either the individual (occupation, income, education, employment) or aggregate level (area deprivation). Only studies conducted in high-income countries (defined as being a member of the OECD), written or translated into English were included.

Studies that did not specify the age of the sample, included a non-validated outcome measures (or measure temperament), or where the primary outcome measure was not stated were excluded. Studies with no exposure comparator or where SECs are not defined were also excluded. Literature reviews and case studies were also excluded. Studies that exclusively use a sub-group of the population, for the example, children in care, were also excluded. Non-English language studies were excluded due to time and resource limitations.

The inclusion and exclusion criteria were applied to the abstracts of identified studies and subsequently, the full text of obtained studies. Table 3.1 summarises the inclusion and exclusion criteria used.

Table 3.1: Inclusion and exclusion criteria to be applied to search results.

Inclusion Criteria
1. Longitudinal observation studies (prospective, cohort, case-control) reporting quantitative results assessing the association of SECs in the perinatal period and subsequent preschool mental health outcomes
2. Studies quantitatively measuring SECs at an individual or aggregate level by income, education, occupation, employment or area deprivation
3. Studies written or translated into the English language
4. Studies reporting on human subjects
5. Studies conducted in high-income countries defined as members of the OECD
Exclusion Criteria
1. Studies that do not specify age of the sample
2. Studies that include non-validated measures of child mental health
3. Studies that measure temperament
4. Studies where no primary outcome measure is stated
5. Studies with no exposure comparator or where SECs are not defined
6. Literature reviews and case studies
7. Studies that exclusively use a sub-group of the population (e.g., children in care)

Search strategy

A review is likely to be biased if literature is missed and omitted from the review (Lefebvre et al., 2011). The review therefore utilised multiple systematic approaches to identify as much relevant literature as possible. A three-stage approach to searching was performed: 1) database, 2) grey literature, and 3) reference list searching. The three stages are described below.

(1) Database search

Databases most relevant to the research question and subject were selected as they were likely to yield the most relevant research papers. Databases were informed by previous health inequality and mental health reviews. The databases selected were; MEDLINE (Ovid), PsycINFO and Web of Science Core Collection. Databases broad in scope were preferred to optimise the search.

The search terms were identified from scoping searches and comprise of broad mental health outcomes and socioeconomic terms (Appendix 4). Relevant synonyms for SECs and child mental health outcomes were identified from previous systematic reviews with a focus on health inequalities or child mental health (Reiss 2013; Uphoff et al., 2014; Adams et al., 2018). The use of the term "mental health" is limited in the population age of interest. To reflect this, the terms included broad mental health outcomes, for example, "psychopathology"; "internalising behaviours" and "externalising behaviours."

Whilst, the list of terms is not exhaustive, the outcome terms were intended to provide a comprehensive range of children's mental health outcomes. As the review focused on longitudinal studies, relevant terms were included as part of the search strategy. Each OECD country was added as a search term to help identify relevant studies. An illustration of the search terms used is reported in table 3.2.

The search terms were initially developed and refined in MEDLINE (Ovid) (Appendix 4). For an optimised search, where possible, search terms were exploded. Search terms could not be exploded in PsycINFO and Web of Science Core Collection, therefore, relevant exploded terms were added as individual keywords in the main search.

To ensure rigor, the same search terms were used for each database query within PsycINFO and Web of Science Core Collection. However, as the design and functionality of the databases varied, searches were adapted when necessary, for example, proximity operators differed for each database. Each term was searched for within the title, abstract and keywords of the documents contained within each database. Careful attention was paid to the variation of search functions within each database.

Database filters were applied to the search in order to narrow down the search results into a more manageable number for screening. Where available, filters for English language, human subjects, age range (e.g., infant, preschool) were applied within each database. Filters were applied to limit the search to studies conducted from 1980 to present date. As methods of classifying SECs and social conditions have changed over time, this ensured data were relevant to present day. Only filters directly related to the inclusion search criteria were applied. Search results were exported into reference management software 'Mendeley', where results from all three databases were pooled and duplicates removed.

Table 3.2: Illustration of search terms used in database searches.

Socioeconomic terms	**Mental health terms**	**Age terms**	**Study design terms**	**Geographical terms**	
Depriv*	External*	Early Life	Case-Control studies	Australia	Korea
Disadvantag*	Internal*	Early Years	Cohort studies	Austria	Latvia
Education*	Mental disorder*	Infan*	Cohort*	Belgium	Luxembourg
Employment	Mental health	Preschool	Follow up	Canada	Mexico
Income*	Psychopatholog*	Toddler*	Longitudinal study	Chile	Netherlands
Inequalit*			Prospective study	Czech Republic	New Zealand
Occupation*				Denmark	Norway
Poorest				Estonia	Poland
Poverty				Finland	Portugal
Social Class				France	Slovak Republic
Social determinant*				Germany	Slovenia
Socio*				Greece	Spain
Socioeconomic Factors				Hungary	Sweden
Socioeconomic*				Iceland	Switzerland
Underprivileged				Ireland	Turkey
				Israel	United Kingdom
				Italy	United States
				Japan	

*indicates truncated term to allow for different suffixes

(2) Grey literature

The second strategy consisted of grey literature searching. The search was conducted by entering the terms; "mental health", "psychopathology", "internalising", "externalising", "socioeconomic", "income", "deprivation", "child", "infant" and "preschool" into the Google and Google Scholar search engines. The inclusion and exclusion criteria were applied to the first 100 results.

(3) Reference list search

The third stage screened the reference lists of included studies from the previous two strategies to identify any relevant publication that may not be stored on electronic databases and were consequently missed in the electronic search.

Screening the search results

The results identified were screened for inclusion applying pre-established criteria (Table 3.1). Titles and abstracts were screened by the principal reviewer (CR), with a random sample (minimum 10%) independently screened to ensure consistency. Any discrepancies were discussed until an agreement was reached.

Quality appraisal of studies

Risk of bias and quality assessment of the identified studies was undertaken using the Newcastle-Ottawa Scale (NOS). The NOS was developed to assess the methodological quality of non-randomised studies, such as cohort and case-control studies and is recommended by the Cochrane Collaboration (Wells et al., 2018). The NOS incorporates a star rating system to assess sample selection, outcome/exposure ascertainment and confounding. Consequently, the results of the quality assessment could be quantified into a score for each study. Using the star ratings, scores were converted into tertiles, whereby, three groups were created according to the distribution of the raw quality scores, to denote studies of high, medium and low quality. A second independent reviewer assessed a random sample (10%) for inter-rater reliability. If needed, any discrepancies between reviewers were discussed until an agreement was reached.

Data analysis and synthesis

To organise and facilitate data comparison, tables were generated in Microsoft Excel by extracting relevant data from each study. A standardised data extraction form provides consistency in a systematic review by reducing the risk of bias, therefore, improving validity and reliability. Data extraction forms should be developed and piloted with the review question and analysis as the focus. Therefore, the extraction forms were modelled on previous systematic reviews with a focus on health inequalities (Uphoff et al., 2014; Adams et al., 2018).

Data extracted included the following: aim/hypothesis, study design, level of analysis, country, sample size, age range/mean, mental health outcome, method of measurement, measure of SECs, covariates, statistically significant results, non-significant results, conclusion and quality assessment.

Due to the broad structure of this review, heterogeneity between study design, populations, exposure and outcome measurements was expected. Consequently, data synthesis was dictated by the data available. To further explore the association between SECs and child mental health outcomes, a sub-group analysis was undertaken on study design factors and potential mediating factors on the relationship. Including, but not limited to, the following: internalising and externalising behaviour problems, sex effects, methods of measurement and level of analysis (at the individual or aggregate level).

Where data allows, stratification by developmental stages (perinatal, infant, preschool) will be explored. The strength of a study's evidence will be informed by NOS, with conclusions from the most robust and reliable studies given greater weight in discussions. Key concepts and trends that emerged will be explored through narrative synthesis. Where data permits, results will be visualised through harvest plots and pooled in a meta-analysis (Ogilvie et al., 2008).

Discussion

This protocol is for a review which aims to highlight any relationship between socioeconomic conditions and subsequent mental health outcomes in preschool aged children. The review will assess the direction of association and may highlight mechanism of risks. The terms have been selected to yield the most relevant literature in order to explore and highlight potential sex differences in mental health outcomes, differing associations by country and level of SEC measurement. The increasing prevalence of mental health problems in children is a major public health concern, and there are stark social inequalities in outcomes. Disadvantage may start before birth and more research is needed for to identify the earliest manifestations of mental health problems. The results from this review will inform the development of further empirical analyses to explore the early origins of child mental health problems in the UK.

Ethical considerations

Secondary research was conducted on published studies. No ethical approval was required. The review process was conducted in a systematic way to ensure rigour and validity.

Prisma-P 2015

The Preferred Reporting items for Systematic Reviews and Meta-Analyses for Protocols 2015 (PRISMA-P, 2015) checklist aided the development of this review (Appendix 4).

As outlined above, a systematic review is the most effective way of synthesising the existing literature to address objective 1 of the thesis, to assess the relationship between socioeconomic conditions and preschool aged children's mental health outcomes. In the next section, I will outline the methods adopted to address objective 2.

3.3: Study 2: Assessing the impact of socioeconomic conditions (SECs) on longitudinal trajectories of child behavioural and emotional problems: Findings from the Wirral Child Health and Development Study

Summary

Study 2 addresses objective 2 of this thesis, to assess the impact of socioeconomic conditions on longitudinal trajectories of child behavioural and emotional problems. In particular, the study aimed to determine whether or not there are distinct trajectories for internalising and externalising behaviour problems for the least and most deprived children and whether any inequalities, narrowed or widened over time. Study 2 employed secondary analysis of data collected as part of the Wirral Child Health & Development Study (WCHADS). The following sections describes: the data source, study design used to address the aims of the research, the selection of dependent and independent variables, and the methods used to analyse the data.

Data Source

Study 2 used data collected as part of the WCHADS. The WCHADS was funded by the Medical Research Council and was set up with support of Wirral University Teaching Hospital NHS Foundation Trust and continues to be supported by Wirral Community NHS Foundation Trust and Cheshire and Wirral Partnership NHS Foundation Trust. The WCHADS was first granted full ethical approval by the Cheshire North and West Research Ethics Committee [REF: 05/Q1506/107 (June 2006). Subsequent ethical permissions were secured for further waves of follow-up in the longitudinal study [REF: 10/H1010/4 (June 2010)]); 14/NW/1484 (December 2014)].

Socioeconomic context of the Wirral

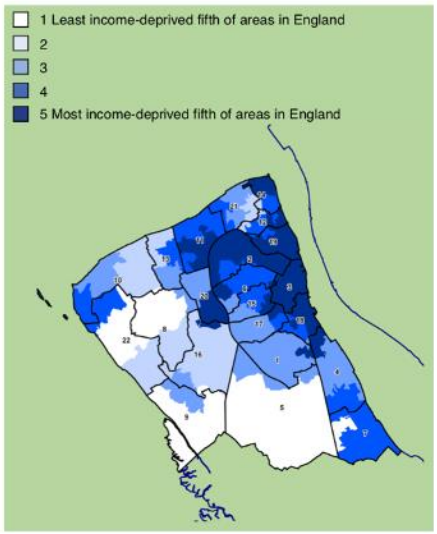
In order to understand the composition and sample of the Wirral Child Health and Development Study this section situates the cohort within the socioeconomic context of the study location. The Wirral is a peninsula, located in the North West of England (Figure 3.1). Understanding the sociodemographic composition of an area is vital for public health as sub-groups of the population are likely to experience differing health outcomes and interactions with health services.

Figure 3.1: Map of United Kingdom showing location of the Wirral (study location)

(Source: Adapted from OpenSteetMap.org, 2022. Contains Ordnance Survey data © Crown copyright and database right 2010-19.)

Socioeconomic conditions on the Wirral range between the deprived inner city and affluent suburbs. Figure (3.2) shows the variation in deprivation due to low income across wards, using deprivation quintiles in relation to England, at the time WCHADS was set up. In 2007, Wirral had significantly worse levels of income deprivation, levels of child poverty, life expectancy and early deaths compared to national average (Department of Health, 2007).

Figure 3.2: Distribution of Wirral income deprivation levels compared to England at the start of WCHADS (Adapted from Department of Health, 2007).

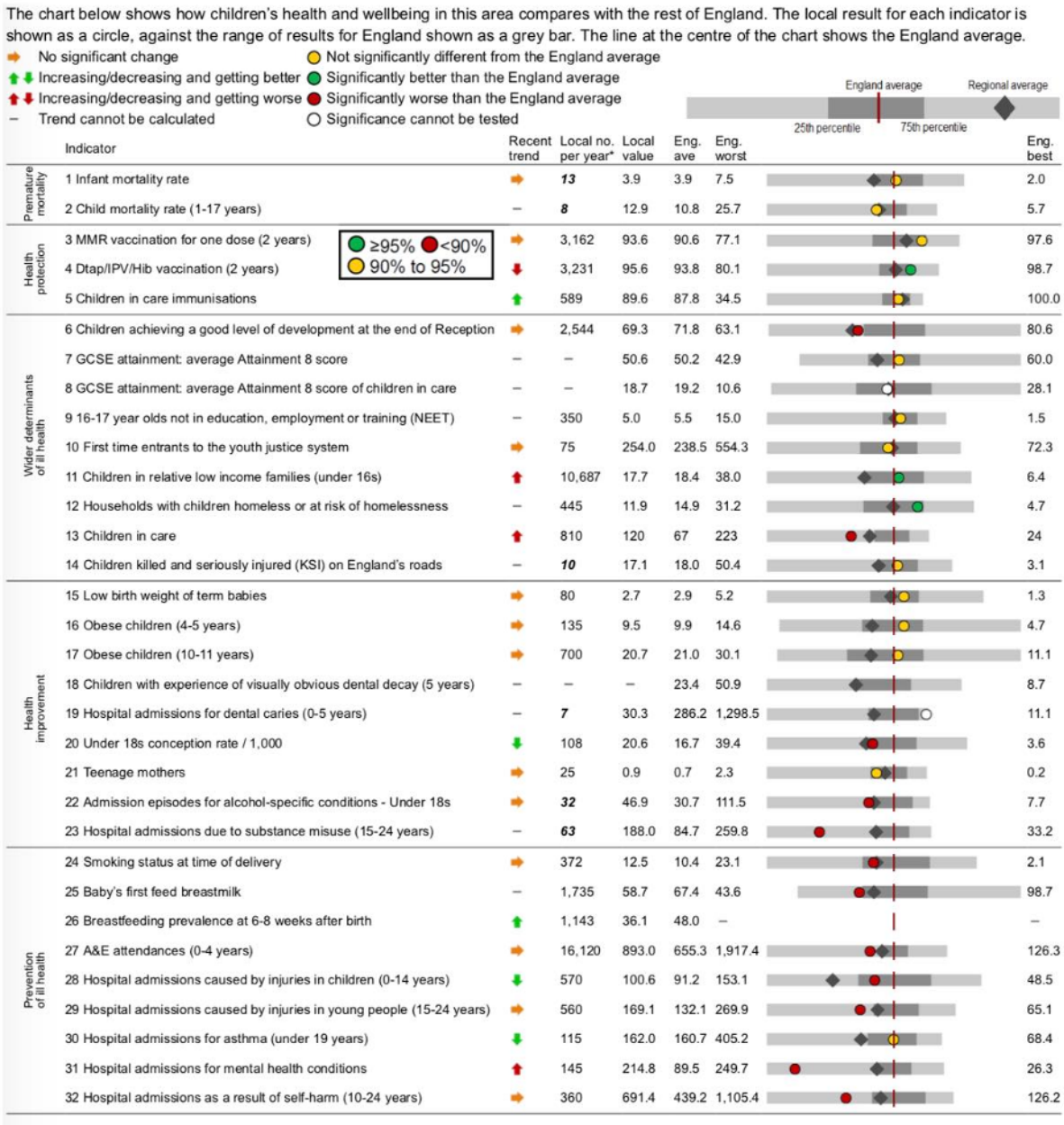


The socioeconomic context of the Wirral has remained relatively stable across the duration of WCHADS. Latest public health reports show that the Wirral is in one of the 20% most deprived local authorities in England. Approximately 1 in 5 children live in a low-income household, however, there is large variation across wards. For example, in Heswall there are less than 1 in 20 children living in low-income families compared to 1 in 3 children in the Birkenhead ward (PHE, 2019).

The Wirral scores significantly lower for poor health indicators such as life expectancy, all age mortality rate and emergency hospital admission rate for intentional self-harm compared with the average for England (Wirral Intelligence Service, 2019; Public Health England, 2020). There are stark health inequalities within the Wirral with life expectancy 12.5 years (men) and 10.1 years (women) lower in the most deprived areas compared with the least deprived areas (PHE, 2017; PHE, 2019).

Figure 3.3 shows the latest child health profile for Wirral comparing a set of indicators against the national average. These profiles are a vital tool in allowing local government and health services to identify health inequalities and areas for improvement in child health and well-being outcomes through public health actions. Children and young people in the Wirral are significantly worse than the national average for hospitalisations due to substance misuse, admissions as a result of self-harm and admissions for mental health conditions. Most strikingly shown is the increasing rate of hospital admissions for mental health conditions.

Figure 3.3: Child Health Profile Wirral 2021 (adapted from PHE, 2021).



Aims of the WCHADS cohort study

WCHADS aims to identify and understand important social, biological and psychological factors that are associated with the development of behaviour problems, for example, conduct problems, early in life. By understanding the complex interplay between risk and protective factors, the study aims to make recommendations for policy and intervention strategies so that problems can prevented for families in the future.

Data from the WCHADS has been used previously to investigate a range of research questions, for example, whether the frequency of infant stroking during the first few weeks of life moderates negative effects of exposure to prenatal depression on later infant behavioural outcomes and, how child sex

moderates associations between maternal prenatal cortisol levels and later child callous-unemotional traits (Sharp et al., 2012; Wright et al., 2019). The WCHADS dataset has not previously been analysed from a health equity perspective.

From a public health perspective, the aim of the WCHADS study, starting from pregnancy, was to identify pathways representing distinct mechanisms of risk and to identify potential intervention targets. WCHADS utilises questionnaires from multiple informants alongside novel experimental and observational measures, embedded within a longitudinal design, to measure child social, emotional and behavioural functioning. The WCHADS collects a wide range of information on exposures including a range of demographic, environmental, perinatal and early-years risk factors such as parental mental health and parenting quality for adverse child mental health outcomes.

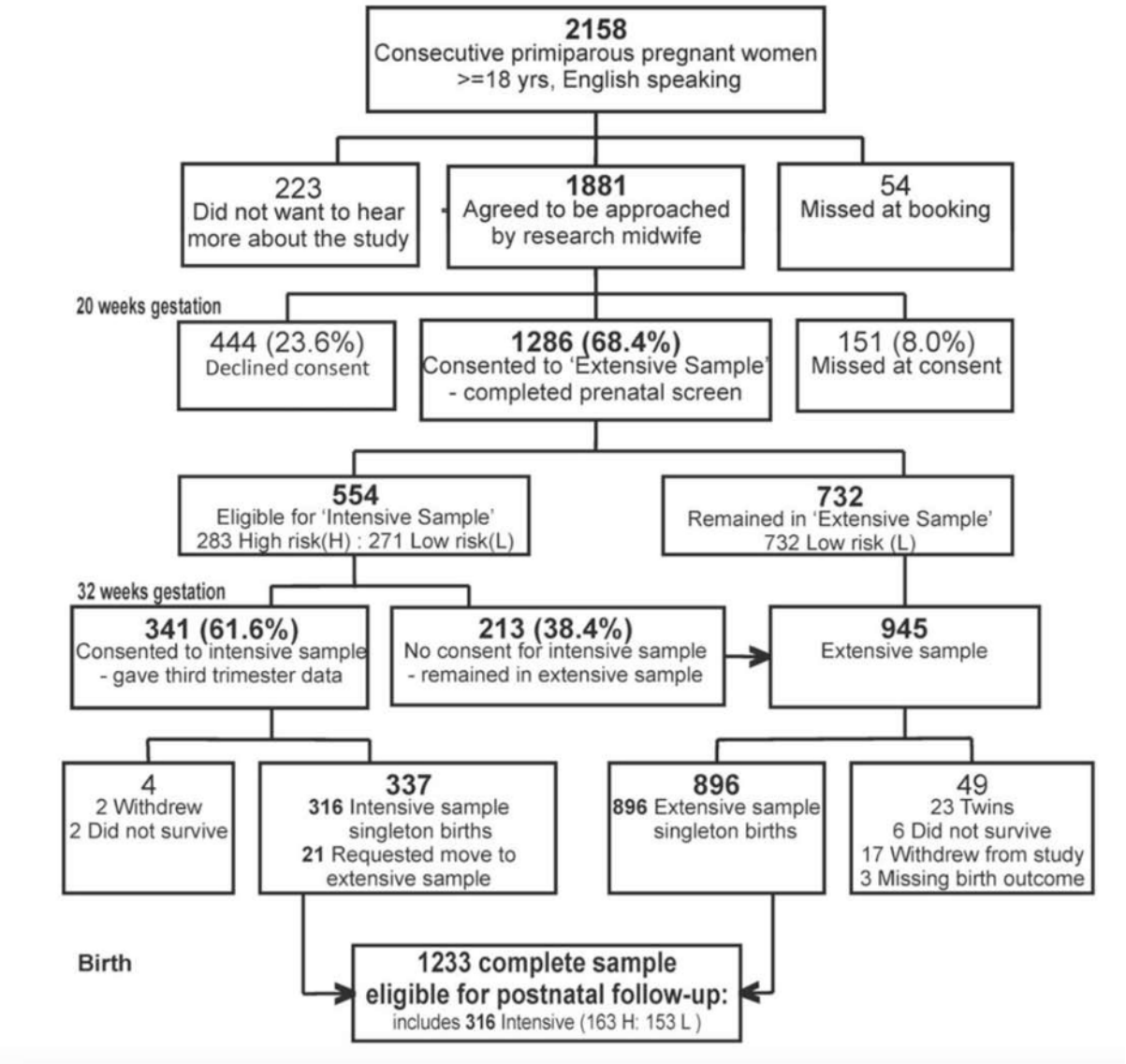
Who is in the cohort?

The sample was derived from a consecutive sample of women pregnant with their first child (n=2158) attending the NHS Wirral University Teaching Hospital between February 2007 and October 2008. The hospital was the sole provider of prenatal care on the Wirral, North West of England. Attendees of the clinic were approached at their 12-week appointment by clinic midwives and asked if they would like to hear more information and details of the study at their 20-week scan.

All women were informed that the study was interested in exploring any possible effects of stress during pregnancy, children's early experiences, their development and influences on children's behaviour and emotions. Women aged 18-years or over were eligible to participate in the study. Babies with a severe congenital abnormality or did not survive were excluded. No exclusions were made for premature births, low birth weight (<2500g), or late antenatal care registration as these have been shown to be associated with prenatal stress and potentially on the pathway to subsequent child mental health problems (Straatmann et al., 2020).

WCHADS employed a two-staged stratified design, whereby a larger general population sample (extensive sample) was used to derive a smaller sub-sample for intensive measurement (intensive sample). The two are run in tandem. The analyses in this thesis use data available on the extensive sample. The aim of extensive sample was to establish a consecutive general population sample of first-time pregnant women for longitudinal epidemiological study. The recruitment and sampling process is shown in figure 3.4 (Sharp et al., 2012).

Figure 3.4: WCHADS sampling and recruitment flowchart.



Baseline demographics of WCHADS sample

Table 3.3 shows demographic characteristics of the baseline sample (n=1233). The majority of the sample (41.8%) were resident in areas in the most deprived quintile of IMD score at recruitment into the study. The mean age at leaving full time education was 18.7 years, with 70.9% of sample achieving 5 GCSEs / O levels at grade C or above. 74% of participants were in full-time paid employment at study entry. The majority of participants were aged between 25-34 (49.3%) and married (38.3%) or cohabitating (37.5%) at recruitment into the study. 51.4% of children in the study are female and 96.4% identified themselves as 'White British' which reflects the ethnicity of the Wirral.

Table 3.3: WCHADS baseline sample demographics (n=1233)

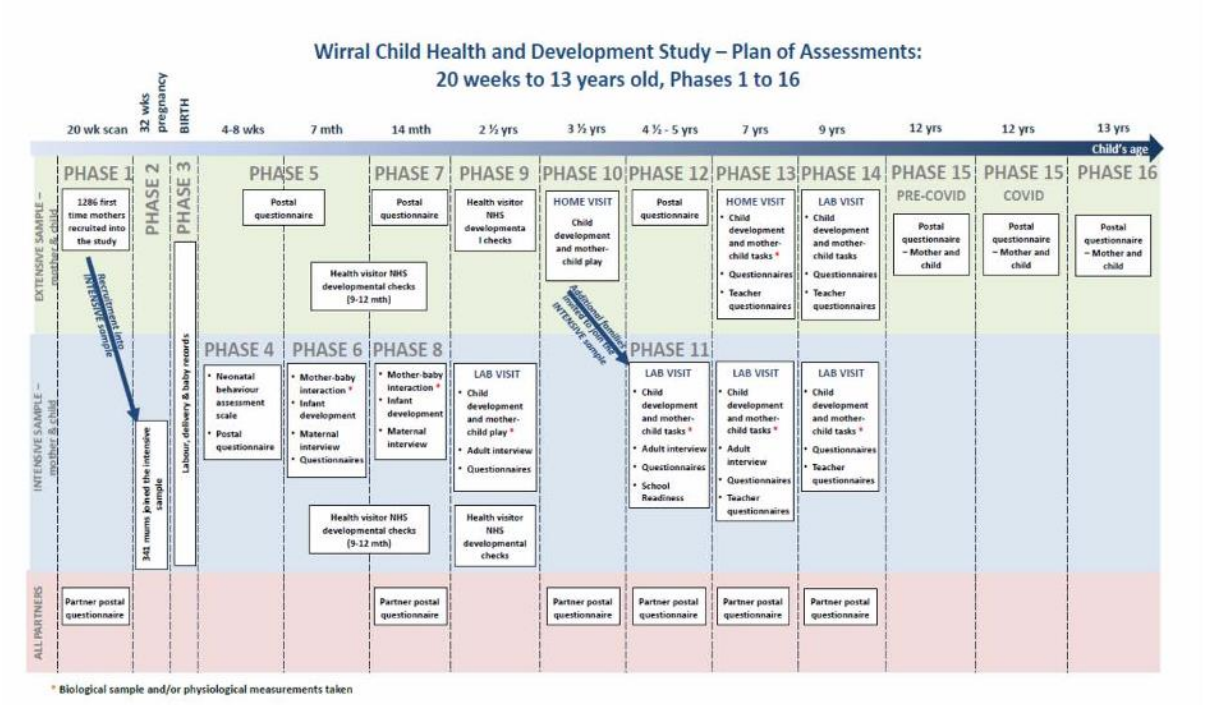
	Overall N (%)
	1233
Index of Multiple Deprivation (IMD) Quintile (%)	
1 = Most Deprived	514 (41.8)
2	225 (18.3)
3	294 (23.9)
4	105 (8.5)
5 = Least Deprived	92 (7.5)
Age finished full-time education	18.65 (2.86)
Gained 5 GCSEs / O levels at grade C or above (%)	832 (70.9)
Maternal age at recruitment into study (%)	
18-24	489 (39.8)
25-34	607 (49.3)
35+	134 (10.9)
Marital status (%)	
Married	472 (38.3)
Single	143 (11.6)
Divorced	1 (0.1)
Separated	4 (0.3)
Cohabitating	462 (37.5)
With partner who lives elsewhere	146 (11.9)
Other	3 (0.2)
Gestational age at birth (days) – Mean (SD)	281.12 (11.71)
Birthweight (g) – Mean (SD)	3405.66 (534.53)
Ethnicity (White British) (%)	1189 (96.4)
Sex (Male) (%)	599 (48.6)
Employment status (%)	
Full-time paid employment	910 (74.1)
Part time paid employment	97 (7.9)
Self-employed	32 (2.6)
Unemployed, looking for work	105 (8.6)
On sick leave or disability	12 (1.0)
Full-time education or training scheme	31 (2.5)
Part-time education or training scheme	6 (0.5)
Voluntary work	2 (0.2)
Full time education + part time work	15 (1.2)
Other	18 (1.5)
Household income (%)	
Up to £10,000	104 (10.2)
£10,000-£20,000	137 (13.4)
£21,000 - £30,000	162 (15.9)

£31,000-£40,000	195 (19.1)
£31,000-£40,000	163 (16.0)
£51,000 - £60,000	130 (12.7)
£61,000-£70,000	61 (6.0)
Over £71,000	68 (6.7)

How often have the parents and children been followed up?

Compared to other birth cohort studies there is a high frequency of assessments in the early-years period, with nine assessment points by the age of 4.5 years (figure 3.5). Comparatively the UK birth cohort study, Millennium Cohort Study has three waves of follow-up by 5 years of age. WCHADS data is supplemented by copies of routinely collected Health Visitor assessments that were gathered at two time points from the government's Healthy Child Programme (pregnancy to age 5) at 9-12 months and 2-2.5 years of age (Shribman and Billingham, 2009).

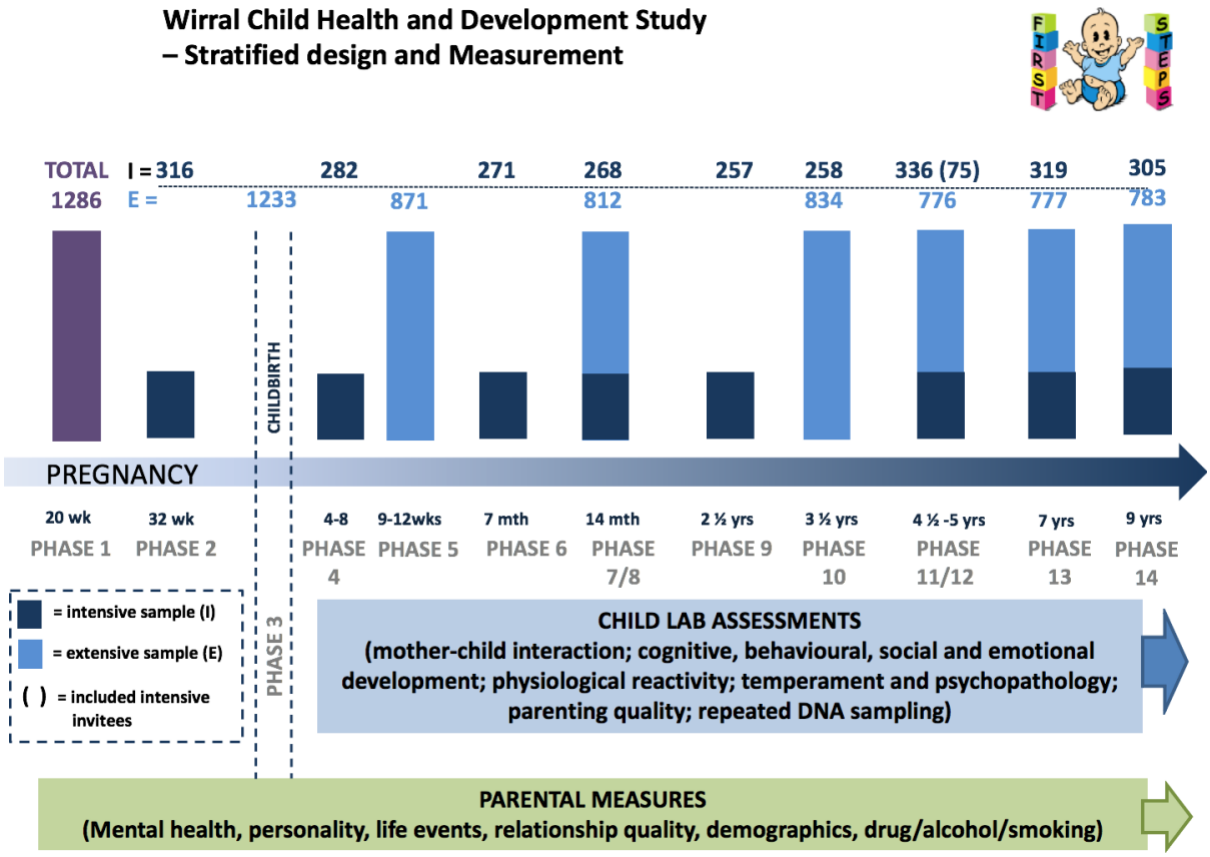
Figure 3.5: Plan of assessments for the Wirral Child Health and Development Study



Cohort attrition is a problem for all longitudinal epidemiological studies. Participants can withdraw from the study at any point or miss a phase or phases of data collection. Consequently, there will be a varied sample size at all phases of follow-up (figure 3.6). WCHADS retains a large sample size for a developmental study. In WCHADS, from the point of birth 1233/1286 remined in the study and had a live, singleton eligible for postnatal follow-up. By age 9 years 908/1233 (73.6%) families in the sample were still retained in the study and eligible for follow-up. Response rates (number completed / number

approached for data) at each extensive postnatal phase were high (Phase 5 – (871/1233) 70.6%; Phase 7/8 – (812/1167) 69.6%; Phase 10 – (834/944) 88.3%; Phase 12 – (776/931) 83.4%; Phase 13 – (777/921) 84.4%; Phase 14 – (783/908) 86.2%.

Figure 3.6: Response rates for WCHADS at each phase of data collection.



What has been measured?

Figure 3.7 shows the scheme of longitudinal measurement for the Wirral Child Health and Development Study. WCHADS collects extensive parental, child and biological data using a range of validated questionnaires, structured interviews and child lab-based assessments to examine (not limited to): mother-child interactions, social and emotional development, child psychopathology and parenting quality. Study 2 in this thesis primarily used maternal reported sociodemographic measures collected using questionnaires during the prenatal period (20 weeks gestation). Child behavioural and emotional measures are collected using maternal reported questionnaires at 3.5, 4.5, 7 and 9 years of age.

Figure 3.7: WCHADS longitudinal scheme of measurement

Type of measure	Prenatal (Weeks)		Months →				Postnatal (age) Years→							
	20 +	32	0	1	2	6	14 +	14	2.5	3.5 +	4.5	4.5 +	7 +	9 +
Parent Measures														
Personality functioning		I						I						
Depression/anxiety – diagnosis and symp	Q	Q I		Q	Q	Q I	Q	Q I	Q I	Q	Q I	Q	Q I	Q I
Smoking/drug/alcohol use	Q	Q I						Q	Q	Q	Q	Q	Q	Q
Discord and psychological abuse	Q	Q				Q		Q	Q		Q I		Q	Q
Partner relationship		Q I						Q I	Q I		Q I		Q I	
Adult antisocial behaviours								Q	Q		Q			
LEs & social support	Q	I				I		I	I		I		I	Q
Maternal attributions for child behaviours		I		Q	Q	Q	Q	Q	Q		Q	Q		
Accidental injury							Q			Q		Q	Q	Q
Obstetric/Health visitor records			R				R			R				
Parent – Infant interaction Quality														
Sensitive/intrusive parenting						E		E	E		E		E	E
Maternal warmth/criticism						QE		QE	QE		QE		QE	
Maternal harsh and gentle discipline								E	E		E		E	
Attachment security - Strange Situation								E						
Parenting self report– 5 domains											Q I		Q	Q
Child maltreatment									I		I		I	Q
Non-parental childcare history							Q	Q	Q	Q	Q	Q	Q	Q
Maternal stroking of infant				Q	Q		Q	Q						
Child Measures														
Eye gaze to inanimate objects / face				E									E	
Temperament incl. positive emotionality				E	Q	QE	Q	QE	Q	Q	Q	Q	E	
Fearfulness/anger proneness				E	Q	QE	Q	QE	QE	Q	QE	Q		
Emotional arousal to pictures & sounds													E	
Psychiatric diagnoses - DAWBA											I		I	I
CBCL total problems							Q	Q	Q	Q	Q I	Q	Q I	Q
Externalizing and peer aggression							Q	Q E	Q E	Q	I E	Q	Q	Q
CU traits and empathy									Q E	Q E	Q E	Q	Q	Q
Anx/Dep, ODD (Irritablility, headstrong)							Q	Q	Q	Q	Q I	Q	Q I	Q I
Emotion recognition (static & dynamic)											E			
Inhibitory control & other Exec f'unctions								E	E		E		E	E
Delay of gratification									E		E		E	E
Behavioural /emotional reactivity to stress								Q E	Q E	Q	Q E	Q	QE	QE
Mentalisation in doll play											E			
Language ability/delay									Q	Q				
Cognitive development						E		E	E		E		E	E
Motor development							R			I R				
Anthropometry								E	E		E		E	E
Internet and social-media activity														Q I
Cyberball social – exclusion paradigm													E	E
Friendship quality												I	I	Q I
Friend exclusivity														Q
Peer victimization & bullying/cyberbull														Q
Borderline features and self-harming														Q
Biological samples														
Maternal Cortisol		DS												
Child cortisol pre & post stress						S		S	S		S		S	
Vagal tone and withdrawal						E		E	E		E		E	E
Child Galvanic skin response to stress											E		E	E
Child saliva for DNA								E	E	E	E		E	
Maternal saliva for DNA									E					

KEY: Shaded cols/cells = whole cohort (includes intensive), Non-shaded bold rows/cells = intensive sample only, Q = questionnaire, I = interview, D = diurnal cortisol, S = stress reactive cortisol, R = medical/child health records, E = experiment lab/observation. + = mother & partner informant data collected.

Procedure for requesting access to WCHADS data

Proposals to access the dataset should be requested as outlined in the Wirral Child Health and Development Study Data Access Policy document. (Found here: https://www.liverpool.ac.uk/population-health/research/groups/first-steps/for-researchers/). All proposals are reviewed by the WCHADS Executive Committee. Data used in this thesis was obtained

through prior agreement and protocols in line with the original ethics agreements. All data has been anonymised.

Recruitment into the analysis sample

Participants were included in the analysis sample if data were provided on the exposure measure (measured at 20 weeks gestation), confounders and at least one time point for the outcome measure (collected at 3.5, 4.5, 7 and 9 years of age). The final sample for the analysis was 760 with data available. A descriptive comparison of the sample demographics between the baseline sample (n=1233) and the analysis sample used in study 2 (n=760) can be seen in table 3.4. The analysis sample remains comparable to the baseline sample with a similar distribution of participants across income bands and IMD groups. The analysis sample contains a smaller proportion of mothers aged between 18-24 years.

Table 3.4: Comparison of sample demographics

	Baseline Sample	**Analysis Sample**
Subjects n (%)	1233	760
Income Band (%)		
Up to £10,000	104 (10.2)	59 (7.8)
£10-20,000	137 (13.4)	92 (12.1)
£21-30,000	162 (15.9)	117 (15.4)
£31-40,000	195 (19.1)	148 (19.5)
£41-50,000	163 (16.0)	126 (16.6)
£51-60,000	130 (12.7)	109 (14.3)
£61-70,000	61 (6.0)	49 (6.4)
Over £71,000	68 (6.7)	60 (7.9)
Maternal Age (%)		
18-24	489 (39.8)	193 (25.5)
25-34	607 (49.3)	461 (60.8)
35+	134 (10.9)	104 (13.7)
Ethnicity (%)		
Other	45 (3.6)	27 (3.6)
Sex (%)		
Male	599 (48.6)	359 (47.2)
IMD Quintile (%)		
1 (Most Deprived)	514 (41.8)	267 (35.1)
2	225 (18.3)	144 (18.9)
3	294 (23.9)	211 (27.8)
4	105 (8.5)	69 (9.1)
5 (Least Deprived)	92 (7.5)	66 (8.7)

Note: Analysis sample: Participants providing data on the exposure measure and at least one measure of the outcome

Exposure

The primary exposure measure in studies 2 and 3 in my thesis is childhood socioeconomic circumstances (SECs). This was measured in pregnancy at 20 weeks gestation (baseline). Mothers were asked 'What is your approximate annual family income?' with responses collected in £10,000 incremental bands (Range: Up to £10,000 – Over £71,000). In robustness tests during data analysis within my thesis IMD is used as an alternative exposure measure. Analyses subsequently use IMD quintiles (coded 1=most deprived, 5=least deprived) modelled as categorical comparing the least deprived quintiles to the most deprived. The rationale for the selection of these measures is outlined below. Measuring socioeconomic position (SEP) is essential for public health surveillance and monitoring inequalities in health outcomes over the lifecourse. Owing to the cumulative and dynamic nature of socioeconomic experiences, a life course approach is best suited to track health outcomes (Chittleborough et al., 2006).

The studies in this thesis use the term socioeconomic circumstances (SEC) as opposed to socioeconomic position (SEP) as children do not have control over their own socioeconomic position (Pearce et al., 2019). Children rely on parents to create their social and economic environment through their education, employment and income (Anderson et al., 2018). A review examining the association of indicators of SEP during early life with health over the life course identified that income, education and occupation are the most commonly used measures as they directly relate to resource and status-basis constructs of SEP. (Chittleborough et al., 2006).

An individual's and a household's income are important measures that directly contribute to access to materials, resources and services. Income also affects an individual's social standing and level of power (Graham, 2007; Siegrest and Marmot, 2006). Income is not a static measure of an individual's social position and can vary over the lifecourse, however, family income measured in the early years has been shown to directly impact health outcomes in later life (Wickham et al., 2017; Straatmann et al., 2020).

Studies that rely on proxy measures of income, such as unemployment or benefit receipt fail to capture the true extent of social conditions. For example, 71% of children in relative poverty live in a household with at least one person in paid work (DWP, 2020). A baseline measure of family income measured in the antenatal period is particularly important for lifecourse studies of the early origins of health inequalities.

Area-level measures can also be used to measure socioeconomic conditions and are often created by aggregating individual-level measures. This aggregation is often taken out over large geographical areas such as local authorities or small areas such as lower-layer super output areas (LSOAs) in the UK. The English Index of Multiple Deprivation (IMD) is a relative measure of social deprivation provided at the

LSOA level. This index is created by using multiple indicators of deprivation relating to employment, education, income, health, crime, the living environment and barriers to housing services (Noble et al. 2004). Each LSOA is then ranked based on their score and this can then be used to assess geographic inequalities in health, for example, comparing life expectancy in the North of the UK compared to the South of the UK.

Outcome

The primary outcome measures in studies 2 and 3 in my thesis are internalising and externalising subscales scores from the parent-reported Preschool Child Behaviour Checklist 1.5 – 5 years (CBCL) (Achenbach & Rescorla, 2000) and the Child Behaviour Checklist 6-18 (Achenbach & Rescorla, 2001) at later phases of study. The preschool version (1.5-5) of the CBCL can be reported by parent (main caregiver) or teacher, whilst the school-age (6-18) version can also be self-reported by the child/adolescent between ages 11-18 years. Each version comprises a set of statements about the child and is designed to be easily completed with responses coded as 0 (not true), 1 (somewhat or sometimes true) and 2 (very true or often true). The CBCL is a well validated instrument, with high rates of validity and reliability across many populations, for measuring child behavioural and emotional problems (Ebesutani et al., 2010; Ivanova et al., 2010).

The preschool measure contains 99 problem items and comprises of scores on seven syndrome scales and a DSM-Orientated scale: emotionally reactive, anxious/depressed, somatic complaints, withdrawn, sleep problems, attention problems and aggressive behaviour (Achenbach & Rescorla, 2001). Composite scales can be derived by summing syndrome scales. Internalising problems are derived by combining the scores of the emotionally reactive, somatic complaints, withdrawn and anxious/depressed syndromes. Externalising problems total score is derived by summing aggressive behaviour and attention problem scores.

The school-aged version (CBCL 6-18) contains 113 problem items and comprises of eight syndrome scales and six DSM-Orientated scales: anxious/depressed, withdrawn/depressed, somatic complaints, social problems, thought problems, attention problems, rule-breaking behaviour and aggressive behaviour. Internalising problems are comprised of the anxious/depressed, withdrawn/depressed and somatic complaints syndromes. Externalising problems are comprised of the social problems, thought problems and attentions problems syndrome scales.

Owing to the longitudinal nature of the study both versions of the CBCL were used across the time points of interest, appropriate to the age of the children. Whilst many of the items overlap, there are different items that contribute to the scales at the preschool and school age time points to ensure each measure is developmentally appropriate.

The CBCL scores are presented as raw, standardised T-scores (compared to population normative sample) and percentiles. The main analysis in study 2 and 3 use raw scores (unadjusted for sex and age) for both internalising and externalising domains, treated as a continuous variable. A dimensional approach was thought to better capture the development of mental health problems across the population as subclinical difficulties are associated with development of clinical disorders (Pike et al., 2008). Study 2 also uses T-scores and raw scores standardised as *z*-scores in robustness tests to account for compositional differences. Study 3 uses T-scores to define a clinical-level and sub-clinical threshold to test assumptions in robustness test (Achenbach & Rescorla, 2001).

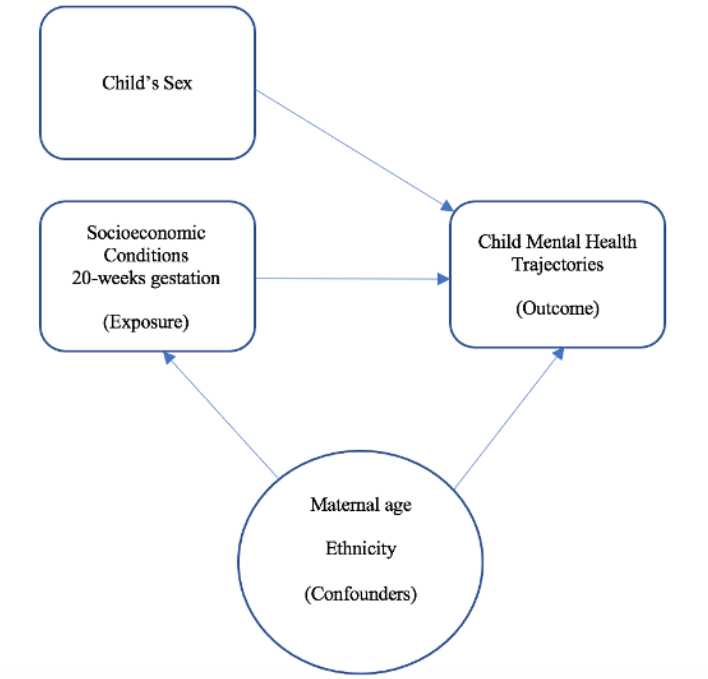
Confounders

Demographic characteristics that are potentially associated with child mental outcomes were included as baseline variables in the analyses. Maternal age at consent into the study was coded as categorical variable with age bands designated as 18-24, 25-34 and 35+. Owing to the small ethnic minority population of the Wirral, there is a small proportion of study participants identifying as other than White-British. Consequently, this measure was dichotomised as 'White British' or 'Other'. Child's sex and ethnicity were also controlled for in the regression analyses.

Analysis Strategy

The hypothesised association between SECs and longitudinal trajectories of mental health outcomes investigated in this study are shown in a directed acyclic graph (Figure 3.8). The analysis progressed in two steps, first an exploratory descriptive analysis of the longitudinal child mental health data, and then formal modelling using linear mixed effects model. The next section explores the advantages of longitudinal data and statistical techniques.

Figure 3.8: DAG for the relationship between exposure, outcome and confounders assessed in this study.



Statistical approaches to longitudinal data

What is longitudinal data?

A longitudinal study collects data from measurements that are repeatedly collected over time on each subject within the study. The rationale for this approach to data is to assess and explore any changes to a response measure of interest over time. The subjects at focus in the studies of this thesis are parental reports of children's behavioural and emotional problem scores. Longitudinal data can add richness to an analytic study, however, there are increased complexities. Compared to a cross-sectional study, a longitudinal study needs to account for correlation of measures within study individuals (Singer & Willet, 2003). In a longitudinal study, independence between subjects is assumed, however, this assumption cannot be applied to repeated measures on the same subject. A response on an outcome provides information about the likely response on the same outcome at a later date. The time between repeated measurements also has an influence, with shorter time between observations likely to be more similar than those measured much later. Therefore, it is necessary to address the nature of repeated measurements and the correlation between multiple values on the same measure to make a statistical prediction. However, this correlation needs to be modelled appropriately to make statistical inferences from the data (Singer & Willet, 2003).

Furthermore, longitudinal studies allow for the assessment of the effects of covariates on outcome measurements and also rates of change in the response within subjects over time. Study 2 is particularly

interested in exploring the difference in outcomes and time-trends between groups of individuals on the basis of their socioeconomic conditions.

Advantages of longitudinal data

A longitudinal approach is needed to help make inferences about the direction of causality and the influence of time factors over the lifecourse (Kuh et al., 2004). Cross-sectional analyses do not allow one to make substantial conclusions about the direction of causality as only an outcome at one time-point is assessed. For example, in a cross-sectional study assessing the effect of poverty on mental health problems in adulthood, it is not possible to definitively state that poverty is the cause of the mental health problem or whether the reverse is true. Studies that explore age-related changes of mental health problems in a population of different ages with only one outcome measure do not statistically address the effect of age on an individual's mental health problem. This approach uses pooled data and therefore, entangles; ages effects, drop-out effects and cohort effects (Diggle et al., 2002; Singer & Willet, 2003).

Additionally, an observation of an individual during longitudinal follow-up can be influenced by many factors, either social, environmental or biological. A measure could be influenced by time in varying ways. For example, a parent report of child psychopathology on a measure may be influenced by their age, the date of the observation (i.e., a period effect) or be a characteristic experienced by individuals born at a particular time (i.e., birth cohort effects). One of the advantages of longitudinal studies is that these effects can be separated, and analyses compared with cross-sectional analyses where they are indistinguishable (Diggle et al., 2002; Fitzmaurice & Ravichandran, 2008). For example, it is possible to explore time-trends (age effects) such as whether scores for externalising behaviour problems decrease over time.

Missing data in longitudinal studies

Due to the nature of longitudinal studies, missing data is a common problem, and this causes further statistical problems. Missing data is likely to be a result of drop-out, infrequent follow-up times or simply practical difficulties of maintain a large study. For example, participants will not always be available for follow-up or have moved away from the study location. In the Wirral Child Health study, there is large variation in the time between follow-up time points. There are very frequent follow-ups in the early stages of the study (due to the intentional focus of the study) 20-weeks scan to 14 months followed by annual follow-up until age five years and then follow-ups taking place every two years. This demonstrates the unbalanced nature of follow-up times in longitudinal studies. Frequency of follow-ups is principally driven by the hypothesis and focus of investigation alongside the logistics of running a cohort study.

A two-step approach was employed to address the aim and objectives of study 2. I undertook an exploratory analysis of the data to help inform the formal statistical modelling.

Exploratory analysis of longitudinal data

An exploratory descriptive analysis was undertaken to look for patterns in the data. For example, I visually explored a linear time trend in mental health outcomes and how outcomes varied by individuals and socioeconomic conditions. Exploring these trends visually helped to inform the formal modelling data. Spaghetti plots are a useful tool for visualising continuous outcomes (see Chapter 5). The first step is to plot a simple scatterplot of the data for all individuals over time. Next, lines that connect repeated measurements on individuals are added to generate a spaghetti plot. However, the plot will be overcrowded if there are too many subjects in a dataset. To accommodate this, a random sample is drawn from the data. The aim of this, is to thin out the dataset and show trajectories for a select number of individuals. Additionally, these plots can accommodate further summary statistical functions, for example, a cross-sectional mean or a linear predictor function. This is a useful exploratory tool of longitudinal data and can indicate whether quadratic terms may be needed in a linear mixed effects model (Diggle et al., 2002).

Formal statistical analysis of longitudinal data

Mixed-effects models are all forms of a generalised linear model (GLM) for longitudinal data and can be categorised as marginal, random effects and transition model (Diggle et al., 2002). These approaches can be applied to linear, binary and ordinal outcome data. This study used mixed- or random-effects models as they allow inference at the individual level. These models focus on a regression relationship between outcomes and covariates for an individual by incorporating a fixed-effects and random effects component. A fixed-effect component describes the covariate effects and are assumed to be identical for each study subject, therefore, common across the population. The random-effects component extends the model to multiple individuals, allowing each study subject to vary from the population average (West et al., 2007). The standard random intercept and slope model approach assumes that any deviation of an individual's trajectory from the population mean is linear in time over the whole of the follow-up period apart from independent random errors. This assumption is reasonable over short-timer periods and was informed by exploratory analysis.

Linear mixed effect models account for the longitudinal nature of the data by comprising of two main components; a model that describes effects of a set of predictor or covariates on mean responses over time alongside a model containing the covariance between repeated measures (Fitzmaurice and

Ravichandaran, 2008). The modelling option used depends on the hypothesis being investigated. In this study, the focus is the effect of factors on mean response over time. The inferences made here are dependent on choosing a robust model that takes into account the covariance structure (Diggle et al., 2002).

Normal statistical assumptions assume that there is independence of subjects. However, with longitudinal studies we cannot have the same statistical assumptions due to repeated measures on the same subject (West et al., 2007). The time between repeated measures can also influence independence of results. Therefore, it is necessary to take this into account when modelling the data. The profile of a subject, particularly behavioural and emotional measurements are likely to vary considerably. Data may also be collected infrequently with measures collected in unequally spaced intervals and likely to contain missing values. Consequently, many of the statistical methods common with analysis cross-sectional data cannot be applied as statistical assumptions are violated by the characteristics of the dataset. This is often the case, even if the study has planned equal time intervals for follow-up. Linear mixed effect models account for missingness (drop-out) common with cohort studies by estimating the outcome measure (CBCL problem score) in a drop-out free population.

I fitted sequential linear mixed effects models adjusting for covariates of interest and estimated model parameters by maximum likelihood estimation. Nested models are extended models that contain the previous model within. Models are described as a two-level structure, observations in time (Level 1) nested in individual subjects (Level 2). The following equation describes the simplest model (baseline model) using a random intercept and a linear trend considered in the fixed effects:

$$\ln(Y_{ij}) = [\beta_0 + \beta_1 t_{ij}] + [b_{0i} + b_{1i} t_{ij} + \varepsilon_{it}] \quad (1)$$

Whereby, the first bracket contains the fixed effects, and the second bracket contains the random effects. Y_{ij} is the outcome variable for child *i* at time *j*. The fixed effects are expressed as β_0 (intercept) and β_1 (linear time function). The random effects are expressed as b_{0i} (individual intercepts) and b_{1i} (individual slopes). Unobserved within and between variation is expressed as ε_{it}.

I compared nested models using generalised likelihood ratio statistics and Wald statistics to test hypotheses about model parameters. These methods assume that the maximum likelihood estimates are unbiased and have a normal distribution. AIC and BIC values are also used in the model tables, for these summary statistics a lover value suggest a ‘better’ fitting model (Singer and Willet, 2003).

I estimated all of the model parameters by maximum likelihood (ML) estimation. This is a favourable approach to statistical estimation as sample size increase. Estimates are asymptotically unbiased; thus,

estimates converge on the true value as sample size increases (Awasthi et al., 2021). These estimates are normally distributed, providing smaller standard errors than other methods of statistical estimation.

This study makes statistical assumptions around missing data necessary for the use of linear mixed-effects models. Missing data is an inevitable in a longitudinal follow-up study. This study assumes data is missing at random (MAR). This is the basis of mixed-effect models assumptions as the probability of missingness can depend on any of the observed data, either outcomes or covariates. Consequently, the estimates generated will be unbiased despite reduction in the size of the dataset. Mixed-effects models allow a more flexible approach to longitudinal data accounting for the nature and likelihood of missingness.

Robustness Tests

To test statistical assumptions made in the main analysis, I undertook a number of robustness tests. First, I repeated the analysis with child age modelled as a quadratic function and also treating income as categorical function. Furthermore, I repeated the analysis using the index of multiple deprivation (IMD) as an alternative measure of socioeconomic conditions. Owing to differences in the item content of syndrome scales and subsequent composition of internalising and externalising domains across the preschool and school-aged CBCL versions, I also repeated the analysis using CBCL standardised z-scores to check the pattern of results was the same.

The section above describes the data source, study design used to address the aims of the research, the selection of dependent and independent variables, and the methods used to analyse the data to address objective 2 of this thesis. The next section will outline this process for objective 3.

3.4: Study 3: How does perinatal maternal mental health explain early social inequalities in child behavioural and emotional problems? Findings from the Wirral Child Health and Development Study

Summary

Study 3 is a secondary analysis of data collected as part of WCHADS, which aims to assess the role of perinatal maternal mental health in explaining early social inequalities in child behavioural and emotional problems (objective 3). The following section describes: the study population, study design used to address the aims of the research, the selection of and dependent and independent variables, and the methods used to analyse the data.

Data Source

Study 3 uses data collected as part of WCHADS. A full description of the data sources has previously been outlined (see above).

Study Population

Participants entered the analysis sample if data were provided on the exposure (20-weeks gestation), confounders (20-weeks gestation) and the outcome measure (4.5 years). Participants who did not have data on any measure were excluded from the analysis. Consequently, the analysis sample comprised of 664 participants. A descriptive comparison of sample demographics between the baseline sample (n=1233) and the analysis sample (n=664) is shown in table (3.5). The analysis sample remains comparable to the baseline sample with a similar distribution of participants across income bands and IMD groups. The analysis sample contains a smaller proportion of mothers aged between 18-24 years; however, the sample remains comparable for the analysis undertaken.

Table 3.5: Comparison of sample demographics

	Baseline Sample	**Analysis Sample**
Subjects n	1233	664
Externalising raw score	8.4 (7.7)	7.7 (6.8)
Internalising raw score	6.7 (6.3)	6.2 (5.5)
Log-Externalising raw score	1.9 (0.9)	1.8 (0.9)
Log-Internalising raw score	1.7 (0.8)	1.7 (0.8)
Income Band (%)		
Up to £10,000	104 (10.2)	48 (7.2)
£10-20,000	137 (13.4)	77 (11.6)
£21-30,000	162 (15.9)	97 (14.6)
£31-40,000	195 (19.1)	134 (20.1)
£41-50,000	163 (16.0)	110 (16.5)
£51-60,000	130 (12.7)	101 (15.2)
£61-70,000	61 (6.0)	46 (6.9)
Over £71,000	68 (6.7)	53 (8.0)
Maternal Age (%)		
18-24	489 (39.8)	160 (24.1)
25-34	607 (49.3)	408 (61.4)
35+	134 (10.9)	96 (14.5)
Ethnicity (%)		
Other	45 (3.6)	19 (2.9)
Sex (%)		
Male	599 (48.6)	317 (47.6)
IMD Quintile		

1 (Most Deprived)	514 (41.8)	229 (34.5)
2	225 (18.3)	126 (19.0)
3	294 (23.9)	186 (28.1)
4	105 (8.5)	63 (9.5)
5 (Least Deprived)	92 (7.5)	59 (8.9)
Maternal Mental Health		
Prenatal	6.8 (4.1)	6.4 (4.0)
Postnatal (14 months)	5.2 (3.6)	5.1 (4.0)
Postnatal (3.5 years)	5.3 (3.4)	5.0 (3.9)

Measures

Exposure

The primary exposure measure of childhood socioeconomic conditions in pregnancy (baseline), was household income measured at 20-weeks gestation. Mothers were asked 'What is your approximate annual family income?' with responses collected in £10,000 incremental bands (Range: Up to £10,000 – Over £71,000). IMD was also used as an alternative exposure measure in robustness tests.

This study measured the socioeconomic gap (SEC gap) in outcomes between the least and most disadvantaged children. The socioeconomic gap measures health inequalities between the most and least deprived groups. It is an important tool as often population averages overlook differences in health between groups. This approach has been used in previous studies of health inequalities in social epidemiology (Graham, 2004; Taylor-Robinson et al., 2016).

Outcome

This study used the internalising and externalising subscale scores at age 4.5 years from the parent-reported preschool Child Behaviour Checklist 1.5 – 5 years (CBCL) (Achenbach & Rescorla, 2000). This measure has previously been described in further detail (see above). Age 5 represents a transition period in child development. Children start primary education and begin a process of detachment from parents and the home environment. The school environment exposes children to new experiences and risks and there is evidence of an 'equalisation of youth', in certain health outcomes (West, 1997).

Confounders

Demographic characteristics that are potentially associated with child mental outcomes were included as baseline variables in the analyses. Maternal age at consent into the study was coded as categorical variable with age bands designated as 18-24, 25-34 and 35+. Child's sex and ethnicity were also controlled for in the regression analyses. Owing to the small ethnic minority population of the Wirral,

there is a small proportion of study participants identifying as other than White-British. Consequently, this measure was dichotomised as 'White British' or 'Other' to preserve statistical power. To account for variation in children's age and subsequent development at the point of outcome assessment, children's age (months) was controlled for in the models.

Mediator

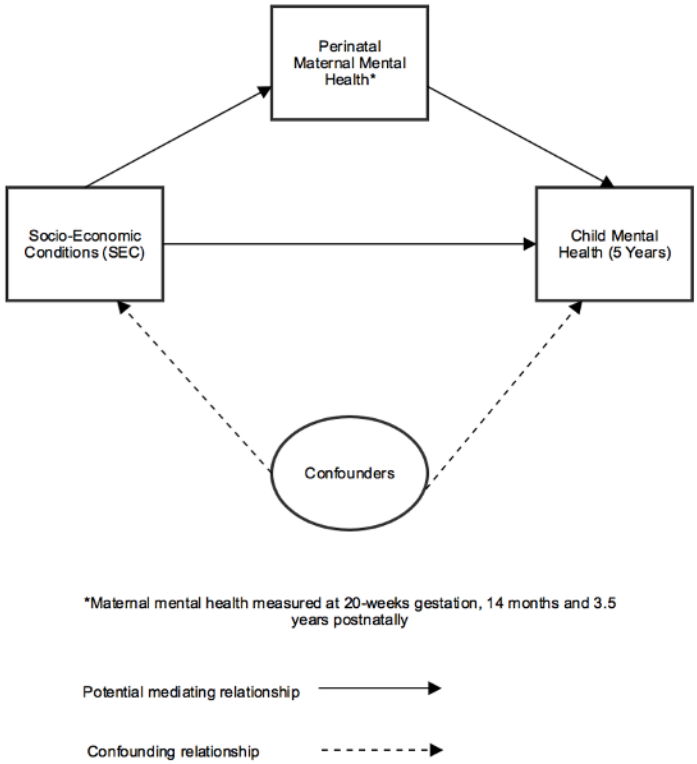
Maternal mental health was assessed as a potential mediator. For maternal mental health, I used total score on the Edinburgh Postnatal Depression Scale (EPDS). The EPDS is a self-reported 10-item measure used as screening tool for depression in the perinatal period (Cox et al., 1987). For the analysis, EPDS was treated as a continuous measure, measured at 20-weeks' gestation, 14 months postnatal and 3 ½ years as a proxy for maternal mental health. Although primarily used a measure for depressive symptoms, the EPDS has been shown to identify anxiety and has a potential use as a screening tool for other mental disorders (Alvarado-Esquivel et al., 2016).

To control for rater bias at CBCL measurement in robustness tests, I used the Centre for Epidemiological Studies-Depression scale (CES-D) at 4.5 years (Radloff, 1977). The CES-D is a 20-item measures that captures reporter experience of depression symptoms. I used total score on the CES-D, as a continuous measure. This measure was not included in the main analysis due to the change of measurement for maternal mental health.

Analysis Strategy

The hypothesised association between socioeconomic conditions (SECs) and child behavioural and emotional problems, with maternal mental health as a potential mediator are shown in a directed acyclic graph (Figure 3.9)

Figure 3.9: DAG for the relationship between exposure, outcome and mediator assessed in this study.



The analysis proceeded in two stages. First, I undertook a univariable analysis estimating effect between exposures outcome and mediators. Secondly, I employed a hierarchical approach to linear regression modelling.

Approaches to statistical modelling

Hierarchical linear models

First, I undertook a univariable analysis estimating association between covariates of interest and total CBCL internalising and externalising problem scores, using linear regression. Due to the outcome data being highly positively skewed, the total scores were log-transformed, with exponentiated beta coefficients interpreted as a geometric means, whereby, a change in the independent variable is represented as a ratio of change in the dependent variable (Batty et al., 2006).

A hierarchical approach was used for the multivariate regression modelling. Firstly, I fitted baseline models for each of the two outcomes by family income, treated as a linear function. Secondly, I adjusted for baseline demographic variables: maternal age at recruitment to the study, child sex and ethnicity. I then fitted models with measures of maternal depression at three separate time periods added separately

(antenatally; at 14 months; and 3.5 years); and finally, I adjusted for maternal mental health at all three time points.

The model in its simplest form can be expressed as:

$$\ln(y) = \alpha + \beta x_i + \varepsilon_i \ (1)$$

Whereby, ln (*y*) is the log-transformed outcome variable, α is the intercept and β is the slope. The hierarchal models add a set of predictor variables at each stage, represented as $\beta x_{i.}$ Unobserved variations are added as error terms $\varepsilon_{i.}$

I took any attenuation in the geometric mean income coefficient on the addition of measures of maternal mental health in a complete case sample to indicate potential mediation of any socioeconomic gap in mental health outcomes (Graham, 2004; Taylor-Robinson et al., 2016) calculated as 100 x (coefficient-adjusted coefficient)/(coefficient-1) to estimate the change in relative gap in behavioural and emotional problems on the basis of family income (Richiardi et al., 2013).

For example, if the baseline SEC gap effect on child externalising problems scores is 1.45 and the effect is 1.31 in the next sequential model (adjusting for next set of predictors), we can say that the SEC effect has been attenuated by 31%. If the effect is rendered statistically non-significant, the SEC gap is mediated by the set of predictors entered.

To calculate the SEC gap, the difference in the number of steps between the lowest and highest values for income is multiplied to the coefficient when exponentiated *Exp*(βn). For example, if the exponentiated beta coefficient for the effect of household income on child externalising behaviour problems is 1.04. We can say that a one-unit increase of the effect of *X* on *Y* is 4%. When the exponentiated beta coefficient for the SEC gap is 1.34, we can say that children from the most deprived households score 34% higher for externalising behaviour problems compared to children from the least deprived households.

Formal mediation analysis

In public health and epidemiological studies, the research question of interest is often trying to establish the pathways that link an exposure to an outcome. The main analysis is informed by the Baron & Kenny approach to mediation, whereby, the effect of a causal variable (X) on the outcome variable (Y) is mediated or explained by another variable (M) (Baron & Kenny, 1986). However, studies have shown

that the traditional approaches may have flaws that can lead to erroneous conclusions as Baron & Kenny approach only holds for linear models (Blakely, 2002; Hafeman, 2011).

Recently there has been rapid development of causal mediation approaches using the counterfactual framework, and I applied this approach as a robustness test (Richiardi et al., 2013). I estimated the Natural Direct Effect (NDE), Natural Indirect Effect (NIE) and Total Effect (TE) for the the directed acyclic graph (DAG) in figure (3.9), adjusting for maternal age at recruitment, ethnicity, child sex and maternal pre- and post-natal mental health, using the 'medflex' package in R software (VanderWeele, 2013). This package offers a flexible set of ready-made functions for fitting natural effect models, which is a novel class of causal models to directly parameterize the path-specific effects of interest, and can accommodate multiple correlated mediators (Steen et al., 2017). I calculated the proportion mediated via maternal mental health applying the formula NIE/(NDE+NIE) (VanderWeele, 2015).

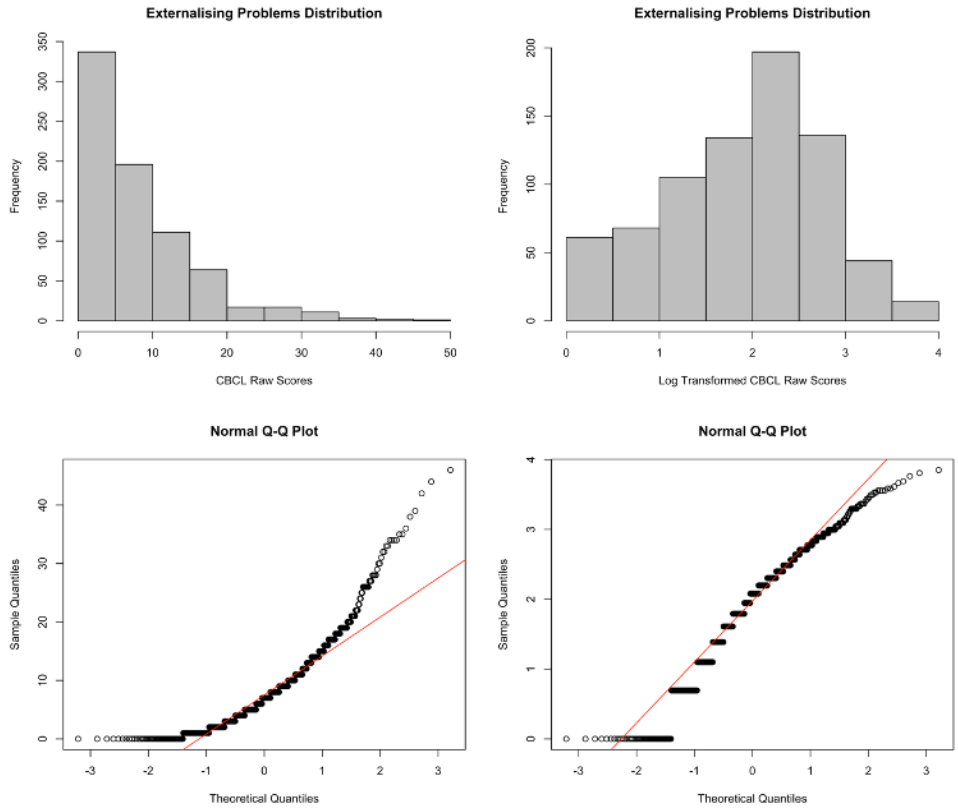
For the mediation analysis to have a causal interpretation, we assume no exposure/mediator interaction; that adjustment for the four types of confounding has been addressed and that there is no post-treatment confounding. The four types of confounding are: (1) confounding of the exposure-outcome relationship; (2) confounding of the mediator-outcome relationship; (3) confounding of the exposure-mediator association; and (4) mediator-outcome confounders also affected by the exposure. (VanderWeele, 2015).

Checking model assumptions

Owing to the distribution of the outcome data, a logarithmic transformation was applied in order to meet necessary statistical assumptions around normality for linear regression methods (figure 3.10).

Plotting the distribution of model residuals acts as a statistical guide as to whether the applied transformation is appropriate in formal model testing. The left panel displays a histogram of the distribution of model residuals and the right panel displays a Quantile-Quantile Plot. The red line in a Quantile-Quantile plot represents a normal (Gaussian) distribution. The black points represent the model residuals. The closer the black points lie to the red line suggest that the model residuals are more normally distributed.

Figure 3.10: Distribution of externalising behaviour problems (outcome) pre- and post-logarithmic transformation at 4.5 years of age.



Robustness analyses

To check the statistical assumptions made in the main analysis I undertook a number of sensitivity analyses. I repeated the analysis using the index of multiple deprivation (IMD) quintile as an alternative measure of socioeconomic conditions. I repeated the analysis using clinical cut-offs for internalising and externalising behaviour problems (coded as; 0= no clinical level score, 1= borderline/clinical level score) to assess the association between SEC and clinical levels of child behavioural and emotional problems. Sensitivity analyses were performed using multiple imputation by chained equations to impute missing data values for all the variables included in the models. I also undertook a formal mediation analysis using the counterfactual framework to assess how much of the effect of SEC (household income) on child behavioural problems is mediated via maternal depressive symptomology measured at all three time points.

3.5 Summary

The methods used within the three empirical studies comprising this thesis have been selected in order to answer the overarching question of how and when socioeconomic inequalities in child mental health develop, as well as the specific research objectives of the chapter. For the first time I have analysed data from the Wirral Child Health and Development Study from a health equity perspective. Multiple

sensitivity analyses have been used to cross-validate and assess the robustness of the findings wherever possible to provide a clearer understanding of the role of SECs in child mental health outcomes. The results of these studies are presented in the chapters that follow.

Chapter 4

Results: Study 1

Relationship between socioeconomic conditions and preschool-aged children's mental health: a systematic review

4.1 Abstract

Background

The association between low socioeconomic conditions (SECs) and child and adolescent (5-16 years) mental health outcomes is well established. However, it is not yet known how early these inequalities develop. This systematic review aims to assess the relationship between SECs and mental health outcomes in preschool-aged children, up to five years of age.

Research Question

Is exposure to lower socioeconomic conditions (SECs) compared to higher SECs associated with the emergence/development of mental health problems in children up to five years of age?

Methods

MEDLINE (Ovid), Web of Science Core Collection and PsycINFO and grey literature were searched from 1980 to May 2020 for longitudinal observational studies reporting a quantitative association between SECs and preschool-aged children's mental health from Organisation for Economic Co-operation and Development (OECD) member countries. Study quality was assessed using the Newcastle-Ottawa Scale (NOS). Harvest plots and narrative synthesis were used to synthesise study findings. The study was registered with PROSPERO (CRD42017071705).

Results

Fifteen studies including 152,635 children met the inclusion criteria. Study methods were heterogenous, with variation in how SECs and mental health were assessed. Five main outcome measures were utilised. The Preschool Child Behaviour Checklist and the Strength and Difficulties Questionnaire were the most commonly used outcome measures, but studies used a variety of sub-domains and thresholds to measure mental health outcomes. 12 out of the 15 studies found an association between SECs and mental health problems, whereby the most disadvantaged children had poorer mental health outcomes. Overall, 82% of the 28 measures of association between SECs (including income, education and occupational measures) and child mental health outcomes were significant.

Conclusion and implications of key findings

In the preschool-age population from high-income countries, disadvantaged children under five have worse mental health outcomes compared to more advantaged children. The review highlights the diversity of socioeconomic exposure measures used, and the range of outcome measures used to capture early child mental health difficulties. Inequalities in child mental health problems are evident in the

preschool period suggesting the need for structural interventions to reduce social inequalities, in addition, to early intervention to improve child mental health in disadvantaged families.

4.2: Introduction

In this chapter, I will present the results from this systematic review as well as the implications of the findings for future research, and the public health implications of this improved understanding of the relationship between SECs and early child mental health. This study was designed to address gaps in the literature identified in Chapter 2. The overall objectives of the research within this thesis are outlined in Chapter 1. This chapter addresses objective 1 by answering the research question: 'For individuals from high-income countries, is exposure to lower socioeconomic conditions (SECs) compared to higher SECs associated with the emergence/development of mental health problems in children up to five years of age?'

A social gradient in health outcomes, whereby the most disadvantaged in society experience less favourable health outcomes, has been well established across multiple conditions, including mental health (Graham 2004, Pickett & Wilson, 2015). Furthermore, there is evidence of rising inequalities in a range of health outcomes in the UK, for both children and adults (Taylor-Robinson et al., 2019; Pearce et al., 2020). These inequalities in health outcomes are preventable and amenable to policy intervention.

Mental health problems affect 10-20% of children and young people worldwide (Kieling et al., 2011). In the UK, there has been an increase in the proportion of serious mental health problems with 1 in 8 children and young people having at least one mental disorder in 2017 compared to 1 in 10 children and young people in 2004 (NHS Digital 2017; Green et al., 2005). The most recent official Mental Health of Children and Young People in England reported that rates of probable mental disorders have increased further since 2018 to one in six (16%) in 2020 (NHS Digital, 2020). The prevalence of mental health problems in preschool age (2-4 years) children was reported for the first time on the basis of this national survey in 2016, with 5.5% of children having at least one mental health disorder (NHS Digital, 2017).

There are additional concerning indications from UK and international studies that the prevalence of affective disorders in adolescents is rising particularly in girls (Collishaw, 2015). Recent data from the UK Millennium Cohort Study reports 24% of girls and 9% of boys aged 14 years self-reporting clinically significant levels of depression (Patalay & Fitzsimons, 2017). In addition, a recent study of child mental health inequalities across three large UK population cohorts in 1999, 2004 and 2012 has shown that inequalities are large and widening over time (Collishaw et al., 2018). Concern is also growing across the EU, with many countries reporting an increase in the prevalence of mental health

problems in children and young people, with studies highlighting social economic disadvantage as a risk factor (Ravens-Sieber et al., 2008).

The psychological and biological mechanisms that lead to the early development of child mental health problems have been well studied. (Essex et al., 2006; Tennant et al., 2007). Growing evidence has suggested the importance of in-utero influences on infant temperament and the developing stress response system. Quality of early parenting and early attachment security is also important for optimal mental health (Keenan et al., 2016). Increasing attention has also been given to the role of early exposure to adverse childhood experiences 'ACEs', for example, parental mental health problems, abuse and neglect. In the UK, 50% of children have experienced one or more ACEs by five years of age, with a social patterning of ACEs also observed. The most disadvantaged children are more at risk of experiencing multiple ACEs and subsequently experiencing poorer health outcomes (Straatman et al., 2020).

Early inequalities in poor mental health are likely to translate into significant health inequalities and associated poor outcomes across the life course. Evidence suggests that if early childhood mental health problems are left untreated, only half of preschool-aged children will show a natural reduction in problems (Kato et al., 2015). The societal costs of persistent problems are considerable, for instance, children who exhibit life-course persistent conduct behaviour problems have been shown to use significantly more health and welfare services in adulthood (Rivenbark et al., 2018). Adverse child mental health is associated with poor educational and health outcomes, lower adult socioeconomic status, and poorer health in adulthood (Brooks-Gunn & Duncan, 1997; Knapp et al., 2011).

Gaps in the literature: why a systematic review is warranted

A previous systematic review explored socioeconomic inequalities in child and adolescent mental health (5-18 years) and found that 52 out of the included 55 studies reported an association between at least one measure of SECs and mental health problems. The review concluded that the most disadvantaged children were up to three times more likely to have a mental health problem compared to less disadvantaged children (Reiss, 2013). My initial scoping searches indicated a growth in published early-years studies since the Reiss (2013) review and that this literature has yet to be systematically reviewed. Furthermore, my scoping searches indicated that search terms should reflect early childhood mental health related terminology to better capture findings from studies which included younger children. Potential issues with searching for a preschool-age population were highlighted, with the starting age for schooling (compulsory or voluntary) varying worldwide. Children can start schooling as early as four years of age and as late as seven years of age. This age variation has

implications for interpretation of results. Therefore, it was necessary to have a well-defined population age and this should also be specified and reflected in the search terms.

Policy context

Using a health inequalities approach may aid our understanding of factors that contribute to the earliest origins of child mental health problems and may help with the identification of children on an emerging pathway to mental health problems. Owing to the increased concern about child mental health, services have become more focussed on identifying problems early in life. With half of all mental health problems starting before the age of 14 years (Kessler et al., 2005), early identification of children on the pathway to poorer health outcomes has been targeted in UK policy, for example, the '1001 critical days' government initiative (DoH, 2013) and funding body research strategies (MRC, 2017). Early interventions are likely to be more cost-effective compared to interventions delivered later in the lifecourse (CMO, 2013).

This review therefore aims to identify when early inequalities in child mental health outcomes are evident in order to identify policy and intervention points. This study therefore systematically reviews current evidence on the relationship between SECs and mental health outcomes in children up to five years of age, using data from prospective longitudinal studies conducted in high-income countries. It provides the first comprehensive assessment of the association between SECs and children's mental health up to five-years of age, in high income countries.

4.3: Methods

The methods utilised in this study are reported in detail in Chapter 3. An overview is provided below.

Protocol and registration

The systematic review was registered within PROSPERO, an international prospective database for registering systematic reviews in health-related outcomes (ID: CRD42017071705). (See Appendix 4).

Eligibility Criteria

Full details of the inclusion and exclusion criteria can be found in Chapter 3. Longitudinal observational (prospective, cohort and case-control) studies reporting quantitative results assessing the association of SECs in the perinatal period and subsequent preschool (up to five years of age) mental health outcomes were included. Only studies that used validated measures of mental health symptoms, for example, internalising and externalising behaviours, were included.

SECs could be measured at either the individual (income, education, employment) or aggregate level (area deprivation). Studies that did not specify the age of the sample, included non-validated outcome measures (or measured temperament as opposed to psychopathology), or where the primary outcome measure was not stated were excluded. Only studies conducted in high-income countries (defined as being a member of the Organisation for Economic Co-operation and Development (OECD)) were included. The focus on high income countries was to ensure that identified studies were similar to present day socioeconomic conditions.

Information sources and search strategies

A three-stage approach to searching was performed: 1) database, 2) grey literature and 3) reference list searching. The three stages are described below.

Firstly, electronic searching of MEDLINE (Ovid), PsycINFO and Web of Science Core Collection was performed. Search terms were piloted prior to selection and comprise of broad mental health outcomes and socioeconomic terms. These search terms are detailed in Appendix 4. Secondly, grey literature was searched using the Google and Google Scholar search engines. The search terms used were "mental health", "psychopathology", "internalising", "externalising", "socioeconomic", "income", "deprivation", "child", "infant" and "preschool". The first 100 results were screened for inclusion. The third stage involved screening the reference lists of included studies from the previous two strategies to identify any relevant publication that may not be stored on electronic databases and were consequently missed in the electronic search. Search results were exported to reference management software 'Mendeley', where results were pooled, and duplicates removed.

Study selection

The search results were screened for inclusion applying pre-established criteria (Chapter 3). Titles and abstracts were screened by the principal reviewer (CR), with a sample (minimum 10%) independently screened to ensure consistency. Any discrepancies were discussed until an agreement was reached. The full text for studies deemed relevant after initial abstract screening were sought and screened in the same way.

Data extraction

Data were extracted into a standardised Microsoft Excel spreadsheet modelled on previous reviews with a focus on health inequalities by the principal reviewer (CR) (Adams et, al., 2018; Uphoff et al., 2014). The data extraction form was piloted prior to the search. Data extracted included the following: aim/hypothesis, study design, level of analysis, country, sample size, age range/mean, mental health outcome, method of measurement, measure of SECs, covariates, statistically significant results, non-significant results, conclusion and quality assessment (Appendix 4). Where available confounder (sex,

ethnicity) adjusted estimates are presented. If studies did not report confounder adjusted estimates, unadjusted univariable and/or multivariable associations are reported. Where multiple SECs and mental health measures were used within a single study, all reported associations were recorded.

Quality appraisal of studies

Risk of bias and quality assessment of included studies was undertaken using the Newcastle-Ottawa Scale (NOS). A second independent reviewer assessed a random sample (10%) for inter-rater reliability. If needed, any discrepancies between reviewers were discussed until an agreement was reached. The NOS incorporates a star rating system to assess sample selection, outcome/exposure ascertainment and confounding. Studies were classified as low, medium and high quality depending on the star rating achieved. Study quality was reflected in data synthesis through the height of bars in harvest plots described below.

Synthesis of results

The principal summary measures extracted from identified studies were odds ratios and beta coefficients (unadjusted or adjusted for confounders if conducted). Main findings from each of the identified studies is included in a summary table. The table displays results assessing the relationship between SECs and mental health outcomes stratified by outcome measure utilised alongside direction of effect. Owing to variation in how each study reports and presents their results, the summary table may present several associations depending on availability. Studies reporting baseline confounder adjusted associations will be given more weight in the discussion. Unadjusted associations from a bivariate analysis or single risk factor model or fully adjusted associations may also be reported. All associations are clearly identified by a key.

Due to the heterogeneity of study design, populations, exposure and outcome measurements a meta-analysis was not possible. Consequently, data synthesis was dictated by the data available. Key concepts and trends were explored through narrative synthesis. Harvest plots were used to help visualise and summarise the results of studies identified in the review (Ogilvie et al., 2008). The harvest plots were stratified by age and SEC measures to show differential effects on child mental health outcomes. In the harvest plots, each measure of SECs was represented by a single bar. Where multiple SECs measures from the same study are reported, these are indicated by a colour code.

The height of each bar was used to demonstrate study quality, with the highest bar representing high quality studies. The harvest plots classify studies into three categories of results: worse mental health outcomes for the more disadvantaged children; worse mental health outcomes for the less disadvantaged children and no significant association found between SECs and mental health outcomes. To further

explore the association between SECs and age of onset of child mental health outcomes, a sub-group analysis was undertaken. Where data allowed, stratification by developmental stages (perinatal, infant, preschool) was explored. Furthermore, to explore sex differences, any SECs by sex interactions coefficients were extracted.

4.4: Search Results

Database search results

The results from the database searches are displayed in Figure (4.1). In total, 3158 studies were retrieved from the three databases combined.

Search functionality varied across databases. Across all databases results were limited to the English language and manuscripts published between the years 1980 to 2020. There was no human subject filter available in Web of Science Core Collection. In PsycINFO, the age filters: neonatal (birth-1 month), infancy (2-23 months) and preschool age (2-5 years) were applied to the search results.

Search results were imported into reference management software Mendeley, where 529 studies were identified as duplicates. In total, 2629 studies were identified for screening.

Grey literature search results

The Google Scholar search from 1st January to 31st May 2020, produced approximately 17,800 results. The first 100 studies in order of relevance were selected, and of these 5 were selected for full-text screening but did not meet inclusion criteria.

Reference list search results

Hand searching of reference lists of identified studies that met the inclusion criteria, resulted in the identification of 7 studies which were then screened. None of the identified studies were included in the final review.

Selection Process

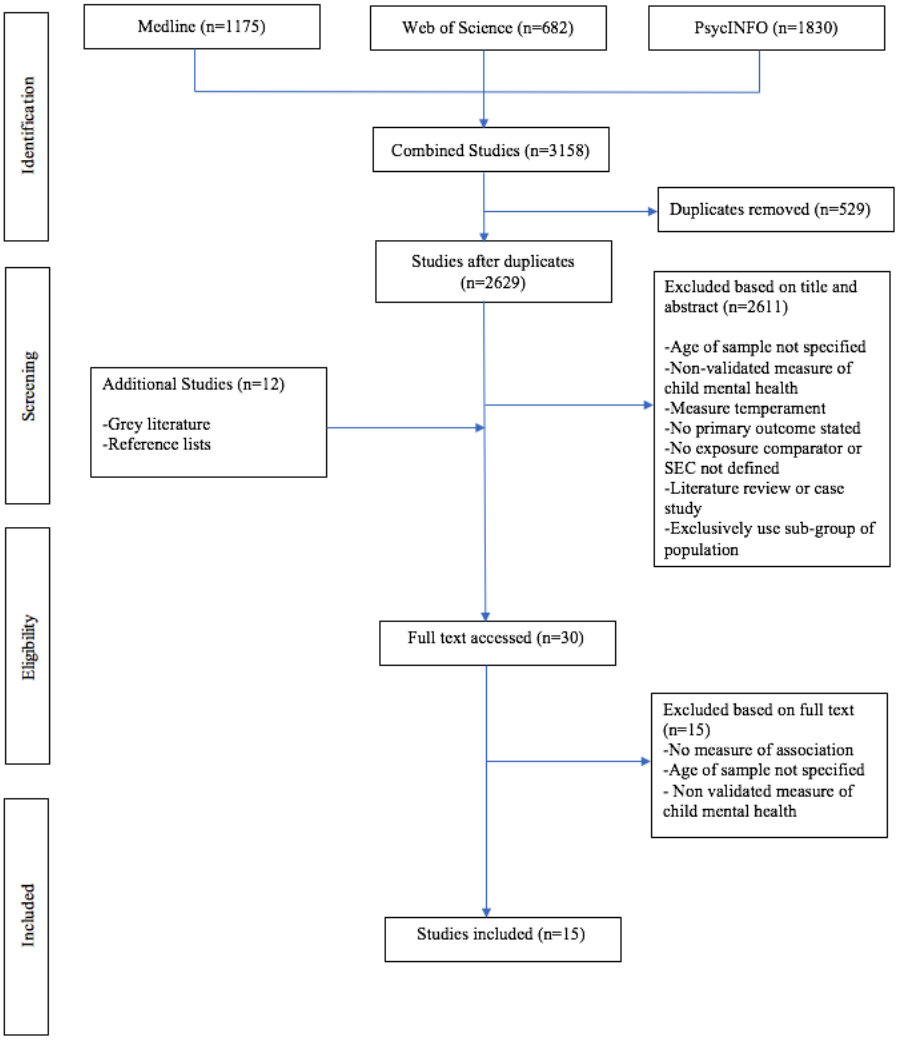
The overall selection process of identified studies is shown in Figure (4.1). Title and abstract screening were performed on 2629 studies. Those with a validated measure of child mental health up to the age of five years and a measure of SECs were selected for full-text screening. Non-observational studies,

literature reviews, case studies, subjects from non-OECD countries, studies with a population sub-group, collected data before 1980, were not available in English or assessed temperament were excluded.

Overall, 15 out of 30 studies identified from all three stages of systematic searching were excluded after full-text screening. The reasons for exclusion included: no measurement of the association between SECs and mental health outcomes reported; age of sample; non-validated measure of child mental health problems.

Finally, in total 15 studies were selected for inclusion in the review (see Appendix 4 for bibliography of included studies).

Figure (4.1) Flowchart detailing selection of studies for inclusion



Risk of bias within studies

Study quality was assessed using the Newcastle-Ottawa Scale which awards star ratings on three areas: exposure ascertainment, comparability (studies provide confounder-adjusted associations) and outcome ascertainment (Wells et al., 2017). The majority of the included studies were graded as medium quality (n=12). Three studies were high quality. Details of the study quality rating for each of the included studies can be found in Appendix 4.

Study Characteristics

This section provides a description of the studies which met the inclusion criteria.

The summary characteristics of the included studies are shown in Table 4.1. Of the studies that met the inclusion criteria, just under half of studies (n=7) were conducted in Oceania, with longitudinal cohort study designs. Studies identified were published between 1997 and 2019 with an increase in publications after 2010.

The sample sizes of the included studies typically ranged from less than 1000 to up to 10,000 participants. Green et al. (2017) and Rijilarsdam et al. (2012) used population-level data and had sample sizes of over 10,000 participants. Two studies used repeated outcome measures within the age range (up to five years of age) (D'Souza et al., 201b; Rijilaarsdam et al., 2012).

Table (4.1) Characteristics of included studies.

Study Characteristics	Number of Studies
Total	15
Year of Publication	
Before 2000	1
2000-2005	2
2006-2010	2
After 2010	10
Level of Analysis*	
Individual	14
Area	7
Region	
Europe	4
North America	4
Oceania	7
Study Design	
Cohort	12
Population	2
Intervention	1
Sample Size	
<1000	2
1001-5000	6
5001-10,000	5
>10,000	2
Mental Health Outcome	
Child Behaviour Checklist (CBCL)	6
Strengths & Difficulties Questionnaire (SDQ)	5
Brief Infant Toddler Social Emotional Assessment (BITSEA)	2
Early Development Index (EDI)	1
Australian Early Development Census (AEDC)	1
SEC Measures*	
Deprivation	9
Education	7
Employment	3
Income#	9
Social class	1

*Included studies belonging to more than one category. # including proxy measures of income

Table (4.2) Detailed characteristics of included studies (design, exposure, outcome)

First author (year) & Study Location	Study Design	Sample Size (Analysis *n*)	Exposure (time)	Outcome Tool	Outcome Measure	Age at Outcome	Present unadjusted associations?
Bayer (2008) Australia	Longitudinal population-based	585	Household income (7 months) Education (7 months)	CBCL Preschool Version	Internalising, Externalising Total problem scores	18, 24, 36 (months)	No
Bor (1997) Mater University Study of Pregnancy (Australia)	Longitudinal cohort	5296	Household income (antenatal, postnatal 6 months)	CBCL Short Version (4-18)	Internalising, Externalising problem scores Social/Attentional/Thought (SAT) subscale	5	No
Davis (2010) Longitudinal Study of Australian Children	Longitudinal cohort	4969	Income, Education (not specified)	SDQ British 3-4 version	Total difficulties, emotional, conduct, hyperactivity, peer problem scores	4	No
D'Souza (2019a) Growing up in New Zealand	Population-based birth cohort	6246	Education (antenatal) Employment (2 years) Area-deprivation (2 years)	SDQ Preschool	Total difficulties, emotional, conduct, hyperactivity, peer problems	2	Yes
D'Souza (2019b) Growing up in New Zealand	Population-based birth cohort	5896	Education (antenatal) Area-level deprivation (4.5 years)	SDQ Preschool SDQ	Total difficulties	2-4.5	Yes
Flouri (2010) Millennium Cohort Study (UK)	Longitudinal birth cohort	4618	Area-level deprivation (9 months) Family socioeconomic deprivation composite index (9 months) Education (9 months)	SDQ	Total difficulties, emotional, conduct, hyperactivity, peer problems	3	Yes (total difficulties) No (specific pathologies)
Flouri (2012) Millennium Cohort Study (UK)	Longitudinal birth cohort	9736	Area-level deprivation (9 months) Family socioeconomic deprivation	SDQ	Total difficulties, emotional, conduct, hyperactivity, peer	3	Yes (total difficulties) No (specific pathologies)

			(9 months) Maternal social class (9 months)		problems		
Green (2017) Australian Early Development Census	Population-based longitudinal study	67,353	Area-deprivation (not specified)	AEDC	Putative risk states for mental disorders	5	Yes
Hetherington (2018) All our Families (Canada)	Longitudinal pregnancy cohort	1314	Household income (2 years) Employment (2 years)	CBCL Short Version	Externalising problem scores	3	Yes
Najman (2005) Mater University Study of Pregnancy (Australia)	Longitudinal cohort	5259	Education (antenatal)	CBCL Short Version (4-18)	Depression subscale	5	No
Palmer (2013) CANDLE Study (United States of America)	Longitudinal, community-based cohort	1070	Household income (antenatal) Education (1 year)	BITSEA	Social-emotional problems	1	No
Palmer (2018) CANDLE Study (United States of America)	Longitudinal, community-based cohort	1103	Household income, Education (antenatal)	BITSEA	Social-emotional problems	2	Yes
Rijilaarsdam (2012) Generation R Study (Netherlands)	Longitudinal population-based cohort	2711	Household income, Education (antenatal)	CBCL Preschool Version	Internalising, Externalising problems scores	1.5 3	Yes
Rutherford (2019) Wirral Child Health & Development Study (UK)	Epidemiological, longitudinal cohort	664	Household Income (20-weeks gestation)	CBCL Preschool Version	Internalising, Externalising problems scores	4.5	Yes

			Area-deprivation (20-weeks gestation)				
Thomson (2017) Canada	Cross-sectional based upon population-level cohort	35 815	Household income (subsidy status)	EDI	Social-emotional development	5	No

Tools: AEDC: Australian Early Development Census; BITSEA: Brief Infant-Toddler Social Emotional Assessment; CBCL: Child Behaviour Checklist 4-18; Child Behaviour Checklist Preschool (1.5-5); EDI: Early Development Instrument; SDQ: Strength and Difficulties Questionnaire (3-16).

Measurement of SECs

Information about SECs was obtained by self-report across all studies except Thomson et al., (2017), which utilised Canadian medical service plan records to obtain household subsidy support as a proxy measure for low household income. The majority of the studies (n=14) identified used an individual-level measure of SECs, with household income the most commonly used measure. The review identified nine studies that used multiple indicators of SECs, with six studies having both an individual and area-level measure.

Income was the most commonly used individual-level measure of SECs (n=9). When reporting differences in mental health outcomes by income, the most common approach used was to dichotomise income as low versus high. Rutherford et al. (2019) treated income as a linear function and also provided estimates for the socioeconomic gap (the difference between the least and most disadvantaged). As studies varied internationally, thresholds for low income differed.

Parental education was another common approach to measuring individual level socioeconomic status used in studies (Bayer et al., 2008; Davis et al., 2010; D'Souza et al., 2019ab; Flouri et al., 2010, Flouri et al., 2012; Najman et al., 2005; Palmer et al., 2013, Palmer et al., 2018; Rijilarsdam et al., 2012; Rutherford et al., 2019). Whilst education varies internationally, with differing qualifications and years of schooling, highest versus lowest education level attained was commonly used to compare effect sizes.

Flouri et al. (2012) was the only study to use maternal occupational social class. Mothers self-reported using the UK National Statistics Socioeconomic Classification (NS-SEC). Employment (job type) was classified into seven categories, ranging from 'high managerial' to 'routine.' Effect sizes were reported for each level of NS-SEC. The results presented in Table (4.3) display the lowest category in reference to the highest.

Area-level measures of socioeconomic conditions were also assessed in six studies (D'Souza et al., 2019a; D'Souza et al., 2019b; Flouri et al., 2010, Flouri et al., 2012; Green et al., 2017; Rutherford et al., 2019). Studies situated within the UK utilised the Index of Multiple Deprivation (IMD). These indices combine social, economic and housing indicators, measured at the census level into a composite deprivation score for small areas in England. Similarly, Bayer (2008) assigned a SEIFA (socioeconomic index for areas) an index of relative disadvantage in Australia in their analysis. D'Souza et al. (2019) utilised the New Zealand deprivation index (NZDep) (Atkinson et al., 2014). Deciles of deprivation were categorised into three categories: low, medium and high deprivation.

Composite measures are increasingly common in research assessing social inequalities in health outcomes (Galobardes et al., 2006; Shavers 2007). A composite measure of SECs uses multiple indicators of socioeconomic status across different domains to better represent social disadvantage. Flouri et al., (2011) constructed a family socioeconomic disadvantage index based upon five items measured in their study: home ownership, in receipt of income support, poverty (below poverty line), overcrowding and lack of home ownership.

Many of the studies analysed SECs as a dichotomous variable and did not investigate a social gradient. Where studies used this approach, the socioeconomic gap (comparing the least to the most disadvantaged) is used to describe difference in mental health outcomes. Full details of the studies can be found in Appendix 4.

Measurement of mental health outcomes

Five assessment tools, used to assess mental health, were identified. The Child Behaviour Checklist (Bayer et al, 2008; Bor et al., 1997; Hetherington et al., 2018; Najman et al., 2008; Rijilaarsdam et al., 2012; Rutherford et al., 2019) and the Strength and Difficulties Questionnaire (Davis et al., 2000; D'Souza et al., 2019a; D'Souza et al., 2019b; Flouri et al., 2010; Flouri et al., 2012) were the most frequently used measures. These measures have been validated across international samples and have clinical utility (Achenbach, 1991; Goodman, 1997).

There are different age versions of the Child Behaviour Checklist available, each with varying items measured. However, all versions that report on internalising problems are derived from combining the anxious/depressed, emotionally reactive, withdrawn and somatic complaints scores, and externalising problems by combining aggressive behaviour and attention problem scores. Three studies utilised the preschool version (1.5-5 years) (Bayer et al., 2008; Rijilaarsdam et al., 2012; Rutherford et al., 2019). The measure contains 99 problem items, scored 0 (not true), 1 (somewhat or sometimes true) and 2 (very true or often true). Bor et al., (1997) used the short version form of the 4-18-year CBCL containing 33 items and created a social, attentional and thought problem subscale alongside internalising and externalising behaviours. Hetherington et al. (2018) used a short version of the CBCL comprising of 25 items however, the version is not specified. Owing to no normative scores available for the short-form version used, the study used the 84th percentile as a cut-off of a child being at risk of externalising behaviour problems. Najman et al., (2005) only utilised the depression subscale from the short-form 4-18-year version of the CBCL, and derived a cut-off based on children who scored above a threshold on four out of the eight items captured due to no clinical data available.

The SDQ comprises of subscales measuring emotional problems, conduct problems, hyperactivity, peer problems and prosocial behaviour from which a composite 'total difficulties' subscale score can be derived. All of the studies that used SDQ reported total difficulties scores. D'Souza (2019a, 2019b) and Davis (2010) utilised the preschool version of the SDQ. D'Souza (2019b) used repeated outcome measurements at 2 and 4.5 years, creating behaviour stability profiles based upon scoring within the abnormal range at each timepoint. Cut-offs can be applied to scores to dichotomise children who score in the normal or borderline/abnormal range. Validated cut-offs were used in two studies (D'Souza et al., 2019a, 2019b; Davis et al., 2010), however, Davis (2010) used UK validated cut-offs based upon the 4-16 years version of the SDQ. Davis (2010) also reported associations between SECs and SDQ outcomes when the child's teacher was the respondent. Both parent and teacher reported associations are displayed in table 4.3.

Two studies utilised risk profiles generated from latent class analysis (Green et al., 2017; Thomson et al., 2017). Green et al., (2017) used a set of measures of early childhood vulnerability (social, emotional, physical, cognitive and communication) from the AEDC to create putative risk states for later mental health problems. Children were considered developmentally vulnerable if they scored below 10% of the population distribution. Risk profiles identified were: no risk, mild generalised risk (moderately increased risk across all domains), misconduct risk (higher probability of vulnerability on behavioural, hyperactivity, respect and inattentive behaviour indicators) and pervasive risk (developmentally vulnerable on 11 out of 16 indicators).

Thomson et al., (2017) used eight indicators from the Early Development Instrument (for example, social competence, responsibility and respect, anxious and fearful, aggressive behaviour) to create developmental profiles. Unique profiles of social-emotional health from the population were derived from latent class models. The association with SECs was tested through multinomial logistic regression. Odds ratios are presented for profile membership in reference to a group with overall high social-emotional functioning. The review included two studies using the Brief Infant-Toddler Social Emotional Assessment to assess social-emotional development (Palmer 2013, Palmer 2018) at age 2 or under. Using total problem score, a standard cut-off was applied using scores below the 25th percentile for age to indicate a potential problem in social-emotional development.

Data transformation

Where applicable, data transformation was undertaken on studies that reported data but offered no interpretation of the association between SECs and child mental health outcomes. For example, D'Souza et al. (2019a) presented frequencies distributions of normal and abnormal scores for total difficulties and each domain of the SDQ by sociodemographic variables. No statistical test to assess the

association was performed. To interpret the results presented, odds ratios were calculated for each domain comparing the most disadvantaged children to the least disadvantaged. Odds Ratio are reported in the main results section of Table (4.3). Where data has been transformed for interpretation, this is noted in the results Table (4.3).

Table 4.3: Summary of findings from identified studies on the association between SECs and child mental health stratified by outcome measure.

Study	Results	Effect of low SECs on poor mental health
	Child Behaviour Checklist (CBCL)	
Bayer (2008) ▲ (Australia)	**From ages 1.5 to 3 years, low family income and maternal education was not significantly associated with scores for externalising or internalising behaviours.** Income: Externalising (β=1.51 (-0.54, 3.56), Internalising (β=0.59 (-0.85, 2.03) *p*=0.15 Education: Externalising (β=-0.10 (-1.40, 1.20), Internalising (β=0.68 (-0.23, 1.59) *p*=0.42	↔
Bor (1997) ● Mater University Study of Pregnancy (Australia)	**At age 5 years, children from low-income families had a greater proportion of externalising, internalising and social, attentional and thought problems compared to less disadvantaged children.** Exposure in antenatal period: externalising behaviour problems (11.9% vs. 9.4%), internalising problems (13.8 vs. 10.1%) and social, attentional and thought problems (15.5% vs. 10.8%). Associations were significant *p*<0.01. Exposure in postnatal period: externalising behaviour problems (13.0% vs. 9.4%), internalising problems (14.2 vs. 10.3%) and social, attentional and thought problems (16.2% vs. 11.1%). Associations were significant *p*<0.01.	↑
Hetherington (2018) ● ▲ All our Families (Canada)	**At age 3 years, low income and maternal employment did not significantly predict externalising behaviour problems.** Income: Unadjusted OR 1.06 (0.71-1.60 *p*=0.755), Adjusted OR 0.86 (0.55-1.35, *p*=0.524) Employment: Unadjusted OR 1.04 (0.78-1.40, *p*=0.799), Adjusted OR 0.94 (0.67-1.31, *p*=0.697)	↔
Najman (2005) ▲ Mater University Study of Pregnancy (Australia)	**At age 5 years, there was no significant mean difference in depression scores between the most and least disadvantaged children.** Adjusted mean depression scores 2.87 (low education) vs. 2.84 (high education) *p*=0.076	↔
Rijilarsdam (2012) ■ Generation R Study (Netherlands)	**At ages 1.5 and 3 years, low income and maternal education significantly predicted higher externalising and internalising behaviour scores.** Income: internalising behaviour problems (β 0.25, *p*<0.001) and externalising behaviour problem scores (β 0.10 p=<0.001) at 1.5 years of age. internalising behaviour problems (β 0.16, *p*<0.001) and externalising behaviour problem scores (β 0.08 *p*=0.001) at 3 years of age. Education (per level): internalising behaviour problems (β 0.19, *p*<0.001) and externalising behaviour problems scores (β 0.10, *p*<0.001) at 1.5 years of age. internalising behaviour problems (β 0.17, *p*<0.001) and externalising behaviour problems scores (β 0.10, *p*<0.001) at 3 years of age.	↑
Rutherford (2019) ■ Wirral Child Health & Development Study (UK)	**At 4.5 years of age, low income and area deprivation was significantly associated with higher scores for externalising behaviours but not for internalising behaviour problems.** Income (low vs. high): Externalising (Exp(β) 1.45 (1.09-1.18), *p*<0.05), Internalising (Exp(β) 1.23 (0.98-1.53) *p*=0.068) IMD (low vs. high): Externalising (Exp(β) 1.37 (1.06-1.78) *p*<0.05), Internalising (Exp(β) 1.23 (0.97-1.55), *p*>0.05)	↑ ↔
	Strengths & Difficulties Questionnaire (SDQ)	
Davis (2010) ▲	**At 4-5 years of age, low income and parental education are significantly associated with higher odds ratios for both parent and teacher reported scores for total difficulties.**	↑

Longitudinal Study of Australian Children	Income: total difficulties (OR 2.4), emotional symptoms (OR 2.0), conduct problems (OR 1.6), hyperactivity problems (OR 1.5) and peer problems (OR 1.8) but only significantly associated with total difficulties (OR 1.4), hyperactivity (OR1.4) and peer problems (OR 1.9) for teacher reported outcomes. Education: total difficulties (OR 2.0), emotional symptoms (OR 1.4), conduct problems (OR 1.3), hyperactivity problems (OR 1.8) and peer problems (OR 1.6) but only significantly associated with total difficulties (OR 1.7), conduct problems (OR 1.4) and hyperactivity problems (1.7) for teacher reported outcomes.	
D'Souza (2019a)† ● Growing up in New Zealand	**At 2 years of age, low education, not in employment and area-deprivation was significantly associated with higher odds for abnormal range scores for all domains of the SDQ.** Education (low vs high): total difficulties (OR 8.68), emotional symptoms (OR 5.14), peer problems (OR 3.56), hyperactivity-inattention (OR 2.20) and conduct problems (OR 8.37) Employment: total difficulties (OR 3.91), emotional symptoms (OR 3.34), peer problems (OR 2.70), hyperactivity-inattention (OR 1.41) and conduct problems (OR 3.72). Area-deprivation: Total difficulties (OR 2.20), emotional symptoms (OR 2.19), peer problems (OR 1.63), hyperactivity-inattention (OR 1.40) and conduct problems (OR 1.84)	↑
D'Souza (2019b) ● Growing up in New Zealand	**Between 2 to 4.5 years of age, there were significant differences in persistent abnormal range scores for total difficulties for the most disadvantaged children compared to the least disadvantaged children.** Using total difficulties scores from age 2 and 4.5, behavioural stability profiles were created. Normal profile representing no abnormal scores at either timepoint, improved from abnormal to normal at 4.5, moved into abnormal at 4.5 and persistent, scoring in the abnormal range at both timepoints. Education: Normal: No secondary (4.4%) vs. Degree (46.0%); Improved: No secondary (11.4%) vs. Degree (18.1%); Concurrent: No secondary (12.8%) vs. Degree (18.9%); Persistent: No secondary (19.25) vs. Degree (12.2%) (chi-square 356.90, *p<.001)* Area-deprivation: Normal: Low (34.4%) vs. High (27.4%); Improved: Low (18.5%) vs. High (51.3%); Concurrent: Low (15.3%) vs. High (58.5%) Persistent: Low (7.2%) vs. High (70.6%) (chi-square 398.48, *p*<.001)	↑
Flouri (2010) ● ▲ Millennium Cohort Study (UK)	**At 3 years of age, area-level and family socioeconomic deprivation was significantly associated with SDQ total difficulties scores.** Low area-level deprivation was associated with lower scores for total difficulties (β = -0.938, SE=0.083) (Unadjusted). Low area-level deprivation was associated with lower scores for total difficulties (β =-0.41, SE=0.085) (adjusted). Area-level deprivation did not significantly predict any specific psychopathologies. Family deprivation was associated with higher scores for total difficulties (β = 0.936, SE=0.037) (Unadjusted). Higher levels of family deprivation were associated with higher total difficulties scores (β =0.889, SE=0.038) (Adjusted) and with higher scores for prosocial behaviour (β =0.043, SE=0.021), conduct problems (β =0.146, SE=0.022) and peer problems (β =0.050, SE=0.017) but not emotional symptoms (β =0.029, SE=0.015), or hyperactivity (β =0.041, SE=0.027) Children with parents with the lowest level of maternal education had higher scores for emotional problems (β =0.278, SE=0.093), conduct problems (β =0.486, SE=0.133), hyperactivity (β =0.939, SE=0.162) and peer problems (β =0.258, SE=0.106) but not prosocial behaviour (β =-0.156, SE=0.130).	↑
Flouri (2012) ● ▲ Millennium Cohort Study (UK)	**At age 3 years, area-level deprivation, family socioeconomic deprivation and social class was significantly associated with SDQ total difficulties scores.** Low levels of deprivation were associated with lower scores for total difficulties (b=-0.938, SE=0.082) (Unadjusted). Area-level deprivation was only significantly	↑

	associated with peer problem scores (β =-0.072) but not prosocial behaviour (β =-0.040, SE=0.029), emotional symptoms (β =-0.032, SE=0.021), conduct problems (β =-0.042, SE=0.030) or hyperactivity (β =0.029, SE=0.036) (Adjusted). Higher levels of family deprivation were significantly associated with higher total difficulties scores (β =0.889, SE=0.038) (Adjusted). Family deprivation was significantly associated with higher scores for emotional symptoms (β =0.045, SE=0.013), conduct problems (β =0.179,0.085, SE=0.022), hyperactivity (β =0.085, SE=0.022) and peer problems (β =0.059, SE=0.015) but was not associated with scores for prosocial behaviour. Low social class was significantly associated with higher total difficulties scores (β =2.004, SE=0.236). Low social class was associated with higher scores for emotional symptoms (β =0.136, SE=0.063), conduct problems (β =0.386, SE=0.090), hyperactivity (β =0.694, SE=0.107) and peer problems (β =0.337, SE=0.071) but was not associated with prosocial behaviour scores (β =-0.092, SE=0.088) (Adjusted).	
	Brief Infant-Toddler Social Emotional Assessment (BITSEA)	
Palmer (2013) ● ▲ CANDLE Study (United States of America)	**At 1 year of age, low education was significantly associated with social-emotional problems using the BITSEA.** Of black children who had a social-emotional problem, a greater proportion had a greater proportion had mothers with lower levels of education (n=171 vs. 58; *p*<0.001). For white children this pattern was (n=15 vs. 23); *p*=0.05). In multivariate models, low maternal education predicted higher odd ratios of social-emotional problems in black children (OR 1.92 (1.24-2.97), *p*=.003) but not for white children. Low income significantly predicted social-emotional problems in white children (OR 3.44 (1.27-9.37), *p*=.002) but not for black children.	↑
Palmer (2018) ● ▲ CANDLE Study (United States of America)	**At 2 years of age, low education and income was significantly associated with social-emotional problems.** In bivariate models, lower maternal education (OR 4.70 [95% CI 3.27, 7.67], p<.001) and low income (OR 3.41 [95% CI 2.43, 4.79], *p*<.001) were associated with social-emotional problems. In multivariate models, only education was associated with social-emotional problems (OR 2.26 [95% CI 1.44, 3.54], *p*<.001)	↑
	Australian Early Development Census (AEDC)	
Green (2017) ● ▲ Australian Early Development Census	**At age 5 years, the most disadvantaged children had higher odds ratios for all developmental risk profiles compared to the least disadvantaged children.** Putative risk profiles generated from latent class models for mental disorders based upon 16 developmental indicators. No risk, 'mild generalised risk' (across all subdomains), 'misconduct risk' (higher probabilities on behavioural, hyperactivity, respect, and inattentive behaviour indicators and 'pervasive risk', developmentally vulnerable on 11 out of 16 indicators. Most disadvantaged children had higher odds of mild risk (OR 2.01); misconduct risk (OR 2.09) and pervasive risk (OR 1.36) profiles (unadjusted associations) Most disadvantaged children had higher odds of mild risk (OR 1.96); misconduct risk (OR 1.33) and pervasive risk (OR 2.02) profiles (adjusted associations)	↑
	Early Development Instrument (EDI)	
Thomson (2017) ■ Canada	**At age 5 years, the most disadvantaged children had higher odds ratios for low social-emotional health compared to the least disadvantaged children.** Children from the most disadvantaged households were four times (AOR 4.54 (3.3-6.2), *p*<0.001) more likely to have a low social-emotional functioning profile compared to children from the least disadvantaged households.	↑

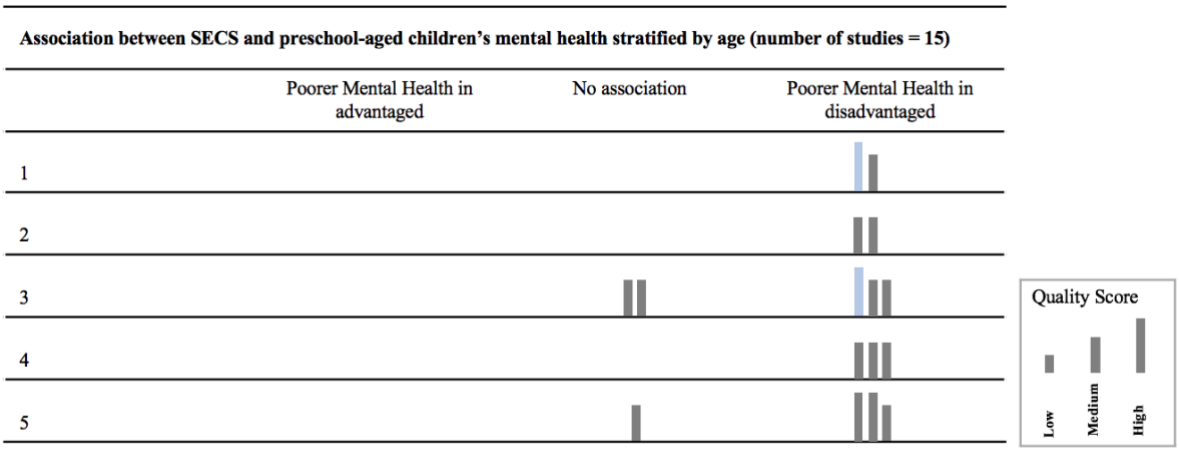
↑ = increasing levels of socioeconomic disadvantage is statistically significantly associated with increased risk or higher scores for mental health problems ↓ = decreasing levels of socioeconomic disadvantage is statistically significantly associated with increased risk or higher scores for mental health problems ↔ = no statistically significant association between SECs and child mental health. †Calculated ORs based upon results presented in study, comparing the most to the least disadvantaged children. ●Unadjusted associations are reported (e.g., bivariate associations or single risk factor model coefficients)■Confounder adjusted associations are reported ▲ Fully adjusted associations are reported (e.g., coefficients taken from a multivariate analysis)

Association between SECs and mental health outcomes

A summary of the associations identified from the included studies are presented in Table 4.3. Where applicable odds ratios, beta coefficients and the direction of association are also displayed. Overall, 12 out of the 15 included studies showed an association between socioeconomic conditions and mental health outcomes, whereby, the most disadvantaged children had worse mental health outcomes compared to less disadvantaged children. None of the included studies reported an increased risk of poorer mental health outcomes for advantaged children compared to disadvantaged children.

The associations between SECs and mental health outcomes are stratified by age in Figure 4.2. Each bar in the harvest plot represents an association between SECs and mental health at a particular age (number of studies = 15). One study that used repeated outcomes measures at different ages appears twice and is highlighted by a colour bar. Inequalities in mental health outcomes were reported at as early as one-year of age (Palmer et al., 2013). The majority of included studies (n=7) used outcome measures between four- to five-years of age (Bor, 1997; Davis, 2000; D'Souza. 2019b; Green, 2017; Najman, 2005; Rutherford, 2019; Thomson. 2017).

Figure (4.2) Harvest plot of the association between SECs and mental health stratified by age (no. of studies =15)

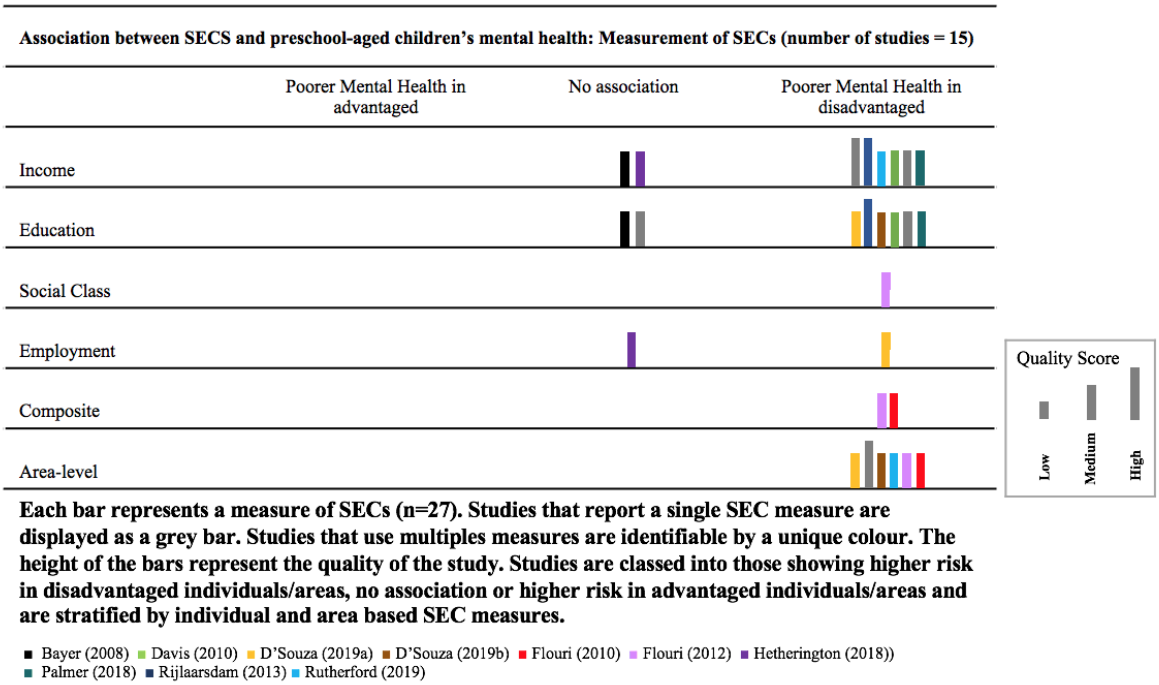


Each bar represents one study. Studies that report data on repeated outcomes are included again (blue bars). The height of the bars represent the quality of the study. Studies are classed into those showing higher risk in disadvantaged individuals/areas, no association or higher risk in advantaged individuals/areas and are stratified by age at which the outcome measures were assessed.

Associations were found between, both, individual and area-level measures of SECs and mental health outcomes. Across the fifteen included studies, a total of twenty-seven measures of SECs were reported on. Twenty-two of the SEC measures (82%) were significantly associated with poorer mental health outcomes for the most disadvantaged children. Figure 4.3 shows the association stratified by SEC measure (individual and area). For studies that reported multiple measures of the associations, each

measure is represented, and these studies are identifiable with a unique colour in the harvest plot. Studies that use a single SEC measure are represented by the grey bars.

Figure (4.3) Harvest plot showing the association between SECs and mental health stratified by SEC measure (number of studies =15)



Association between SECs and CBCL outcomes

The breakdown of associations between SECs and CBCL outcomes is displayed in Table (4.3). Of the six studies using the CBCL, three studies reported a significant association (Bor et al., 1997; Rijilarsdam et al., 2012; Rutherford et al., 2019). For instance, Rutherford et al., (2019) found that the most disadvantaged children had scores for externalising behaviour problems 45 percentage points higher compared to the less disadvantaged children at 4.5 years of age. Both Bor et al., (1997) and Rijilarsdam et al., (2012) found associations between SECs and externalising and internalising behaviour problems, whereas Rutherford et al., (2019) reported only finding association between SECs and externalising behaviour problems. All of the studies reporting on CBCL used individual-level measures of SECs except Rutherford et al., (2019) which also reports on an area-level measure of SECs. Area-level deprivation was associated with externalising behaviours but not internalising behaviours (Rutherford et al., 2019).

Association between SECs and SDQ outcomes

All of the included studies showed an association between individual and/or area-level measures of SECs and SDQ total score, whereby, the most disadvantaged children had poorer mental health. Inequalities in SDQ outcomes were evident as early as two years of age (D'Souza et al., 2019a). Most strikingly, D'Souza et al (2019a), reported that children with mothers with no secondary education were eight times more likely to have an abnormal range score compared to children from mothers with a degree level of education. Identified studies that report associations between SECs and subscale measures of the SDQ (for example, peer and conduct problems) are also displayed in table (4.3). Furthermore, Davis et al. (2010) explored the relationship between SECs and SDQ outcomes as reported by parent and teachers. The strength of association between SECs and total difficulties differs when reported by the parent (OR 2.4) and the teacher (OR 2.0). This suggests that associations and their corresponding strengths between SECs and mental health may vary by outcome respondent but are broadly consistent.

Association between SECs and other outcome measures

Four of the identified studies reported on the association between SECs and mental health using other outcome measures. Two studies (Palmer et al., 2013; Palmer et al., 2018) used the BITSEA to demonstrate that poorer SECs were significantly associated with increased odds ratios for social-emotional problems as early as one year of age. However, caution is needed as the reported associations are derived from the same study sample. These studies highlighted that associations may vary by the measure of SEC used when the sample is stratified by race. Green et al., (2017) and Thomson et al., (2017) both used latent-classes to develop risk profiles of social-emotional problems. Both studies reported that by age 5 years, the most disadvantaged children had higher odds of belonging to the most 'at-risk' profile of social-emotional development.

Effect Sizes

Twelve out of the fifteen included studies reported an association between socioeconomic conditions and mental health outcomes, whereby, the most disadvantaged children had worse mental health outcomes. As shown in Table 4.3, studies across high-income countries reporting on multiple measures of early child mental health reported different effect sizes but they were small to moderate with reported odds ratios ranging between 1.4 (Davis et al., 2010) – 4.5 (Thomson et al., 2017). This finding supports a previous a review exploring this association in children and adolescents, which found that disadvantaged children were two-to-three times more likely to have a mental health problem (Reiss, 2013). There is reliable evidence that the low to moderate effect size for the association is similar across mental health outcome measures and geographical locations. Palmer et al., (2013) in a USA sample

found that low maternal education was associated with increased risk of socio-emotional problems (OR 1.9) using the BITSEA. In an Australian sample using the SDQ, Davis et al., (2010) found that children of mothers with low maternal education were twice as likely to have socio-emotional difficulties (OR 2.4).

Overall, there is reliable evidence to suggest that the socioeconomic disadvantage can negatively impact a child's social-emotional health and that these effect sizes are likely to have impacts at a population-level (Thomson et al., 2017; Davis et al., 2010). Studies also show that effects sizes may differ by the measure of socioeconomic disadvantage used. (Davis et al., 2010; Rijilaarsdam et al., 2012; Rutherford et al., 2019) found that the effect size was larger when using household income, whereas D'Souza et al., (2019a, 2019b), found a higher risk for mental health problems when using maternal education compared to unemployment or area-level deprivation. Furthermore, Palmer et al, (2013) found differences in the association between both income and education measures of SECs by race. Low maternal education was associated with higher odds for social emotional problems in Black children but not for White children, whereas low income was associated with higher odds ratios for White children but not Black children. Whilst this may suggest a differing role of SEC measures in the risk of mental health outcomes, effect sizes remained comparable across outcomes and study location.

Caution must be exercised in interpreting effect sizes as they may be handled differently in analysis and adjust for different confounding measures effects (see Table 4.2 - 4.3). For example, Najman et al., (2005), found no association between SECs and internalising or externalising behaviour problems scores, however, all socio-demographic variables (e.g., partner changes, education, poverty, partner arrested) were adjusted for in the analysis. It is possible this approach is an over-adjustment and measures (e.g., whether a partner has been arrested or change in household composition) could be on the causal pathway. Consequently, the included studies suggest possible mechanisms which may explain the association between socioeconomic disadvantage and child mental health.

Studies strongly suggested that maternal mental health is a risk factor and potential mediator of the association between SECs and child mental health problems (Bor et al., 1997; Najman et al., 2005; Rijilaarsdam et al., 2012; Palmer et al., 2013; Green et al., 2017; Hetherington et al., 2018; Palmer et al., 2018; Rutherford et al., 2019). However, Flouri et al., (2012) found that the association was only slightly attenuated when accounting for maternal mental health with an independent effect remaining. Maternal stress was also identified as a possible risk factor (Palmer et al., 2013; Palmer et al., 2018; D'Souza et al., 2019a). Additionally, D'Souza et al. (2019a) found that perceived maternal stress during pregnancy was the only prenatal factor associated with later child mental health problems whilst only moderate-severe postnatal stress was associated with emotional and hyperactivity scores. Palmer et al., (2013) found that Black mothers were more likely to experience variable mood and energy with higher

cyclothymic scores compared with White mothers who had a more pessimistic mood and higher dysthymic scores. Consequently, this may influence parent-infant interactions to support healthy social-emotional development. Parenting quality and home environment were identified as possible protective factors which reduced the effect of social disadvantage (D'Souza et al., 2019b; Rijilaarsdam et al., 2012). The included studies show that there are possible social, family and environmental factors that may explain the association between SECs and child mental health outcomes. However, the effect of social disadvantage is still harmful to a child's healthy development.

In conclusion, the study findings indicated that socioeconomic disadvantage increased the risk of later mental health problems in children, but, overall, study results were not homogenous.

4.5: Discussion

Summary of main results

In this systematic review of longitudinal observational studies from high income countries, consistent evidence for an association between socioeconomic conditions and mental health outcomes in preschool-aged children (defined as 0-5 years) was identified. In total, 12 out of the 15 studies identified reported differences in mental health by SECs, whereby, children from the most disadvantaged environments were more likely to have a mental health problem (social-emotional, internalising or externalising behaviour problem) compared to the least disadvantaged children. Overall, 82% of socioeconomic measures reported were significantly associated with child mental health outcomes.

Overall completeness and quality of evidence

Quality and generalisability of evidence

The majority of studies (n=12) included in this review were graded as medium quality and three studies were deemed high quality. The generalisability of the review findings may be affected by the study population setting with just under half of the included studies (n=7) conducted in Oceania. The review only included studies conducted within OECD countries, where socioeconomic conditions are broadly similar.

Measurement of SECs

There is evidence to indicate that inequalities in child mental health outcomes can be identified on the basis of both area and individual-level measures of SECs. This review identified studies that used a range of measures of SECs. The review highlights that income and education were the most commonly

utilised measures and predominantly showed the same pattern of association across a range of OECD countries. Measures such as employment status and composite indexes were underrepresented in assessing the association between SECs and child mental health outcomes.

There were differences in how SEC measures are accounted for in statistical analysis. The review sought to identify the impact of SECs and child mental health outcomes from observational studies, therefore appropriately confounder-adjusted estimates were sought. Most of the studies identified reported unadjusted (univariate associations) but in some cases adjusted coefficients were reported. This issue could lead to bias, most likely to underestimate the impact of SECs on mental health outcomes. (Westerich & Greenland, 2013; Bandoli et al., 2018). To account for this, potentially over-adjusted estimates were penalised within the quality assessment.

Measurement of mental health

This review highlights variation in how child mental health is assessed and reported in the preschool-age population even when the same assessment tool is used. There are a growing number of tools available to researchers and clinicians and these measures are likely to diversify further. A review identified 75 measures of child social and emotional development in early childhood (0-5 years) and that six assessment tools were strongly recommended for use, including the Child Behaviour Checklist and Infant-Toddler Social Emotional Assessment (Halle et al, 2018). Whilst this study only included validated measures, studies of child mental health should ensure that validated measures are used and that where possible, all outcomes are reported on.

Furthermore, to ensure the quality of evidence available in early years period, all mental health measures used must be developmentally appropriate, reliable, valid, accessible and robust yet there are limited measures available to use in children aged up to two years (MacCrae & Brown, 2017). The studies reviewed here mainly use the BITSEA, SDQ preschool version, and preschool CBCL which are high quality and well validated examples (Gridley et al., 2019). It is common for studies of early childhood mental health to utilise parent-reported questionnaire measures, rather than clinician rated interviews, as they are easier to access, cost-effective, and are a reliable method of assessment within large-scale studies for young children (0-5 years) (Gridley et al., 2019). However, as shown within this systematic review, there is large variation within how a well-established measure such as the CBCL is used. Consequently, without a clear and standardised approach to assessing and reporting mental health outcomes, efforts to directly compare findings across studies are hampered and this may mean that efforts to build a coherent evidence base to justify the introduction and targeting of effective early interventions may be frustrated. In future, early years studies should pay special attention to

measurement issues and to previous recommendations based on psychometric pedigree for measure selection (Gridley et al 2019).

Age & Sex

Although, there were 15 studies included across the whole preschool period, there were only four in the first two years of life. The review found evidence of inequalities in child mental health as early as one year of age in one study. Early identification of children on the pathway to mental health problems and inequalities in outcomes is vital. However, this has previously been challenging due to the lack of studies specifically examining this issue in very young children (Ravens-Sieber et al., 2008). Rijilaarsdam et al. (2012) found that low income was associated with higher scores for externalising behaviour problems (β 0.10, $p<0.001$) and internalising behaviour problems (β 0.25, $p<0.001$) at 1.5 years of age. However, replication of these studies in early infancy and toddlerhood is required since only four studies reported on outcomes age 2 years and under. (D'Souza 2019a, Palmer 2013, Palmer 2018, Rijilarsdam et al., 2012).

The review could not distinguish if associations between SECs and child mental health outcomes varied by sex as only one study (Thomson et al., 2017) explicitly examined a SECs by sex interaction. Thomson et al (2017) found that boys were more likely to experience higher levels of social emotional problems particularly for aggression and hyperactivity. Future studies should look to explore any SECs by sex interactions in early child mental health problems.

Agreements and disagreements with other studies or reviews

Previously, a systematic review reported consistent evidence for associations between poorer SECs and poorer child and adolescent mental health in school age children (5-18 years) (Reiss, 2013). The review presented in this chapter summarised data from studies reporting on outcomes from as early as one year of age to five years of age. This review therefore extends the findings from Reiss (2013) providing evidence that social inequalities in child mental health outcomes are evident in infancy and toddlerhood. For example, Palmer (2013) found that the most disadvantaged children were three times more likely (OR 3.4) to have a social emotional problem at 1 year of age.

Limitations and strengths

Owing to heterogeneity in the outcome measures used it was not feasible to conduct a meta-analysis to synthesise and pool an estimate of the association between SECs and mental health outcomes, which could then have been stratified by key developmental periods. Furthermore, owing to the variation in how each study reported and presented their results, it was not possible to consistently report on only

baseline confounder adjusted associations. Consequently, the associations presented are either unadjusted, baseline confounder adjusted or fully adjusted coefficients. To help the reader, I have presented all available associations to help with interpretation.

This study is also limited by its inclusion of studies that are only published in the English language. Translation of studies was not feasible due to lack of resources (financial and logistics). Consequently, language bias may have been introduced into the study. This bias could arise due to studies conducted in non-English speaking countries with statistically significant results being more likely to be published in an English language journal compared to those reporting non-significant results. It is possible for a study to have its title and abstract in English, but the full text is only available in its native language. Therefore, if a review only includes English language studies the results and statistical inferences may be biased if estimates have not been examined from overlooked data (CRD, 2008).

However, the review has several strengths. First, it is the first review to summarise evidence for social inequalities in child mental health outcomes in the preschool years, Second, it builds on a previous school-age review by accounting for limitations in the search strategy they used. The Reiss (2013) review broadly searched for mental health outcomes and restricted search terms to "mental health" or "mental disorder". This terminology has limited applicability in studies of infants, toddlers or early childhood. The current review made use of relevant database functions and exploded terms where applicable and included terms as keywords in the search, if necessary. Therefore, the current review utilised age-appropriate terminology, to capture a broader range of studies. Third, multiple systematic search strategies were utilised to yield the best possible results. Relevant databases and grey literature sources were searched. To address the research question, only longitudinal observational studies with a validated measure of mental health were included so as to maximise the quality of the outcome measure assessed. Only including studies conducted in OECD member countries, where active policies addressing and monitoring poverty, also adds to the robustness of results identified.

Implications for policy, practice and research

In this chapter, I have systematically reviewed the current evidence to show that social inequalities in child mental health are evident within a preschool-age population in high income countries. There was moderate to high quality evidence showing the existence of inequalities in mental health outcomes already evident in the early preschool years. These findings underscore the importance of directing policies and interventions to appropriate early entry points in the life-course in order to better address the emergence of such early inequalities in child mental health.

Recent policy shifts are in line with the findings of this review and give greater attention to the importance of the early-years period, with recognition and emphasis placed on early intervention (DoH,

2013; DoH 2015). Recommendations highlight providing greater support and services to disadvantaged families particularly before pregnancy and with more action in the early years period, for example, increased health care professional visits during the first three years of life (CMO 2013; DoH 2017). This approach could potentially help identify families in need of intervention and help improve factors such as parental mental health problems, parenting, insecure infant attachment and exposure to adverse childhood experiences that mediate the relationship between SECs and mental health outcomes, thereby reducing the risk of child mental health problems over time and reducing inequalities (Straatman et al., 2019; Deighton et al., 2019; Hope et al., 2018).

While policy action on mediating factors, for example, parental mental health is needed, efforts to reduce child mental health problems will be hindered unless the wider social determinants of mental health are addressed. The updated Marmot review highlights that although action has been taken on reducing health inequalities over the last ten years, there is worrying evidence that efforts to help give every child the best start in life have stalled (Institute of Health Equity, 2020). Over the last ten years, child poverty rates have risen and essential funding to children centres has been cut, particularly, in the most disadvantaged areas. The results in this chapter corroborate proposals suggested in the Marmot review recommending enhanced efforts to reduce child poverty rates in order to address inequalities in child mental health problems. Investment in the early years and provision of high-quality early years services are likely to lead to a reduction in child mental health problems at a population level, however, inequalities will persist without action to address the wider social determinants of health outcomes (Institute of Health Equity, 2020).

In summary, the findings of this chapter show that social inequalities in mental health are quite consistently evident within a preschool-age population. Associations between SECs and child mental health outcomes may be explained or mediated by factors, such as parental mental health (Lai et al., 2020) and that there may be differing trajectories of mental health through childhood on the basis of socioeconomic conditions (Mazza et al., 2016). These hypotheses will be tested further in studies 2 and 3.

Chapter 5

Results: Study 2

Assessing the impact of socioeconomic conditions (SECs) on longitudinal trajectories of child behavioural and emotional problems: Findings from the Wirral Child Health and Development Study

5.1: Abstract

Background

Socioeconomic disadvantage is a well-established risk factor for child mental health problems. Little is known about when inequalities in mental health outcomes are established in childhood and whether these inequalities widen or narrow with age. Furthermore, few studies have utilised a measure of socioeconomic conditions measured in pregnancy to assess trajectories of child mental health. This study assessed the impact of childhood socioeconomic conditions (SECs) on early life longitudinal trajectories of mental health outcomes from ages 3.5 to 9 years. I explored whether any inequalities in emotional and behavioural problems increased or decreased over time and assessed whether effects were moderated by sex.

Methods

Longitudinal analysis of data from the Wirral Child Health and Development Study (WCHADS), a prospective study of the early origins of child mental health (n=1233), in the North West of England. Household income at 20-weeks gestation, a measure of socioeconomic conditions (SECs) in pregnancy, was the main exposure measure. The outcome measure was longitudinal trajectory of child externalising and internalising problems, as measured by the Child Behaviour Checklist at 3.5, 4.5, 7 and 9 years of age. Linear mixed effects models were used to assess the association of household income with longitudinal mental health outcomes, assessing the intercept term at 3.5 years and the rate of change over time, whilst adjusting for potential confounders.

Results

Average log-transformed CBCL scores were higher for externalising problems than internalising problems in the sample at age 3.5 years. Child mental health improved over time, with scores for both externalising and internalising problems decreasing over time, with a greater decrease for externalising behaviour problems. There was no significant difference in scores for internalising or externalising problems by childhood SECs at age 3.5 years. However, the rate of improvement for both externalising and internalising problem scores over time was slower for the most disadvantaged children compared to the least disadvantaged, increasing inequalities over time. Each year the gap in log-transformed CBCL score between children at the top and bottom of the income distribution increased by 0.10 points (95% CI 0.03 to 0.15) for externalising behaviour problems score and 0.06 for internalising behaviour problems score (95% CI 0.02 to 0.20).

Male sex was associated with an increased log-transformed CBCL score of 0.11 for externalising behaviour problems at 3.5 years, but there was no such association between sex and internalising problems. There was no significant association of sex with the rate of change of CBCL score over time (slope term), or any interaction with income, indicating that the association of income and the rate of change in externalising and internalising scores did not differ by sex.

Conclusion

Whilst scores for internalising and externalising behaviour problems steadily decrease with age between the age of 3.5 and 9 years, the rate of improvement is slower for the most disadvantaged children, with increasing inequalities in child mental health up to the age of 9 years. These findings underscore the importance of directing policies and interventions earlier in the life course to better address the early origins of inequalities in child mental health.

5.2: Introduction

In this chapter, I will present the results from a longitudinal analysis assessing the impact of childhood SECs on trajectories of behavioural and emotional problems. I will discuss the implications of the findings for future research, and the public health implications of this improved understanding of the relationship between SECs and longitudinal trajectories of child mental health. The systematic review (Chapter 4) identified very few studies which explored trajectories of early child mental health with an emphasis on social inequalities. This chapter addresses this issue by assessing the impact of SECs on longitudinal trajectories of internalising and externalising behaviour problems from 3.5 to 9 years of age using data from the Wirral Child Health and Development Study.

Child mental health is poor in the UK and there is growing concern over the rising prevalence of mental health problems in children and young people (Collishaw et al., 2018; Institute of Health Equity, 2020). In the UK, the most recent official survey of mental health in children and young people found that one in six children (16%) had a probable mental health disorder (NHS Digital, 2020). Rates have increased since 2016, when one in eight children and young people were identified to have a clinically diagnosed mental health problem (NHS Digital, 2017). Furthermore, the prevalence of mental health problems in preschool age (2-4 years) children was reported for the first time in 2016, with 5.5% of children having at least one mental health disorder (NHS Digital, 2017).

Addressing and preventing the emergence of child mental health problems in the early years of a child's life is a public health priority (Marmot, 2020). In high income countries there has been an epidemiological transition, whereby, mental health problems have overtaken infectious diseases as the

leading contributor to disability adjusted life-years lost (DALYs) in the Global Burden of Disease (GBD) index (Baranne & Falissard, 2018). Experiencing a mental health problem in childhood can have adverse effects on educational attainment, physical health and mental health later in life (Taylor-Robinson et al., 2019; Pearce et al., 2020).

Socioeconomic disadvantage is a well-established risk factor for developing mental health problems. Disadvantaged children are more likely to be exposed to psychological and biological risk factors that lead to the early development of mental health problems (Pickett & Wilson, 2015; Ravens-Sieber et al., 2008; Essex et al., 2006; Tennant et al., 2007; Wille et al., 2008). For example, there has been a growth in literature on the role of early exposure to adverse childhood experiences (ACEs), such as, parental mental health, domestic violence and abuse. Over half of children in the UK experience one or more ACEs in the preschool years, with the most disadvantaged children having greater risk of exposure to, and experiencing multiple ACEs and, consequently, poorer health outcomes (Straatman et al., 2020).

Social inequalities in mental health are established in childhood and have been shown to track through into adulthood (Viner et al., 2012; Arango et al., 2018). As identified in the systematic review (Chapter 4), there has been a growth in literature assessing the relationship between socioeconomic disadvantage and mental health outcomes in childhood, however, few studies explore social inequalities in trajectories of mental health across the early years.

Predominantly, research on child and adolescent mental health trajectories have explored changes in behavioural and emotional profiles through key development phases (i.e., childhood into adolescence) and whether trajectories vary by sex (Odgers et al., 2008; Petersen et al., 2015; Murray et al., 2018; de Lijster et al., 2019). For example, Odgers et al., (2008) identified distinct trajectory profiles for antisocial behaviour delineating life-course persistent, adolescent-onset, childhood-limited and low trajectory groups.

Currently, there is limited and mixed evidence as to when early inequalities in child mental health are established and whether inequalities in trajectories widen or narrow across childhood. Bayer et al., (2008) in a population-based study of 585 children in Australia found that household income (measured at 7 months postnatally) was not associated with changes in externalising or internalising behaviour scores from 1.5 to 3 years of age. Contrastingly, D'Souza (2019) found in a sample of 5896 New Zealand children, that the most disadvantaged children (defined by low maternal education) were more likely to have persistent mental health problems between 2 and 4.5 years of age, compared to the least disadvantaged children. Furthermore, Mazza et al., (2016) demonstrated in a sample of 2045 Canadian children that exposure to poverty influenced longitudinal trajectories for hyperactivity, opposition and

physical aggression behaviour profiles. Children that were exposed to persistent poverty had higher levels of these symptom profiles from age 1.5 to 5 years of age, before a much slower rate of decline through to eight years of age compared to children who were not exposed to poverty (Mazza et al., 2016).

Since inequalities in health outcomes are preventable and amenable to policy intervention, it is vital that the identification of children on the emerging pathway to mental health problems is made as early as possible in the lifecourse. The study presented in this chapter extends what is known from previous literature and will add to our understanding of the role SECs play in longitudinal trajectories of children's mental health across the early years. This study will build on existing literature by using a measure of socioeconomic conditions captured in the pre-natal period.

5.3: Methods

Data, Design and Setting

This study used data from a prospective longitudinal cohort study of children born on the Wirral, in the North West of England. The Wirral Child Health and Development Study (WCHADS) recruited 1286 participants consecutively from first-time mothers who booked for antenatal care between February 2007 and October 2008 at the Wirral University Teaching Hospital. Of these, 1233 gave birth to live singleton infants and were eligible for postnatal follow-up. Due to the socio-demographic composition of the Wirral, 41.7% of the sample were living in conditions equivalent to the most deprived quintile of deprivation in the UK at recruitment, using the English Index of Multiple Deprivation (IMD 2004) (Noble et al., 2004).

This study was granted ethical approvals by the Cheshire North and West Research Ethics Committee [REF: 05/Q1506/107 (June 2006); 10/H1010/4 (June 2010); 14/NW/1484 (December 2014)]. This study involved secondary analysis of anonymised data and did not require further ethical approval.

Outcome

The Child Behaviour Checklist (CBCL) is an internationally well-established and validated measure of preschool and school-aged children's behaviours (Achenbach, 1991). This study uses internalising and externalising behaviour composite scales measured at 3.5, 4.5, 7 and 9 years of age. Internalising problems are derived from combining the anxious/depressed, emotionally reactive, withdrawn and somatic complaints scores, and externalising problems by combining aggressive behaviour and attention problem scores (Achenbach, 1991). Owing to the longitudinal nature of this study, two

versions of the CBCL were used, the preschool version (CBCL 1.5-5) and the school-aged version (CBCL 6-18). Whilst many of the items overlap, there are some different items that contribute to the internalising problem and externalising problem scales at the preschool and school age time points, so as to ensure each measure is developmentally appropriate. This study used parent-reported (primarily mother reports) on the CBCL at all outcome points. Total raw scores, which are unadjusted for age and sex, for the internalising and externalising problems scales were used (Achenbach & Rescorla, 2000; Rutherford et al., 2019). Due to the outcome being positively skewed, the total scores were log-transformed for the analysis following our previous study using these data (Rutherford et al., 2019), and log-total CBCL internalising and externalising scores were analysed as continuous outcomes.

Exposure

The primary exposure measure to capture childhood socioeconomic conditions (SECs) used in this study was annual household income, measured at 20-weeks gestation (recruitment into the study). Participants were asked to report on the question "What is your approximate annual family income?" Responses were reported in £10,000 incremental bands (Range: Up to £10,000 – Over £71,000). Income was treated as both continuous and categorical in exploratory analysis, with the highest income band (Over £71,000) coded as the reference group. The main analyses used income as a continuous measure, with each incremental unit associated with an increase or decrease in the outcome measure score. The analysis also estimates the inequalities gap in mental health outcomes between the least (Over £71,000, n=60) and most deprived (Up to £10,000, n=59) households.

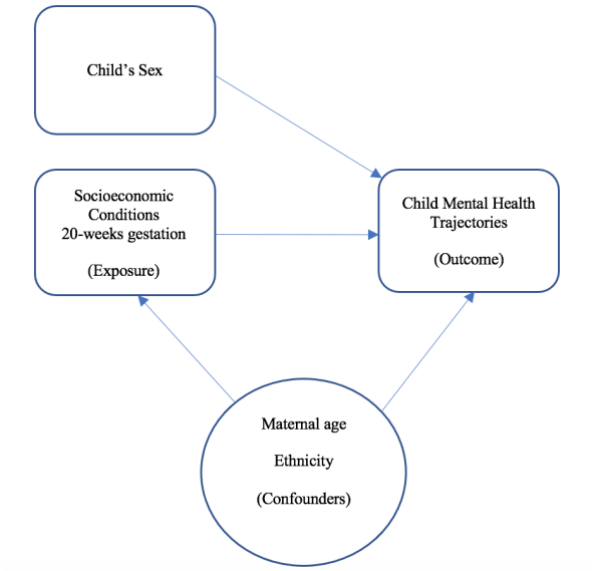
Confounders

Demographic characteristics potentially associated with child social-emotional and behaviour problems are included as baseline variables in the analysis: Maternal age at consent into the study (coded as 18-24, 25-34 and 35+); child's sex and ethnicity. As only 2.9% of the WCHADS sample identified as being other than White-British, the ethnicity variable was dichotomised to 'White-British' or 'Other'.

Analysis Strategy

The hypothesised association between SECs and longitudinal trajectories of mental health outcomes investigated in this study are shown in a directed acyclic graph (Figure 5.1). The analysis then progressed in two steps, an exploratory descriptive analysis which informed fitting linear mixed effects models to the data. A hierarchical approach was used for model building (Table 5.1).

Figure (5.1) DAG for the relationship between exposure, outcome and confounders assessed in this study.



First, I fitted a linear mixed effects model with a linear trend in time, as indicated by the descriptive analysis. Then my main exposure measure, household income, was added to the model as a continuous variable. To test my main hypotheses as to whether income was associated with both the average level of log-internalising and externalising CBCL subscale scores and also the rate of change over time, a time by exposure interaction was added. In the next step, I further adjusted for baseline demographic variables and confounders: maternal age at recruitment into the study, child sex and ethnicity. Additionally, to assess whether trajectories for CBCL scores differed by sex, I formally tested for a child age by sex interaction and a three-way interaction between child age, sex and income (Appendix 5). I estimated all model parameters by maximum likelihood. I compared nested models using generalised likelihood ratio statistics and Wald statistics to test hypotheses about model parameters.

To aid with interpretation, coefficients are also presented for the socioeconomic (SEC) gap. The socioeconomic gap measures health inequalities between the most and least deprived groups. It is an important tool as often population averages overlook differences in health between groups. This approach has been used in previous studies of health inequalities in social epidemiology (Graham 2004; Taylor-Robinson et al., 2016). Furthermore, coefficients from the final model are plotted to show trajectories for log-transformed internalising and externalising behaviours for the least and most disadvantaged children (the socioeconomic gap). Analyses were conducted in statistical software R version (3.5).

Table 5.1: Sequential models showing analytical approach

Model	Variables
1 (Time effects)	Age
2 (Exposure)	Model 1+ Income
3 (Interaction)	Model 2 + Age*Income
4 (Confounders)	Model 3 + Maternal Age + Sex + Ethnicity

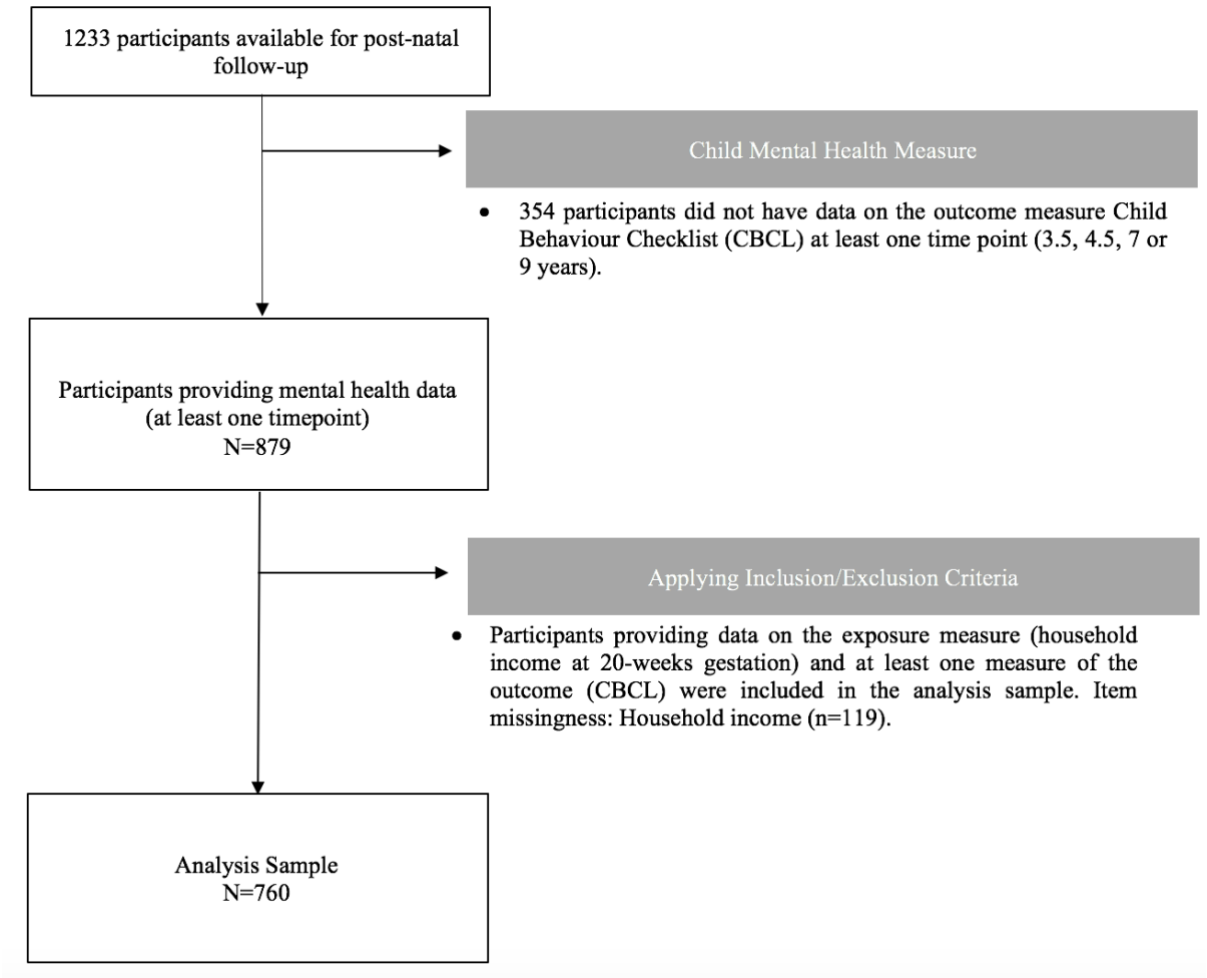
Robustness Tests

I undertook a number of robustness tests. First, I repeated the analysis with child's age modelled as a quadratic function and also treating income as categorical function. Furthermore, I repeated the analysis using the index of multiple deprivation (IMD) as an alternative measure of socioeconomic conditions. Owing to differences in the wording of items, items reported and subsequent composition of internalising and externalising domains across the preschool and school-aged CBCL versions, I also repeated the analysis using CBCL scores standardised as z-scores to check the pattern of results was the same (Appendix 5).

5.4: Results

Overall, 1233 study participants were available for post-natal follow-up. Participants were included in the analysis sample if data were provided on exposure, confounder and outcome (at least one time point) measures (Figure 5.2). The final sample for analysis was 760 with data available.

Figure (5.2) Flowchart of inclusion into the analysis sample.



Exploratory Descriptive Data Analyses

Table (5.2) shows child mental health and demographic characteristics of the analysis sample stratified by household income. There were descriptive differences in mean and median scores for externalising and internalising behaviour problems across the income range. This cross-sectional summary of the distribution of the data suggests that there is no difference in mental health outcome scores by household income at 3.5 years, but differences can be observed at 9 years of age. Furthermore, mean scores for externalising and internalising CBCL scores reduce over time and that by age 9 years, children had higher scores for internalising problems. Only 3.6% of the sample identified their ethnicity as 'Other'. Higher maternal age (>35 years) was more common in the higher household income groups.

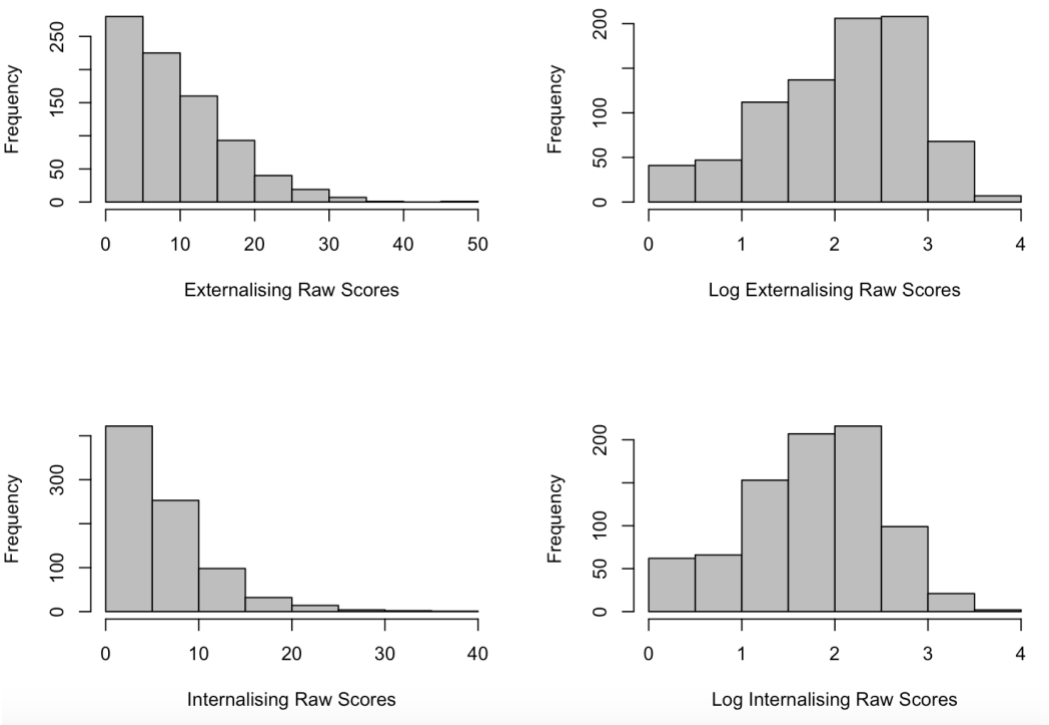
Table (5.2) Child mental health and demographic characteristics of study population by household income

	Whole sample	Up to £10,000	£10-20,000	£21-30,000	£31-40,000	£41-50,000	£51-60,000	£61-70,000	Over £71,000
Subjects (n)	760	59	92	117	148	126	109	49	60
CBCL Age 3.5									
Externalising Raw Score	8 (0-46)	8 (0-32)	9 (0-28)	7 (0-46)	8 (0-38)	8 (0-35)	8 (0-30)	9 (0-30)	9 (0-30)
Internalising Raw Score	5 (0-40)	5 (0-25)	5 (0-27)	6 (0-40)	5 (0-29)	6 (0-26)	5 (0-31)	5 (0-31)	5 (0-19)
Log-Externalising Raw Score	2.06 (0.84)	2.00 (0.85)	2.04 (0.88)	2.02 (0.86)	2.10 (0.79)	1.99 (0.93)	2.09 (0.79)	2.06 (0.89)	2.16 (0.81)
Log-Internalising Raw Score	1.74 (0.79)	1.72 (0.78)	1.67 (0.80)	1.80 (0.82)	1.75 (0.74)	1.74 (0.80)	1.73 (0.83)	1.65 (0.80)	1.80 (0.88)
CBCL Age 4.5									
Externalising Raw Score	7 (0-46)	8 (0-35)	9 (0-38)	5 (0-34)	5 (0-34)	7 (0-30)	6 (0-28)	6 (0-23)	5 (0-36)
Internalising Raw Score	5 (0-55)	7 (0-23)	7 (0-36)	4 (0-36)	4 (0-26)	6 (0-26)	5 (0-35)	4 (0-21)	5 (0-21)
Log- Externalising Raw Score	1.88 (0.91)	2.08 (0.89)	2.17 (0.87)	1.75 (0.88)	1.62 (0.87)	1.80 (0.96)	1.82 (0.85)	1.94 (0.67)	1.65 (0.87)
Log-Internalising Raw Score	1.73 (0.83)	2.01 (0.66)	1.89 (0.84)	1.52 (0.89)	1.50 (0.83)	1.78 (0.76)	1.79 (0.73)	1.63 (0.76)	1.52 (0.79)
CBCL Age 7									
Externalising Raw Score	4 (0-39)	8 (0-30)	5 (0-34)	4 (0-25)	3 (0-28)	4 (0.28)	3 (0-27)	4 (0-14)	3 (0-27)
Internalising Raw Score	4 (0-46)	5 (0-46)	5 (0-29)	4 (0-22)	3 (0-28)	4 (0-22)	4 (0-27)	3 (0-11)	4 (0-21)
Log-Externalising Raw Score	1.51 (0.88)	1.93 (0.90)	1.63 (0.83)	1.50 (0.88)	1.24 (0.84)	1.48 (0.81)	1.35 (0.89)	1.41 (0.76)	1.32 (0.89)
Log-Internalising Raw Score	1.53 (0.81)	1.82 (0.84)	1.65 (0.87)	142 (0.81)	1.36 (0.81)	1.57 (0.79)	1.57 (0.76)	1.34 (0.73)	1.39 (0.80)
CBCL Age 9									
Externalising Raw Score	3 (0-34)	5 (0-28)	4 (0-30)	3 (0-22)	2 (0-17)	2 (0-21)	2 (0-27)	2 (0-14)	2 (0-16)
Internalising Raw Score	4 (0-47)	6 (0-47)	5 (0-26)	4 (0-42)	4 (0-18)	5 (0-34)	3 (0-31)	3 (0-13)	2 (0-26)
Log-Externalising Raw Score	1.35 (0.94)	1.69 (1.00)	1.44 (0.99)	1.32 (0.89)	1.20 (0.83)	1.30 (0.89)	1.16 (0.91)	1.11 (0.86)	1.20 (0.86)
Log-Internalising Raw Score	1.58 (0.84)	1.82 (0.91)	1.64 (0.89)	1.57 (0.90)	1.46 (0.77)	1.67 (0.79)	1.51 (0.77)	1.38 (0.62)	1.27 (0.81)
Maternal age years n (%)									
18-24	193 (25.5)	48 (81.4)	52 (56.5)	47 (40.2)	34 (23.1)	8 (6.3)	2 (1.9)	2 (4.1)	0 (0.0)
25-34	461 (60.8)	8 (13.6)	36 (39.1)	59 (50.4)	91 (61.9)	105 (83.3)	83 (76.9)	36 (73.5)	43 (71.7)
35+	104 (13.7)	3 (5.1)	4 (4.3)	11 (9.4)	22 (15.0)	13 (10.3)	23 (21.3)	11 (22.4)	17 (28.3)
Child's ethnicity: other (%)	27 (3.6)	2 (3.4)	4 (4.3)	4 (3.4)	8 (5.4)	5 (4.0)	2 (1.8)	1 (2.0)	1 (1.7)

Child's sex: female (%)	401 (52.8)	34 (57.6)	57 (62.0)	67 (57.3)	70 (47.3)	62 (49.2)	58 (53.2)	17 (34.7)	34 (56.7)

Next, I undertook an exploratory analysis of the longitudinal data in order to visualise the data and explore any visual trends which might inform appropriate statistical methods for handling longitudinal data. First, I visualised the distribution of the CBCL internalising and externalising outcome measures at all timepoints using both the raw and log-transformed data (Figure 5.3). Since the distribution of the raw data for each subscale was significantly skewed the main analysis subsequently used log-transformed CBCL scores.

Figure (5.3) Distribution of CBCL internalising and externalising raw and log-transformed scores at 3.5 years of age.



CBCL Trajectories 3.5 – 9 Years

I used spaghetti plots to visualise trajectories for a random sample of study participants drawn from the data. The population average is also plotted using a mean smoother (blue line) (Singer & Willet, 2003), which visually suggests that modelling child age as a linear function in time is a reasonable assumption for this outcome. This assumption is formally tested later on in the analysis by modelling income as both a linear and quadratic term. This initial descriptive plot suggests that child mental health improves over time, indicated by a decrease in log-externalising scores from 3.5 to 9 years (Figure 5.4).

Figure (5.4) Spaghetti plot for log-Externalising CBCL scores versus child age illustrating the longitudinal nature of the data. Each coloured line represents a random individual in the dataset. The population average is also modelled (blue line).

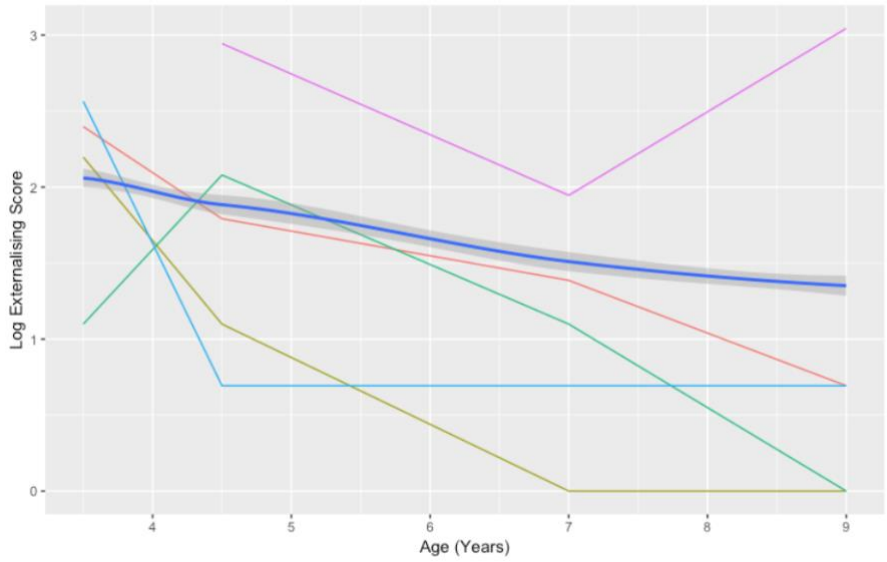
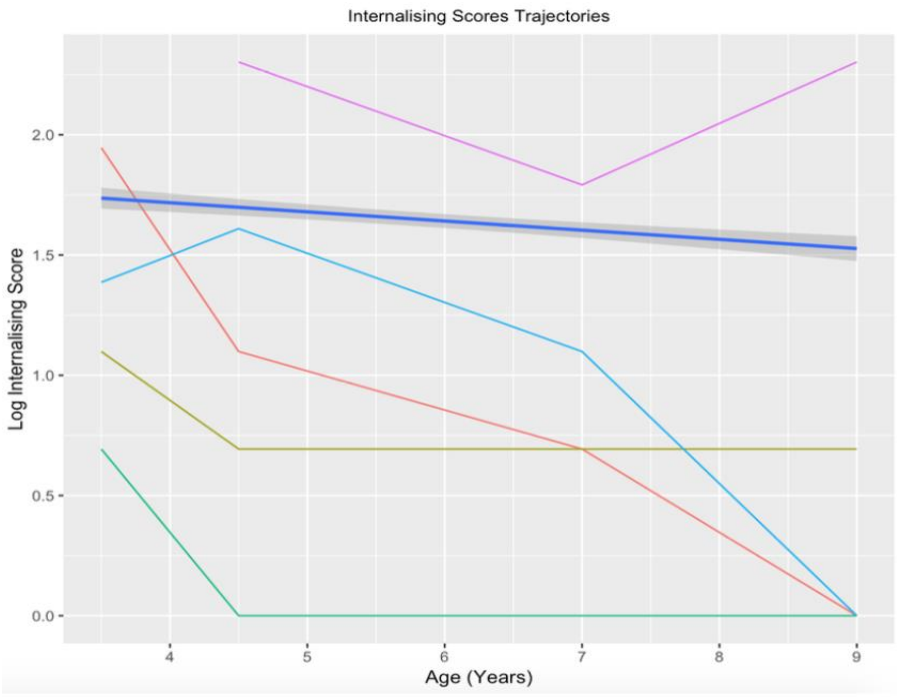


Figure (5.5) shows that for the Wirral population there is a slight decline over time for mean log-CBCL internalising problem scores. There are clear cross-sectional differences between the random sample of study participants and the rate of decline (slope) over time, suggesting that fitting both a random intercept and slope model may be appropriate.

Figure (5.5) Spaghetti plot for log-Internalising CBCL scores versus child age illustrating the longitudinal nature of the data. Each coloured line represents a random individual in the dataset. Population average is also modelled (blue line).



CBCL Trajectories 3.5 – 9 Years by Household Income

Next, I visually explored trends in child mental health outcomes stratified by the exposure measure, household income (Figures 5.6 and 5.7). The plots show the trend in mean scores for log-externalising and log-internalising problems for a child from each level of household income beginning with the intercept at age 3.5 years and showing how scores decline (slope) with age through to 9 years. Visually, there is a social gradient in the trajectories of log-externalising behaviour scores, whereby, the rate of decline (slope) is slower for the lowest income households (pink line) compared with the highest income households (red line). A similar trend is observed for log-internalising behaviour scores, however, visually there is an initial increase for the lowest income households from 3.5 to 4.5 years of age.

Figure (5.6) Log-Externalising CBCL scores over time by household income. Each line represents the population average for each level household income.

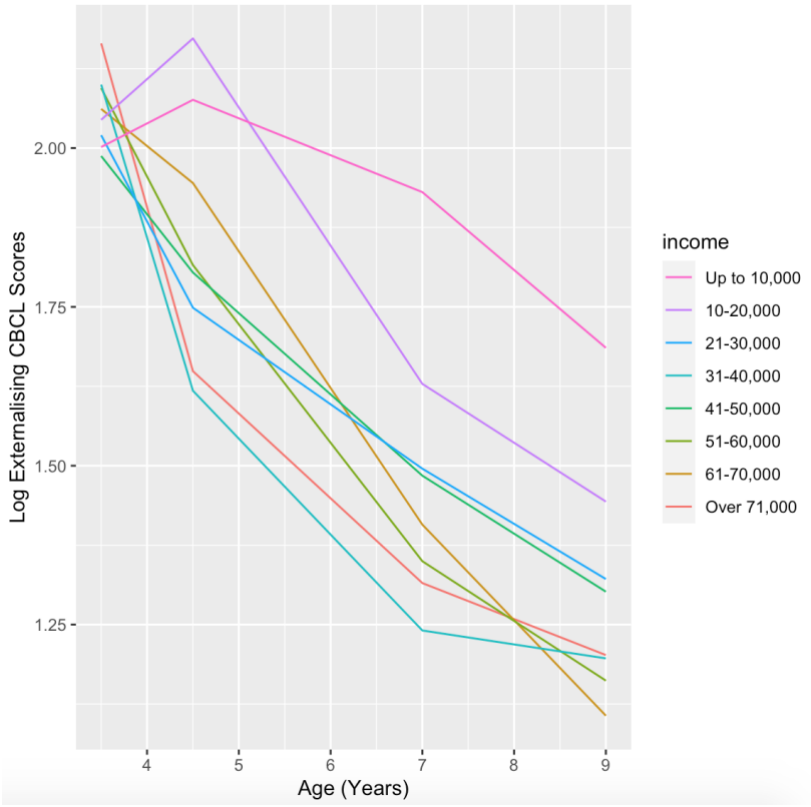
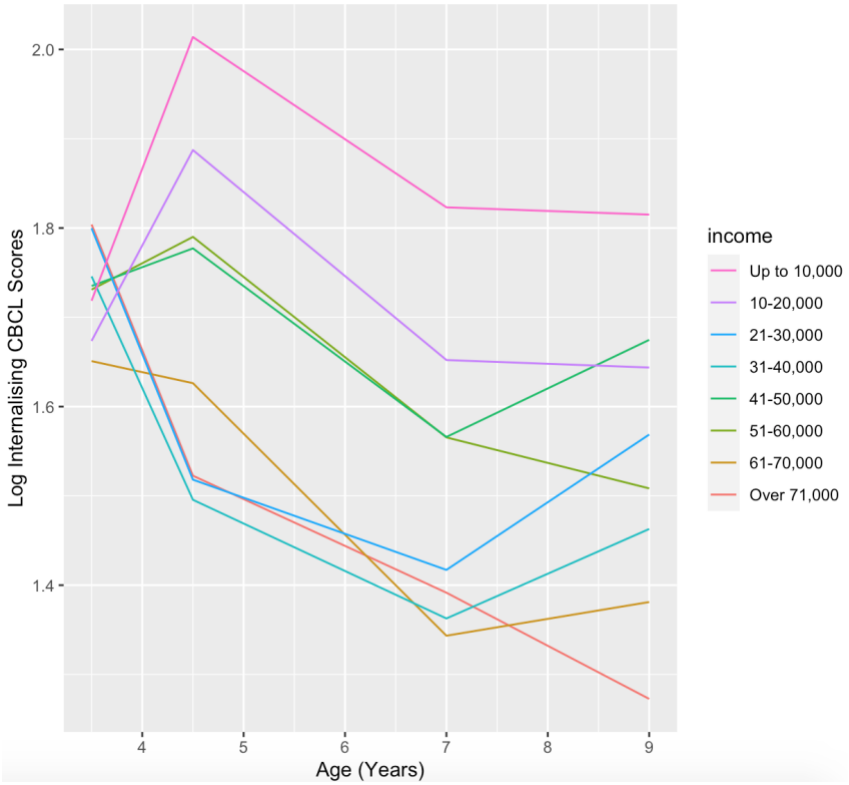
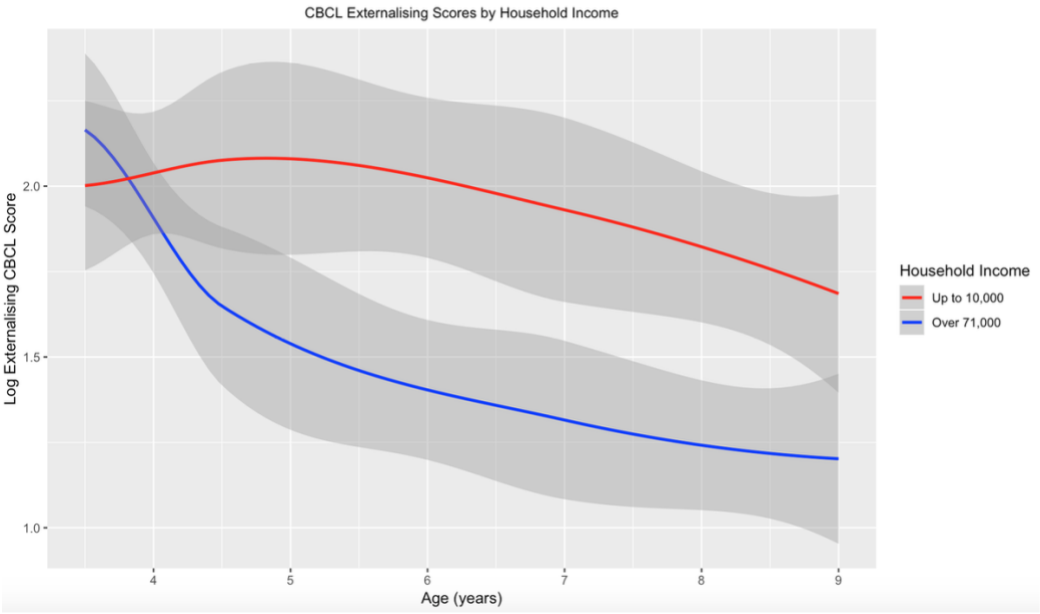


Figure (5.7) Log-Internalising CBCL scores over time by household income. Each line represents the population average for each level household income.



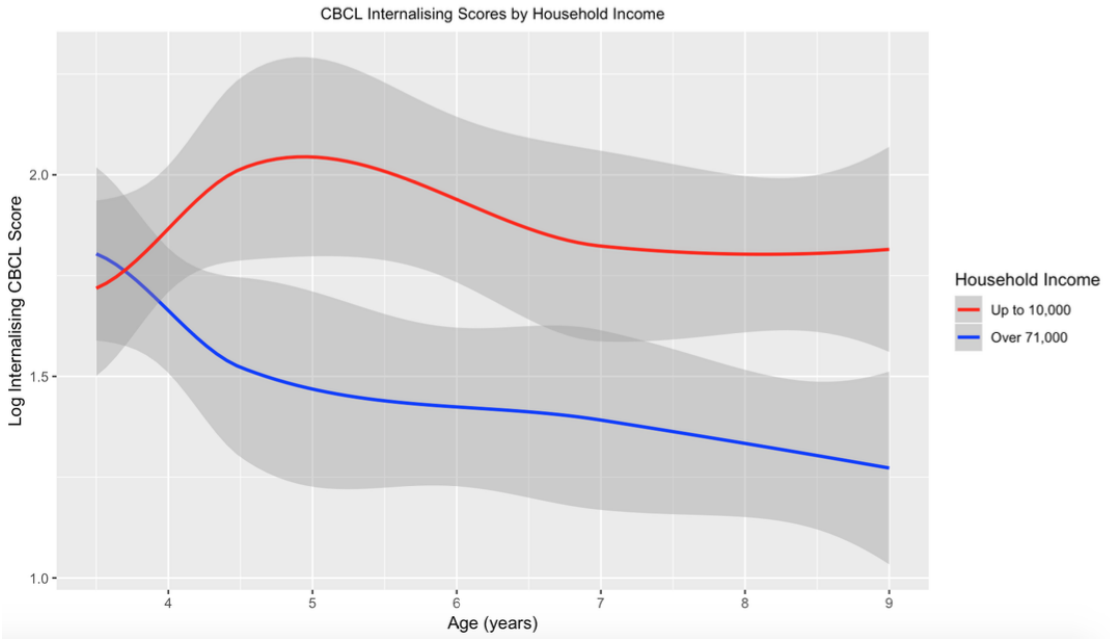
Figures 5.8 and 5.9 show population smoothed mean scores and cross-sectional confidence intervals for externalising and internalising problem scores by contrasting trends over time for the least and most disadvantaged children. Mean scores for the lowest income group (red line) are contrasted to the highest income group (blue). Visualising the trajectories for the extreme groups helps to show the inequalities gap in outcomes over time.

Figure (5.8) displays the trajectories of externalising problems over time by household income.



The exploratory plots have shown that externalising problem scores decrease with age for the whole population. The above plot explores this trend for children from the most disadvantaged (red) and least disadvantaged (blue) households. The plot shows that whilst there is a decline of externalising problems over time for both groups, the trajectories differ. Visually there is a more rapid decline for children from the least deprived households, particularly, between ages 3.5 to 4.5 years. For children from the most deprived households there is an increase in scores between the same age range before starting to decline. The socioeconomic gap between scores is maintained throughout early childhood. The visual trends displayed here are formally tested in a linear mixed effects model.

Figure 5.9 displays the trajectories of internalising problems over time by household income. The exploratory plots show that there is a decrease in internalising problem scores for the study population over time. Visually, the trajectories differ for children from the most and least deprived households.



Figures 5.8 and 5.9 suggest that trajectories of child mental health vary on the basis of income. From the exploratory plots, the data suggests that at the intercept (3.5 years) there is little difference in log-externalising and log-internalising behaviour scores on the basis of household income. However, a gap between the least and most disadvantaged children appears to widen over time. Visually, the data supports modelling and testing for a time by exposure (income) interaction.

Although scores for externalising behaviour problems decline over time for both SEC groups of children, there is visually a large gap between the average scores at different ages (intercept) and the rate of decline (slope). However, these exploratory trajectories do not account for the correlated nature of the longitudinal outcomes. These associations are assessed formally using a linear mixed effects model, taking into account the longitudinal nature of the data.

Furthermore, Figures 5.8 and 5.9 suggest that there may be age-related effects in trajectories of internalising and externalising behaviour problems. For example, scores for children from the most disadvantaged households initially increase for internalising and externalising behaviour problems before decreasing. Previous studies exploring trajectories classes have distinguished separate pathways of development (Murray et al., 2020). Moffitt (1993) has shown evidence of life-course persistent and adolescent limited trajectories of externalising behaviour problems. Visually, figures 5.8 and 5.9 suggest that trajectories may be influenced in specific developmental time periods.

Sensitive periods are developmental time periods when individuals are more receptive to influences from the wider environment during particular developmental stages (Hensch, 2004; Frankenhuis &

Walasek, 2020). Effects that occur during sensitive periods are not fixed or irreversible but are likely to exert greater influence at this time point (Hensch, 2004). Contrastingly, critical periods suggest that the ability to change learning or influences outside a particular time point are much harder. These concepts help when exploring trajectories of child mental health outcomes as development periods may explain the emergence of certain behaviours. For there to be evidence of a sensitive period, factors (e.g., SECs, parental mental health) must be shown to lead to change in that time period what would not otherwise occur (Woodward & Pollard, 2020). Much of the sensitive and critical periods research in relation to socio-emotional development has focused on the effects of atypical caregiving (Fries et al., 2005; Esposito et al., 2016).

There are significant challenges in researching sensitive periods for socio-emotional difficulties. The influences of emotional behaviours are likely in operation over multiple developmental periods and may even overlap. Furthermore, long term negative effects have often been mistakenly presented as evidence for sensitive periods (Woodward & Pollard, 2020).

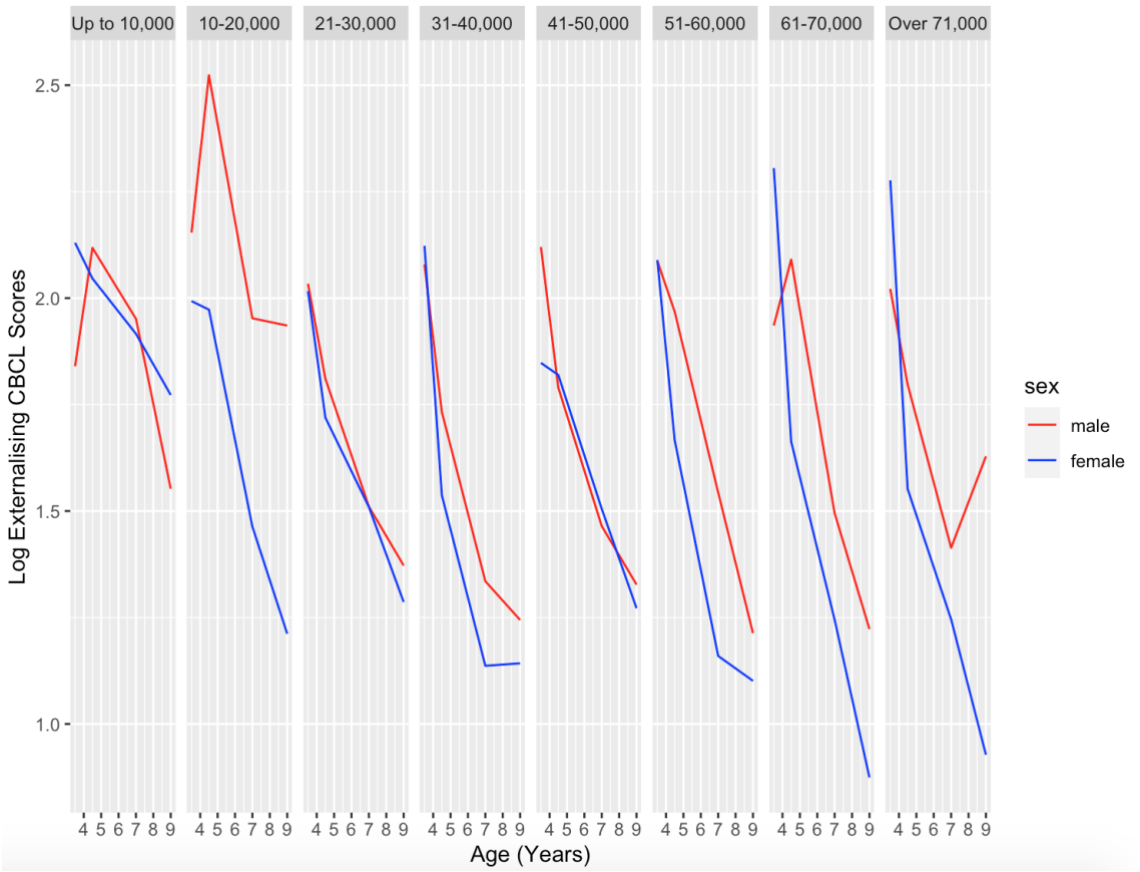
Previous studies have found evidence for employing time as a quadratic function for developmental trajectories (Mazza et al., 2016; Murray et al., 2022). In the formal analysis I will assess if this is also observed for trajectories in the WCHADS sample. This will allow for further investigation of the influence of risk and protective factors at specific developmental stages.

CBCL Trajectories 3.5 – 9 Years by Sex and Household Income

Next, I expanded on the previous plots by stratifying by both sex and household income. This approach allows investigation into whether there may be a sex by income interaction. The stratification of the plots below, visualise any potential sex differences by each level of household income.

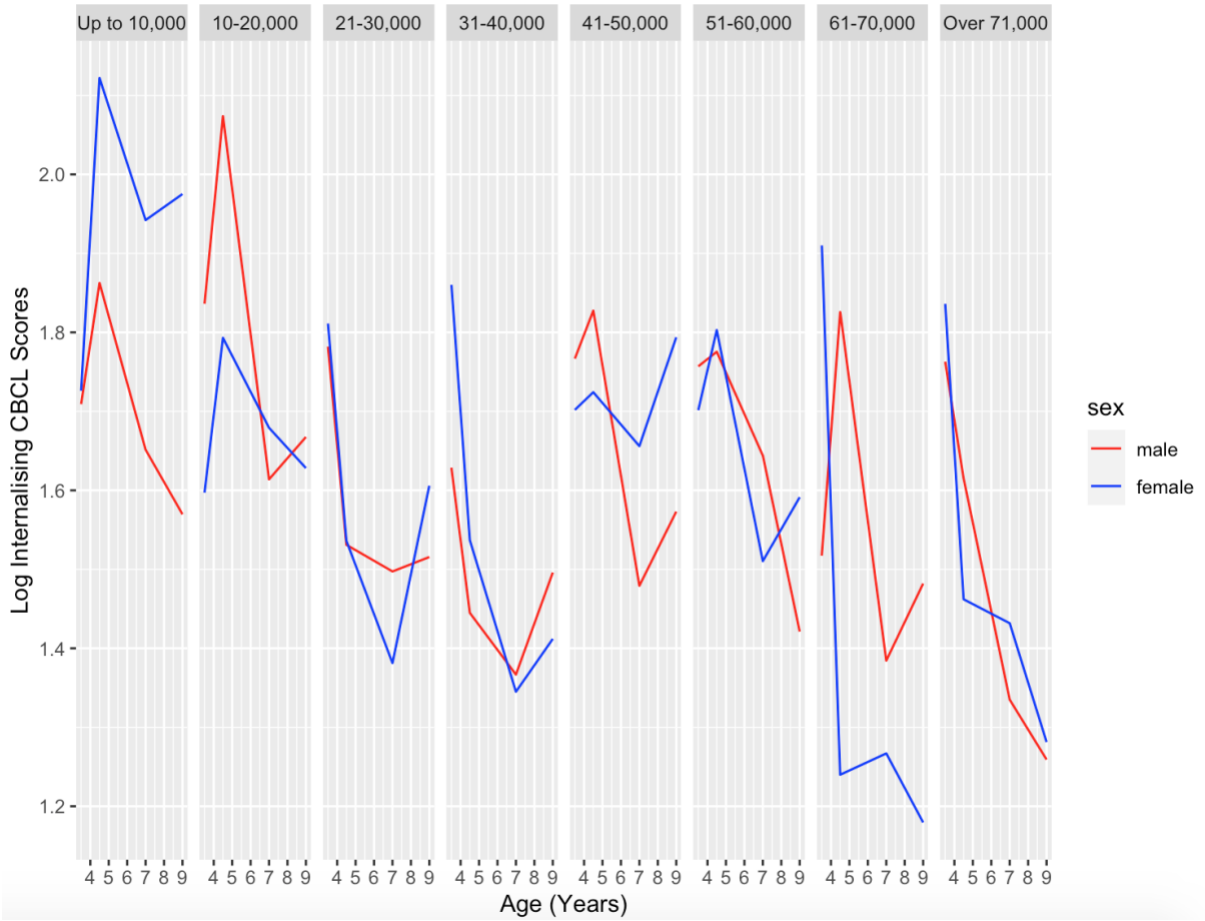
Figures 5.10 and 5.11 display the population average for log-externalising and log-internalising behaviour problems by sex and household income. Each panel represents a level in the household income variable. The first panel shows the population mean scores for log-externalising scores for children in the ‘Up to £10,000’ income group. The red lines display scores for boys and the blue line scores for girls.

Figure (5.10) Plot of mean log-externalising behaviour problems over time stratified by sex and household income.



Visually, the overall trends demonstrate a decline in externalising problem scores, although, there are differences within income levels. The most observable differences in trends by sex are for the two lowest income groups and highest income group. Visually, the trend for internalising scores is not as clear, with scores varying by sex at different ages and across household income groups. Consequently, I will model an age by sex and a three-way interaction between age, sex and income in the formal analysis. This will test the hypotheses that the rate of decline (slope) varies by sex and whether any association between income and the slope varies by sex.

Figure (5.11.) Plot of mean log-internalising behaviour problems over time stratified by sex and household income.



Results from formal linear mixed effects models

First, I fitted a linear mixed effects model using age centred at 3.5 years as the time metameter, comparing the fit of a model with a random intercept only, to one with a random intercept and slope. I found that the random intercept and slope model had the better fit (see Table 5.3). A reduction in the Akaike Information Criterion (AIC), a method of assessing model fit, was observed. This model was used as the baseline model to build a set of hierarchical models. Additional analysis of variances (ANOVAs) were performed as an approach to model selection, with the most parsimonious models chosen (see Appendix 5).

Table 5.3: Analysis of Variance comparing a random intercept and a random intercept and random slope model

	Df	AIC	BIC	-2 Log Likelihood	Deviance	Chi-Square	p-value
Random Intercept	4	7577.30	7601.40	-3784.60	7569.30		
+ **Random Slope**	6	7463.00	7499.10	-3725.50	7451.00	118.33	<0.001

Note: Df: degrees of freedom; AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion.

Tables 5.4 and 5.5 display the β coefficients for log-externalising and log-internalising behaviour problem score nested models respectively. Results and model summary statistics are shown for each linear mixed model with time effects, exposure, exposure by time interaction and baseline confounders added sequentially (see Table 5.1).

Table 5.4: Sequential linear mixed models predicting log-externalising behaviour problem scores.

	Model I			Model II			Model III			Model IV		
	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI
Fixed Effects												
Intercept	2.486	2.407	2.564	2.368	2.233	2.502	2.638	2.420	2.857	2.566	2.320	2.812
Age	-0.130	-0.144	-0.117	-0.139	-0.154	-0.124	-0.194	-0.232	-0.156	-0.194	-0.232	-0.156
Income				0.026	0.004	0.049	-0.032	-0.076	0.011	-0.029	-0.075	0.017
SEC Gap				0.208	0.032	0.392	-0.256	-0.608	0.088	-0.232	-0.600	0.136
Age x Income							0.012	0.004	0.019	0.012	0.004	0.019
Age x Income SEC Gap							0.096	0.032	0.152	0.096	0.032	0.152
Maternal Age 18-24										0.001	-0.162	0.164
Maternal Age 25-34										0.008	-0.122	0.139
Sex (Male)										0.111	0.023	0.199
Ethnicity (Other)										-0.009	-0.252	0.235
Random Effects												
Residual Variance	0.448			0.447			0.447			0.447		
Intercept Variance	0.234			0.256			0.242			0.247		
Slope Variance	0.011			0.011			0.010			0.010		
-2 Log Likelihood	-3725.500			-3220.500			-3215.800			-3204.700		
Deviance	7451.000			6440.900			6431.500			6409.400		
AIC	7463.000			6454.900			6447.500			6433.400		
BIC	7499.100			6496.100			6964.600			6504.000		

Note: β coefficients presented on log-scale. Maternal Age (Ref: 35+); Sex (Ref: Female); Ethnicity (Ref: White British). Age x Income represents a time by exposure interaction effect and is interpreted as an effect on the slope. The socioeconomic (SEC) gap represents the difference between the most and least deprived households. AIC: Akaike information criterion; BIC: Bayesian information criterion.

Table 5.5: Sequential linear mixed models predicting log-internalising behaviour problem scores.

	Model I			Model II			Model III			Model IV		
	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI
Fixed Effects												
Intercept	1.869	1.794	1.944	1.760	1.637	1.884	1.945	1.734	2.156	1.967	1.733	2.200
Age	-0.038	-0.051	-0.025	-0.041	-0.055	-0.027	-0.077	-0.113	-0.041	-0.076	-0.112	-0.040
Income				0.022	0.002	0.042	-0.018	-0.060	0.024	-0.017	-0.061	0.028
SEC Gap				0.176	0.016	0.336	-0.144	-0.48	0.192	-0.136	-0.488	0.224
Age x Income							0.008	0.001	0.015	0.008	0.000	0.015
Age x Income SEC Gap							0.064	0.008	0.12	0.064	0.001	0.120
Maternal Age 18-24										-0.034	-0.179	0.111
Maternal Age 25-34										-0.030	-0.147	0.086
Sex (Male)										-0.017	-0.095	0.062
Ethnicity (Other)										0.138	-0.081	0.357
Random Effects												
Residual Variance	0.421			0.417			0.417			0.417		
Intercept Variance	0.196			0.232			0.227			0.228		
Slope Variance	0.009			0.010			0.009			0.009		
-2 Log Likelihood	-3540.100			-3063.500			-3061.300			-3054.400		
Deviance	7080.100			6127.100			6122.600			6108.900		
AIC	7092.100			6141.100			6138.600			6132.900		
BIC	7128.300			6182.300			6185.700			6203.500		

Note: β coefficients presented on log-scale. Maternal Age (Ref: 35+); Sex (Ref: Female); Ethnicity (Ref: White British). Age x Income represents a time by exposure interaction effect and is interpreted as an effect on the slope. The socioeconomic (SEC) gap, the difference between the most and least deprived households. AIC: Akaike information criterion; BIC: Bayesian information criterion

For log-externalising scores, Model I revealed a significant time trend across the study population, whereby, there was an annual reduction of mean scores. For example, the annual change in log-externalising score was -0.13 (95% CI -0.14, -0.12). Next, I added the exposure measure, household income (coded as a continuous variable), to the model without adjusting for the baseline confounders (model II) to assess the effect on the intercept. Children from the most disadvantaged households were associated with an increased score of 0.21 (95% CI 0.03, 0.40) for log-externalising behaviour problems compared to children from the least disadvantaged households. Adding the exposure measure, household income, significantly improved the model fit, reducing the Akaike Information Criterion (AIC) by 1008.1 compared to model I. Adding a time by exposure interaction (Model III) rendered the effect of income on the intercept at age 3.5 non-significant. However, there was a significant interaction between age and income, whereby, the rate of improvement over time was slower for the most disadvantaged children compared to the least disadvantaged children, increasing inequalities over time. Each year the gap in log-externalising scores between children at the top and bottom of the income distribution increased by 0.10 (95% CI 0.03, 0.15). Model IV proceeds to provide the adjusted effect for the exposure variable by controlling for baseline confounders. Compared to the previous model (model III), adjusting for baseline confounders did little to attenuate the effect of child age on log-externalising scores -0.19 (95% CI -0.23, -0.16). The time by exposure interaction remains significant with similar estimates. Each step in the hierarchical approach to model building improved the model fit.

For log-internalising scores, Model I established a significant time trend across the study population, whereby, there was an annual reduction of mean scores. For example, the annual change in log-internalising score was -0.04 (95% CI -0.05, -0.03). Next, I added the exposure measure, household income, to the model without adjusting for the baseline confounders (Model II) to assess the effect on the intercept. Children from the most disadvantaged households were associated with an increased score of 0.18 (95% CI 0.02, 0.33) for log-internalising behaviour problems compared to children from the least disadvantaged households. Adding the exposure measure, household income, significantly improved the model fit, reducing the Akaike Information Criterion (AIC) by 951 compared to Model I. Adding a time by exposure interaction (Model III) rendered the main effect of income on the intercept at age 3.5 non-significant. However, there was a significant interaction effect between age and income, whereby, the rate of improvement over time was slower for the most disadvantaged children compared to the least disadvantaged children, increasing inequalities over time. Each year the gap in log-externalising scores between children at the top and bottom of the income distribution by increased by 0.06 (95% CI 0.01, 0.12). Model IV proceeds to provide the adjusted effect for the exposure variable by controlling for baseline confounders. Compared to the previous model (Model III), adjusting for baseline confounders did little to attenuate the effect of age on log-internalising scores -0.08 (95% CI -

0.11, -0.04). The time by exposure interaction remains significant with similar estimates. Each step in the hierarchical approach to model building improved the model fit.

There were no significant associations identified between maternal age or ethnicity and either log-externalising or log-internalising behaviour problems. I found an association between sex and the intercept for log-externalising behaviour problems, whereby, boys scored 0.11 (95% CI 0.02, 0.20) higher at age 3.5 years.

Assessing whether trajectories for log-externalising and log-internalising scores differed by sex

Exploratory analysis suggested that log-internalising and log-externalising behaviour score trajectories may vary by sex. I formally assessed an age by sex interaction and a three-way interaction between age, sex and income. I compared interaction models to a model which did not include any sex interactions. To test whether an interaction model was necessary, I used ANOVAs to compare nested models. For both log-internalising and log-externalising behaviour scores extending the model to include a sex interaction did not improve the model fit. Therefore, the most parsimonious model does not include an age by sex or age, sex and income interactions (see Appendix 5 for ANOVA results).

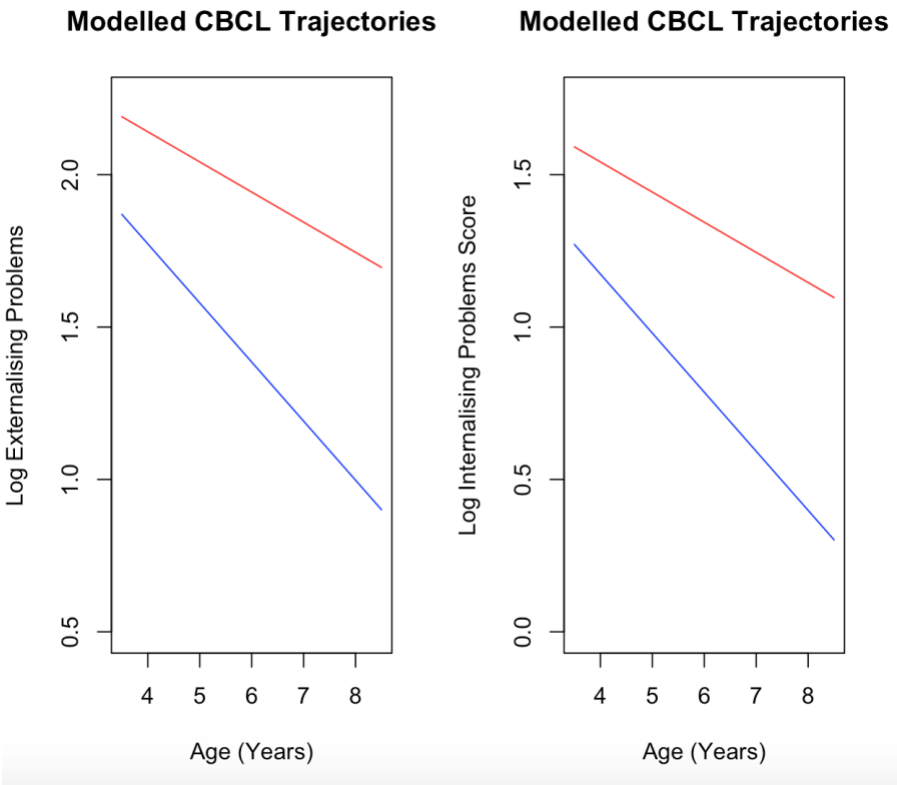
Plotting modelled trajectories for log-externalising and log-internalising scores for children from the least and most disadvantaged households

To help with the interpretation of linear mixed effects model output, I plotted the coefficients to create trajectory lines for children from the least and most income disadvantaged households. For linear mixed effects models this involves plotting the modelled population average (fixed effects) for different values of the variable of interest (e.g., SECs), whilst holding other variables in the model constant. Figure 5.12 shows the trajectories of the least disadvantaged children, with covariates set as: female, maternal age 35 and over and White British ethnicity. The red line represents children from the most disadvantaged households and the blue line represents children from the least disadvantaged households. This was achieved by multiplying the age by income interaction coefficient term by the difference in units between the lowest and highest income households (n=8), allowing the visualised slopes to represent the contrast between the extreme groups.

Figure 5.12 shows the trajectories for log-externalising and log-internalising behaviour scores for the most and least disadvantaged children, modelled from the fully adjusted model (*Model IV*). The lines represent the trajectories for a child from the most and least disadvantaged households. The plots show that scores decline for both internalising and externalising problems over time for children from both income groups, however, the rate of decline differs.

The plots highlight that the rate of improvement for internalising and externalising behaviour problem scores differ significantly by socioeconomic conditions.

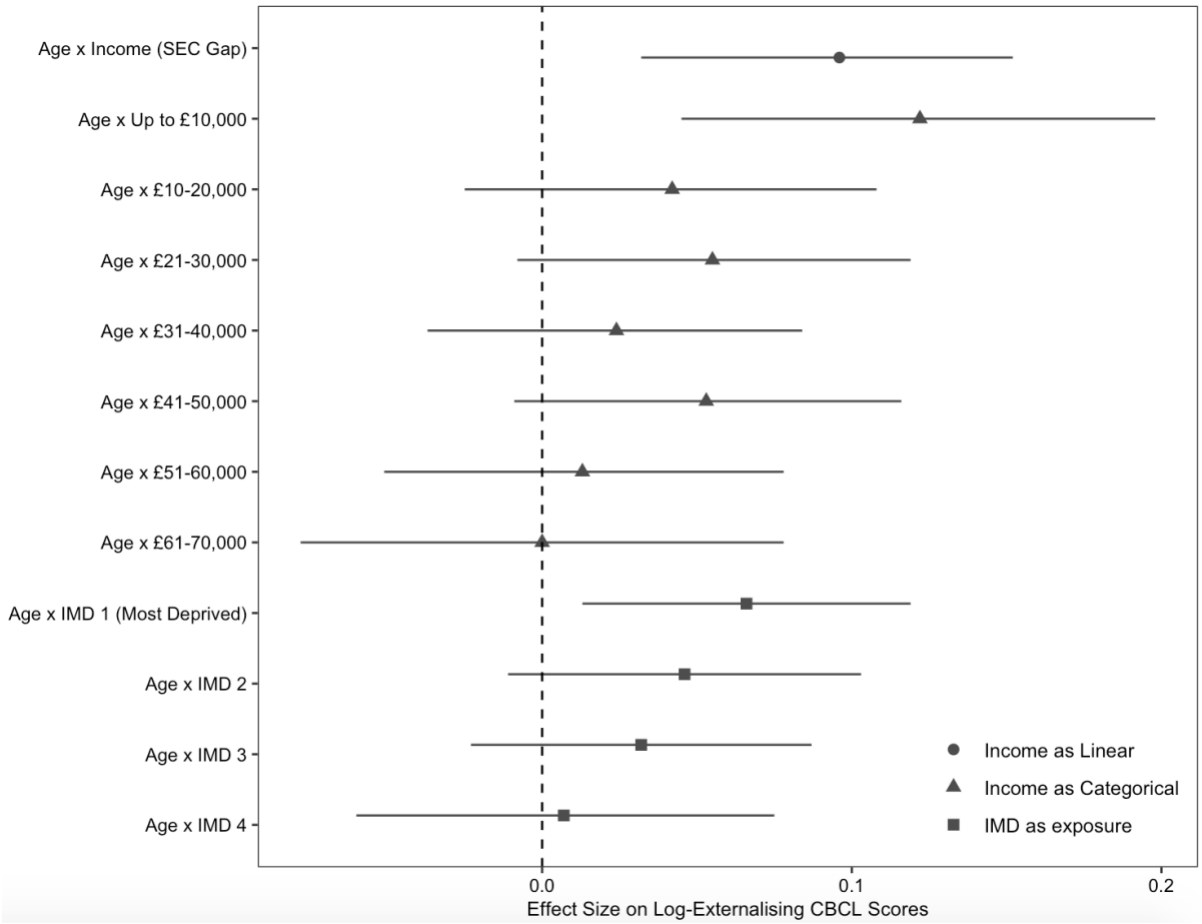
Figure 5.12: Visualising modelled trajectories of log-externalising and log-internalising behaviour scores from 3.5 to 9 years of age.



Robustness Tests

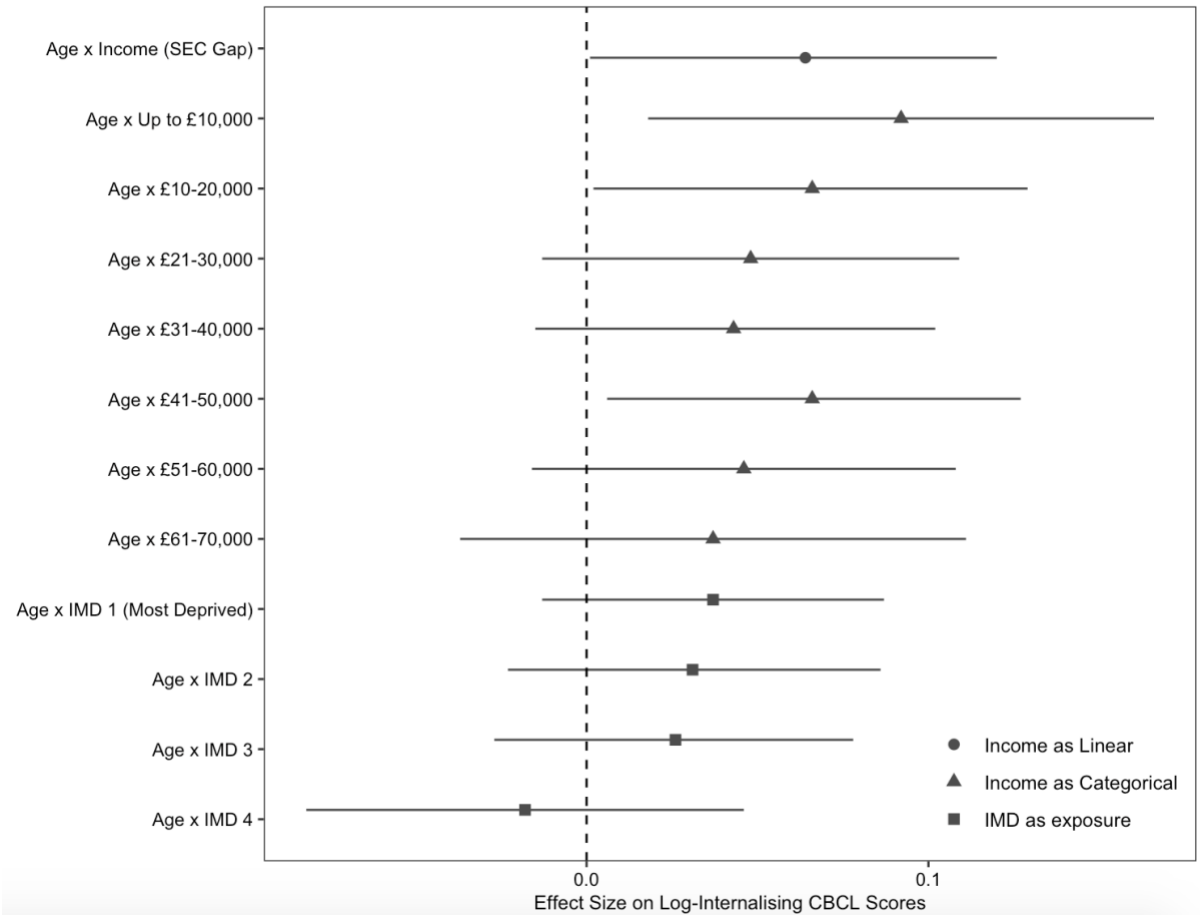
I undertook a number of robustness analyses to test statistical assumptions made in this study. First, I repeated the analysis treating age as a quadratic function. For both outcome models, extending the model to allow for a quadratic trend in age did not improve the model fit. Therefore, the most parsimonious model treats age as a linear function. To test statistical assumptions made in the main analysis, the exposure measure was also modelled as a categorical function. Furthermore, I repeated the analysis using the index of multiple deprivation (IMD) quintiles as an alternative measure of socioeconomic conditions. Figures 5.13 and 5.14 show the effect size for the main parameter of interest, age by exposure interaction, across the robustness models.

Figure (5.13): Age by exposure interaction parameter across robustness models for log-CBCL externalising problem scores.



Note: β coefficients presented on log-scale. Coefficients extracted from fully adjusted model controlling for a set of covariates (Maternal Age (Ref: 35+); Sex (Ref: Female); Ethnicity (Ref: White British). Age x Income represents a time by exposure interaction effect and is interpreted as an effect on the slope. The socioeconomic (SEC) gap, the difference between the most and least deprived households. IMD (Index of multiple deprivation).

Figure (5.14): Age by exposure interaction parameter across robustness models for log-CBCL internalising problem scores.



Note: β coefficients presented on log-scale. Coefficients extracted from fully adjusted model controlling for a set of covariates (Maternal Age (Ref: 35+); Sex (Ref: Female); Ethnicity (Ref: White British). Age x Income represents a time by exposure interaction effect and is interpreted as an effect on the slope. The socioeconomic (SEC) gap, the difference between the most and least deprived households. IMD (Index of multiple deprivation).

When treating income as a categorical measure, a slower rate of improvement in both log-externalising and log-internalising scores was observed for the most disadvantaged children compared to the least disadvantaged children. Furthermore, the parameter effect size is larger than the one observed in the main analysis, suggesting that the estimate in the main analysis is a conservative one. When using IMD as an alternative exposure, a significant age by exposure interaction was found only for log-externalising scores. Analyses were also undertaken using standardized CBCL Z-scores as an alternative outcome measure. The models showed similar conclusions to the main analyses with a socioeconomic gap in log-externalising and log-internalising scores over time (see Appendix 5).

5.5: Discussion

The aim of this study was to assess whether socioeconomic conditions were associated with both the average level of CBCL internalising and externalising behaviour scores and the rate of change over time. This study found that scores for both externalising and internalising behaviour decreased over time, with a greater decrease for externalising behaviour problems. Importantly, this study identified

that improvement in outcomes was significantly slower for the most income disadvantaged children. Furthermore, whilst no inequalities were observed at baseline (3.5 years of age) they emerged before 9 years of age, with the gap between the least and most disadvantaged children widening over time. Additionally, this study examined whether trajectories of child mental health varied by sex. Male sex was associated with higher scores for externalising behaviour problems at baseline (3.5 years of age). The rate of decline in scores over time and the observed association between income and mental health trajectories did not vary by sex.

Findings in context

The main finding of the analyses presented in this chapter shows that mental health improved less for the most disadvantaged children from 3.5 to 9 years of age. Consequently, a socioeconomic gap in mental health outcomes is established by 9 years of age. This finding supports and adds to the limited evidence base. There is evidence in the UK to show that the prevalence of behavioural disorders is three times higher for children (aged 5-19 years) from low-income households. (NHS Digital, 2017). Socioeconomic disadvantage can therefore impact the potential trajectories of mental health. Mazza et al., (2016) found that the effect of poverty on mental health trajectories was time dependent, whereby, the gap in outcomes widened over time from 1.5 to 8 years of age. This finding has also been identified in a US sample of 6950 children followed from birth to 14 years of age. Children who had never experienced poverty were associated with a greater decrease in externalising and internalising behaviours compared to children who experienced either persistent or intermittent poverty (Comeau & Boyle, 2017).

Additionally, Flouri et al., (2014) in UK sample of 3- to 7-year-old children identified that socioeconomic disadvantage was associated with both a linear and quadratic rate of change. Whereby, the most disadvantaged children had poorer mental health outcomes over time. Additionally, a child's ability to self-regulate moderated the rate of improvement. For example, children in persistent poverty with low self-regulation had higher internalising problems scores compared to children in persistent poverty with high levels of self-regulation and compared to more advantaged children with both high and low levels of self-regulation (Flouri et al., 2014).

Transitions in and out of poverty have also been associated with mental health trajectories. Fitzsimons et al., (2017) found in UK sample of children aged 5- to 11- years, that both persistent and transitions into poverty are strongly associated with the development of child mental health problems. Similarly, in a study of Canadian children, from birth to 13 years of age, the gap in behaviour problems increased over time for children in persistent poverty. This study also examined the timing of poverty in the development of subsequent mental health problems finding that exposure to poverty, particularly, in the

early years (0-3 years) had a larger effect compared to poverty exposure later in the lifecourse (Mazza et al., 2017).

Whilst my analysis used composite scales of externalising and internalising behaviour problems, this relationship may differ at a behavioural subscale level. In the UK, prevalence of specific behavioural disorders varies by age and sex. Prevalence was highest for oppositional defiant disorder in 5-16-year (2.9%) olds compared to 17-19-year olds and lowest in conduct disorder confined to the family (0.1%) (NHS Digital, 2017). Mazza et al., (2016) observed that the socioeconomic gap increased for hyperactivity but remained constant for physical aggression. Additionally, associations between SECs and mental health trajectories may differ, depending on which measure is utilised. For example, Christensen et al., (2017) used three measures of socioeconomic conditions (family income, maternal education and area-level deprivation) and found that only family income was significantly associated with improvements in mental health outcomes over time. McLaughlin et al., (2015) found that different measures of SECs measured in childhood predicted onset, persistence and severity of mental health problems later in the lifecourse. For example, low parental education was associated with disorder persistence and severity but not the onset of a disorder. This suggests that trajectories may differ by measure of childhood SECs used.

This study identified that male sex was associated with increased externalising scores at intercept (3.5 years) and that the rate of improvement over time did not vary by sex. Previous studies have shown that boys are more likely to score higher for externalising behaviour problems (Amone-P'Olak et al., 2009; Boe et al., 2017). This is reflected in the UK population, where the prevalence of behavioural disorders in boys aged 5-10 years is 6.7% compared to 3.2% in girls aged 5-10 years (NHS Digital, 2017). Christensen et al., (2017) found that although male sex was associated with higher SDQ scores from 4-5 to 14-15 years of age, scores improved for both male and females. Similarly, the rate of improvement did not vary by sex.

My study did not observe any sex differences for internalising behaviour problems. Studies have shown that with the transition into adolescence, sex differences emerge in anxiety and depressive symptoms (Fanti et al., 2010; Legerstee et al., 2013). This is evident in the UK, where the prevalence for emotional disorders increases for both boys and girls, however the growth is more pronounced in girls. The prevalence of emotional disorders increases from 4.6% (aged 5-10) to 7.9% (aged 17-19) in boys. Whilst prevalence increases from 3.6% (aged 5-10) to 22.4% (aged 17-19) in girls (NHS Digital, 2017). Although, my study did not find a significant interaction between age, income and sex, in the prediction of trajectory for internalising problems this has been shown to emerge later in the lifecourse with socioeconomic disadvantage associated with only female mental health development in adolescence

(Patalay & Fitzsimons, 2017). Therefore, there are likely to be varying trajectories by sex later in the lifecourse that are not presently identified in this study up to age 9.

Trajectories for externalising behaviours have been found to peak at 3 years of age before declining through childhood and subsequent transition into adolescence (Coie & Dodge, 1998). Contrastingly, trajectories for internalising problems tend to rise through middle-childhood and peak in adolescence (Bongers et al., 2003). My study identified that scores for both externalising and internalising CBCL scores decreased with age between 3.5 and 9 years, showing a general improvement in mental health over this age period.

This study also identified a greater rate of improvement in externalising behaviour problem scores. This finding corroborates similar findings across other high income country study populations. Shaw et al., (2005) found in a US sample using the CBCL that conduct problems decreased between 2 and 10 years of age. Additionally, Mazza et al. (2016) found that CBCL syndrome scores decreased by 8 years of age. This finding has also been observed in Australian and UK studies using the Strengths and Difficulties Questionnaire (SDQ) as a measure of child mental health (Flouri et al., 2014; Christensen et al., 2017).

Whilst these studies have shown a decrease in mental health outcome scores through childhood, trajectories for mental health problems are not stable and are likely to fluctuate throughout the lifecourse and key developmental periods. For example, de Lijister et al., (2019) identified a decrease in scores from preschool-limited profiles in children aged 1-10 years. There are likely to be different trajectories with the transition into adolescence, alongside pre-established pathways (Odgers et al., 2008). For example, Patalay & Fitzsimons (2017) show that there is an increase in emotional and depressive symptoms particularly in females from ages 11 to 14 years. Additionally, with the transition into adolescence and use of self-reported measures of mental health (as opposed to parental reports), predictors and associations vary. Parent-reported symptoms in childhood were found to be a poor predictor of self-reported depressive symptoms at 14 years of age (Patalay & Fitzsimons, 2017).

Exploratory data analysis suggested that it would be appropriate to explore time as a quadratic function when assessing trajectories of internalising and externalising behaviour problems in the Wirral population. However, the formal analysis identified a significant linear decrease in mental health scores over time and that modelling a quadratic age effect did not improve the model fit. Contrastingly, Mazza et al., (2016) found a significant quadratic time trend, at the syndrome level, whereby, scores for hyperactivity peaked at 5 years of age before declining by 8 years of age. Flouri et al., (2014) in a UK population sample of 16,916 children found that emotional and behavioural difficulties decreased from 3 to 5 years of age before increasing from age 5 to 7 years. Furthermore, Murray et al., (2020) identified

a linear and quadratic trend in a sample of 1620 children from Switzerland when exploring internalising and externalising behaviours from 7 to 15 years of age. This suggests there are challenges to modelling longitudinal mental health trajectories across key developmental periods and behaviour-types. My study has attempted to address these issues by allowing for slopes to vary for individuals, modelling a quadratic time effect and testing for sex interactions.

Murray et al., (2022) using data from a cohort study in Switzerland explored trajectory classes for both externalising behaviour problems and ADHD in children aged 7 -15 years. The study identified four distinct trajectory classes, with the highest proportion of children belonging to a "normative maturing" group in which symptoms initially increase before declining over time. Odgers et al., (2008) identified distinct trajectory profiles for antisocial behaviour delineating life-course persistent, adolescent-onset, childhood-limited and low trajectory groups. The analysis presented focuses on trajectories at a population-level compared to distinct developmental classes. However, the decrease in scores would support a childhood-limited and low trajectory groups interpretation of developmental trajectories.

Moffit (1993) identified two distinct trajectory paths for externalising trajectories, a life-course persistent path were scores start high and persist across developmental periods and an adolescent limited trajectory. The analysis presented in this chapter is limited to age 9 years, however, further research into the developmental profiles identified above is warranted.

Whilst the analysis presented in this chapter did not provide evidence of the importance of a particular developmental period for trajectories of internalising and externalising behaviour problems in the Wirral population, they should not be ruled out. Wider social and environmental factors may influence on scores at key developmental stages such as the transition into formal schooling.

Strengths & Limitations

The results from this study add to the sparce evidence-base exploring social inequalities in child mental health trajectories using data from the early-years period. This study used data from a prospective longitudinal study with repeated measures of child behavioural and emotional outcomes. WCHADS is a rich dataset, with socio-demographic and environmental risk factors collected during pregnancy and the early-years. WCHADS retains a large sample size for a developmental study which allows for investigation into causal pathways in the early years.

The measure of socioeconomic conditions used in this study relied on self-reported income, with participants selecting an incremental band range as a response. However, the measure of SECs used, is reported in the prenatal period and this is a key strength in allowing a clear temporal ordering of our

main exposure, income, and longitudinal mental health trajectories from age 3.5 years. Whilst this study does not explore poverty transitions, other studies have shown that first-transition, repeated transitions and persistent poverty are associated with poorer mental health outcomes across the lifecourse (Mazza et al., 2016; Wickham et al., 2017; Pryor et al., 2019).

Outcomes were assessed using the CBCL, a well-established and internationally validated measure of assessing behavioural outcomes from early to late childhood (Achenbach 1991). However, this study relies on maternal reports and not a clinical diagnosis of child emotional and behaviour problems. Although clinical cut-offs are available, this study focuses on a dimensional approach, in order to better explore the development of behavioural and emotional problems. Sub-clinical scores in early life are associated with potential clinical disorders later in life (Pike et al., 2006).

Attrition is a common issue with cohort studies. Of the 1233 study participants eligible for postnatal follow up, 71.3% provided outcome data at least one timepoint. Using data on participants providing complete outcome data can introduce selection bias. Restricting analyses to a sub-sample of a study population in health inequalities research, where the most disadvantaged are more likely to drop-out, can lead to underestimation of the effect sizes of socioeconomic measures (Mazza et al., 2016). To account for this issue, a key strength of this study is the use of linear mixed effects models. These models account for missingness common within cohort studies by estimating the outcome measure in a drop-out free population.

The pathways and mechanisms that contribute to the development of mental health problems in children are complex. Temporal effects of SECs have also been identified as playing an important role in the development of child mental health problems. (Wickham et al., 2017; Pryor et al., 2019). Furthermore, there are likely to be distinct trajectories in co-occurring mental health problems across childhood and adolescence (Murray et al., 2020). Given the complex nature of child mental health problems, this study adds to the sparce evidence-base exploring social inequalities in child mental health trajectories using data from the early-years period. This study assessed the effects of SECs on child mental health trajectories but did not take into account the role of potential mediators in explaining the association. Parental psychopathology has been identified as a risk factor for varying trajectories of anxiety and depression symptoms in early to late childhood (1-10 years) (de Lijster et al., 2019). Consequently, the role of parental mental health in explaining early social inequalities in mental health outcomes will be explored in the next chapter.

Policy and Practice Implications

In this chapter, I have shown that whilst scores for log-internalising and log-externalising behaviour problems decrease with age (3.5 to 9 years), the rate of decline is much slower for the most disadvantaged children. These findings underscore the importance of directing policies and interventions earlier in the lifecourse to better address inequalities in child mental health. More research is needed to explore the role of SECs on trajectories of child mental health, particularly with repeated outcome data in the early-years period and longitudinal joint modelling of co-occurring mental health outcomes across key developmental periods. Furthermore, the association between SECs and early child mental health problems may be explained or mediated by child, parental and societal factors.

Trajectories for mental health problems vary across the lifecourse. There has been an increase in literature exploring the role of SECs on mental health trajectories particularly in the early years period. Currently, policy attention is shifting towards placing greater recognition and emphasis on early intervention (DoH, 2013; Allen et al., 2014; DoH, 2015). Early intervention is needed to address the early emergence of inequalities in child mental health, which tend to track forward to become greater inequalities in later life.

There are worrying indications that existing services to address these issues have stalled and even declined (Institute of Health Equity, 2020). Over the last ten years, child poverty rates have risen and essential funding to key services such as children centres has been cut, particularly, in the most disadvantaged areas (Mason et al., 2021). Whilst interventions to address important meditating factors such as parental mental health are welcomed to reduce child mental health at a population level, they may not address underling wider structural inequalities. Efforts to reduce child mental health problems will be hindered unless the wider social determinants of mental health are addressed.

Chapter 6

Results: Study 3

How does perinatal maternal mental health explain early social inequalities in child behavioural and emotional problems? Findings from the Wirral Child Health and Development Study

6.1: Abstract

Background

This study aimed to assess how maternal mental health mediates the association between childhood socioeconomic conditions at birth and subsequent child behavioural and emotional problem scores.

Methods

Analysis of the Wirral Child Health and Development Study (WCHADS), a prospective epidemiological longitudinal study of the early origins of child mental health (n=664). Household income at 20-weeks gestation, a measure of socioeconomic conditions (SECs) in pregnancy, was the main exposure. The outcome measure was externalising and internalising problems, as measured by the Child Behaviour Checklist at 5 years. We assessed the association of household income with child behavioural outcomes in sequential linear models adjusting for maternal mental health in the pre- and post- natal period.

Results

Children of mothers in more disadvantaged households had higher scores for externalising behaviour with a difference of 3.6 points comparing the most affluent to the most disadvantaged families (the socioeconomic (SEC) gap). In our regression model adjusting for baseline confounders, comparing children of mothers in the most disadvantaged households to the least disadvantaged, we found that most disadvantaged children scored 45 percentage points (95% CI 9, 93) higher for externalising problems, and 42% of this difference was explained in the fully adjusted model. Adjusting for prenatal maternal depressive symptomology attenuated the SEC gap in externalising problems by about a third, rendering the association non-significant, whilst adjusting for pre- and post-natal maternal mental health attenuated the SEC gap by 42%. There was no significant relationship between household income and internalising problems.

Conclusion

Social disadvantage is associated with higher child externalising behaviour problems scores at age 5, and about 40% of this was explained by maternal perinatal mental health. Policies supporting maternal mental health in pregnancy are important to address the early emergence of inequalities in child mental health.

6.2: Introduction

In this chapter I will present the results from a cross-sectional analysis assessing how perinatal maternal mental health explains early social inequalities in child behavioural and emotional problems. I will discuss the impactions of the findings for future research and the public health implications of this improved understanding of the relationship between SECs and child mental health problems in early childhood.

Reducing inequalities in mental health outcomes is a public health priority (Marmot et al., 2010). In the UK, one in ten children and young people (aged 5-16 years) have a clinically diagnosed mental health problem (behavioural 6% and emotional 4%) (Green et al., 2004). The prevalence of mental health problems is a growing concern, with 24% of girls and 9% of boys aged 14 years self-reporting high levels of depression in the UK (Patalay & Fitzsimons, 2017). Poorer socioeconomic conditions (SECs) are associated with worse mental health outcomes (Reiss, 2013). A systematic review of 52 studies from 23 countries found that children and young people from disadvantaged families are two-to-three times more likely to develop mental health problems compared to economically advantaged children (Reiss, 2013). A number of theories describe the pathways through which SECs influence child health, including mental health, with the most commonly cited differentiating between material, psychosocial, behavioural and structural factors (Pearce et al., 2018). For example, experiences of poverty can have a negative impact on maternal mental health and behaviour, which in turn influences child health (Wickham et al., 2017).

Inequalities in mental health outcomes are established in the early years of a child's development and these inequalities widen as children start primary education (Marryat et al., 2017). More support is needed earlier in the lifecourse to narrow inequalities (Marryat et al., 2017). In order to design and implement effective policies to tackle inequalities, a clearer understanding of the pathways, in the early years, is needed. Furthermore, it is unclear if these putative pathways differ for internalising problems (e.g., depression, anxiety) and externalising behaviour problems (e.g., aggression, attention) in children.

Maternal mental health is a well-established risk factor for child psychopathology and has been identified as a potential mediator of the association between socioeconomic conditions and child mental health outcomes (Carneiro et al., 2016; Goodman et al., 2011). One in five women experience depression in the perinatal period (Schmeid et al., 2013), although 60% of women are not detected and clinically diagnosed (Gavin et al., 2015). A previous episode of perinatal depression is associated with future risk (Lancaster et al., 2010) and around 15% of women who experience an episode of depression during pregnancy, experience a new episode within three months postpartum (Gavin et al., 2015).

Maternal mental health problems have been associated with the level of emotional support a child receives. Furthermore, poor parental mental health can affect children's emotion regulation, development and attachment (Murray et al., 2002; Murray et al., 2011). Few studies have explored the role of maternal mental health in generating social inequalities in child mental health. A greater understanding of the interplay and social patterning of maternal perinatal mental health and their impact on the socioeconomic gap in early child mental health problems is needed in order to design effective policy interventions to improve child mental health outcomes and reduce inequalities across the lifecourse (Diderichsen et al., 2018).

Using a prospective longitudinal study of child mental health trajectories, with frequent early-years measures, the aim of this study was therefore to assess the impact of childhood socioeconomic conditions (SECs) on child internalising and externalising behaviours at age 5 years. I further aimed to explore the role of maternal mental health in explaining any social patterning of early child behavioural and emotional problems identified**.**

6.3: Methods

This study was granted ethical approval by the Cheshire North and West Research Ethics Committee [REF: 05/Q1506/107 (June 2006); 10/H1010/4 (June 2010)]. This study involved secondary analysis of anonymised data and did not require further ethical approval.

Sample

This study used data from a longitudinal cohort study of children born on the Wirral, in the North West of England. The study recruited 1233 participants consecutively from first-time mothers who booked antenatal care between February 2007 and October 2008 at the Wirral University Teaching Hospital, North West of England (Sharp et al., 2012). Owing to the socio-demographic composition of the Wirral, 41.7% of the sample were in the most deprived quintile of deprivation at recruitment, using the English Index of Multiple Deprivation (IMD) (Noble et al., 2004). These indices combine economic, social and housing indicators measures at the census into a composite deprivation score for small areas in England.

WCHADS utilises multiple informant questionnaires alongside novel experimental and observational measures, embedded within a longitudinal design, to measure child social, emotional and behavioural functioning (Sharp et al., 2012). A full description of the Wirral Child Health and Development Study can be found in Chapter 3. A comparison of demographics between the baseline and the analysis sample can be found in the appendix (Appendix 6).

Measures

Outcome measures

The main outcome measures were internalising and externalising problem subscale scores on the Child Behaviour Checklist (CBCL) at age five. When the cohort child was aged 4.5 - 5 years (58.5 months (3.6)) parents completed the preschool version of the Child Behaviour Checklist, a validated instrument, with high rates of validity and reliability across many populations, measuring child emotional and behavioural disorders (Achenbach, 1991; Ivanova et al., 2010). The measure contains 99 problem items, scored 0 (not true), 1 (somewhat or sometimes true) and 2 (very true or often true). Internalising problems are derived from combining the anxious/depressed, emotionally reactive, withdrawn and somatic complaints scores, and externalising problems by combining aggressive behaviour and attention problem scores (Achenbach, 1991). The subsequent main analysis uses raw scores (unadjusted for sex and age) for both internalising and externalising domains, treated as a continuous variable.

Early-life risk factors

The primary exposure measure of childhood socioeconomic conditions in pregnancy, our baseline, was household income measured at 20-weeks gestation. Mothers were asked 'What is your approximate annual family income?' with responses collected in £10,000 incremental bands (Range: Up to £10,000 – Over £71,000). Our analysis uses the socioeconomic gap, which is the difference between the least (Over £71,000, n=53) and most deprived (Up to £10,000, n=48) households, to explore inequalities in mental health outcomes. In sensitivity analyses, we used IMD quintile score as an alternative exposure of childhood socioeconomic conditions.

For maternal mental health, we used total score on the Edinburgh Postnatal Depression Scale (EPDS). The EPDS is a self-reported 10-item measure used as screening tool for depression in the perinatal period (Cox et al., 1987). Screening for depressive symptomology could help with the detection, management and treatment of perinatal depression (Levis et al., 2020). The EPDS is the most widely utilised validated screening questionnaire and has been used in some areas of the UK by health visitors (Gibson et al., 2009). The measure is recommended by the UK National Institute for Health and Care Excellence guidelines as part of a full assessment, if depression is suspected, but advises against screening all women (NICE, 2014). Both the UK National Screening Committee and Canadian Task Force on Preventive Health Care advise against screening owing to concerns about false positives and the implications this may have in causing harm to the individual and lack of evidence supporting improved mental health outcomes (Hill, 2010; Joffres et al., 2013).

Cut-off points have been suggested to indicate possible or probable depression, however, a clinical diagnosis by a health professional is subsequently needed (Cox, 1987; Gibson, 2009). A systematic review found significant differences in the sensitivity and specificity of the EPDS across populations,

socioeconomic groups and cultural groups (Gibson et al., 2009). One of the possible dangers of employing the EPDS at a population-level is that owing to differences in sensitivity and specificity, there are likely to be false positive which can be costly for healthcare service providers (Gibson et al., 2009). However, this is a common issue with screening tools. The strength and utility of the EPDS to healthcare providers is that it is easy to administer, has acceptability amongst women and is free to use (Gibson et al., 2009).

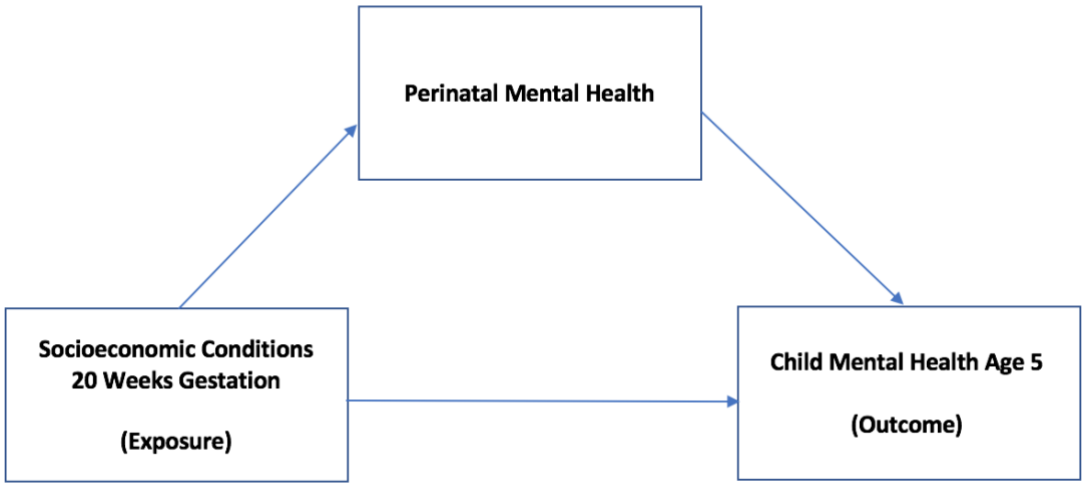
We used the EPDS as a continuous measure, measured at 20-weeks gestation, 14 months postnatal and 3 ½ years as a proxy for maternal mental health. Although primarily used a measure for depressive symptoms, the EPDS has been shown to identify anxiety and has a potential use as a screening tool for other mental disorders (Alvarado-Esquivel et al., 2016).

Demographic characteristics that are potentially associated with child mental health outcomes included as baseline variables in the analysis: maternal age at consent coded as 18-24, 25-34, 35+), child's age, sex and ethnicity. As only 2.9% of the sample identified as other than White-British, we dichotomised ethnicity to be 'White-British' or 'Other'.

Analysis strategy

The hypothesised association between socioeconomic conditions (SECs) and child behavioural and emotional problems, with maternal mental health as a potential mediator are shown in a directed acyclic graph (figure 6.1).

Figure 6.1: DAG for the relationship between, exposure, outcome and mediator assessed in this study.



First, I undertook a univariable analysis estimating association between covariates of interest and total CBCL internalising and externalising problem scores, using linear regression. Due to the outcome data being highly positively skewed, the total scores were log-transformed, with exponentiated beta coefficients interpreted as a geometric means, whereby, a change in the independent variable is represented as a ratio of change in the dependent variable (Batty et al., 2006).

A hierarchical approach was used for the multivariate regression modelling. Firstly, I fitted baseline models for each of our two outcomes by family income, treated as a linear function. Secondly, I adjusted for baseline demographic variables: maternal age at recruitment to the study, sex and ethnicity. I then fitted models with measures of maternal depression at our three separate time periods added separately (antenatally; at 14 months; and 3.5 years); and finally, I adjusted for maternal mental health at all three time points.

This study employs the Baron and Kenny (1986) approach to mediation analysis. Mediation analysis is the application of association causation modelling to help understand the temporal ordering of effects (Gelfand et al., 2009). In its simplest form, this approach to mediation, represents the addition of a third variable to the relationship between an exposure and outcome variable, whereby, the exposure causes the mediator and subsequently the mediator causes the outcome (see figure 6.1). This approach has been widely used across epidemiological and psychology studies (Gelfand et al., 2009). Furthermore, by using variables with nonoverlapping time periods to assess change, allows researchers to rule out directions of temporal prediction (Gelfand et al., 2009). This approach to mediation analysis can be employed when the outcome is continuous and ordinary least squares regression is used in the analysis of associations (Mackinnon et al., 2007). Recently, methodology for mediation to assess the importance of mechanisms and pathways has evolved to incorporate causal inference and epidemiological research. Many of these approaches are developing and offer the chance to expand on traditional approaches, for example, to assess multiple mediators and time-varying effects (VanderWeele, 2016). I also repeated the analysis using the counterfactual framework as a robustness test.

I took any attenuation in the geometric mean income coefficient, on the addition of measures of maternal mental health in a complete case sample to indicate potential mediation of any socioeconomic gap in mental health outcomes (Graham, 2004; Taylor-Robinson et al., 2016) calculated as 100 x (coefficient-adjusted coefficient)/(coefficient-1), to estimate the change in relative gap in behavioural and emotional problems on the basis of family income (Richiardi et al., 2013) (Figure 6.1).

The socioeconomic gap measures health inequalities between the most and least deprived groups. It is an important tool as often population averages overlook differences in health between groups. This

approach has been used in previous studies of health inequalities in social epidemiology (Graham, 2004; Taylor-Robinson et al., 2016).

Missing data was handled using listwise deletion. To account for item missingness on the Edinburgh Postnatal Depression scale I used mean substitution (Horowitz et al., 2013). Analyses were conducted using R software (version 3.5).

Robustness test

I undertook a number of sensitivity analyses to test statistical assumptions. I repeated the analysis using the index of multiple deprivation (IMD) quintile as an alternative measure of socioeconomic conditions (Galobardes et al., 2007). Additionally, I repeated the analysis using clinical cut-offs for internalising and externalising behaviour problems (0= no clinical level score, 1= borderline/clinical level score) to assess the association between SEC and clinical levels of child behavioural and emotional problems. Sensitivity analyses were performed using multiple imputation by chained equations to impute missing data values for all of the variables included in the models. Furthermore, I also undertook a formal mediation analysis using the counterfactual framework to assess how much of the effect of SEC (household income) on child behavioural problems is mediated via maternal depressive symptomology measured at all three time points (Appendix 6).

6.4: Results

Overall, 1233 study participants were available for post-natal follow up. Participants were included in the analysis sample if data were provided on the exposure measure, household income and the outcome measure, CBCL at age 5 years (figure 6.2). The final sample for analysis was 664 with data available.

Figure 6.2: Flowchart of inclusion into the analysis sample.

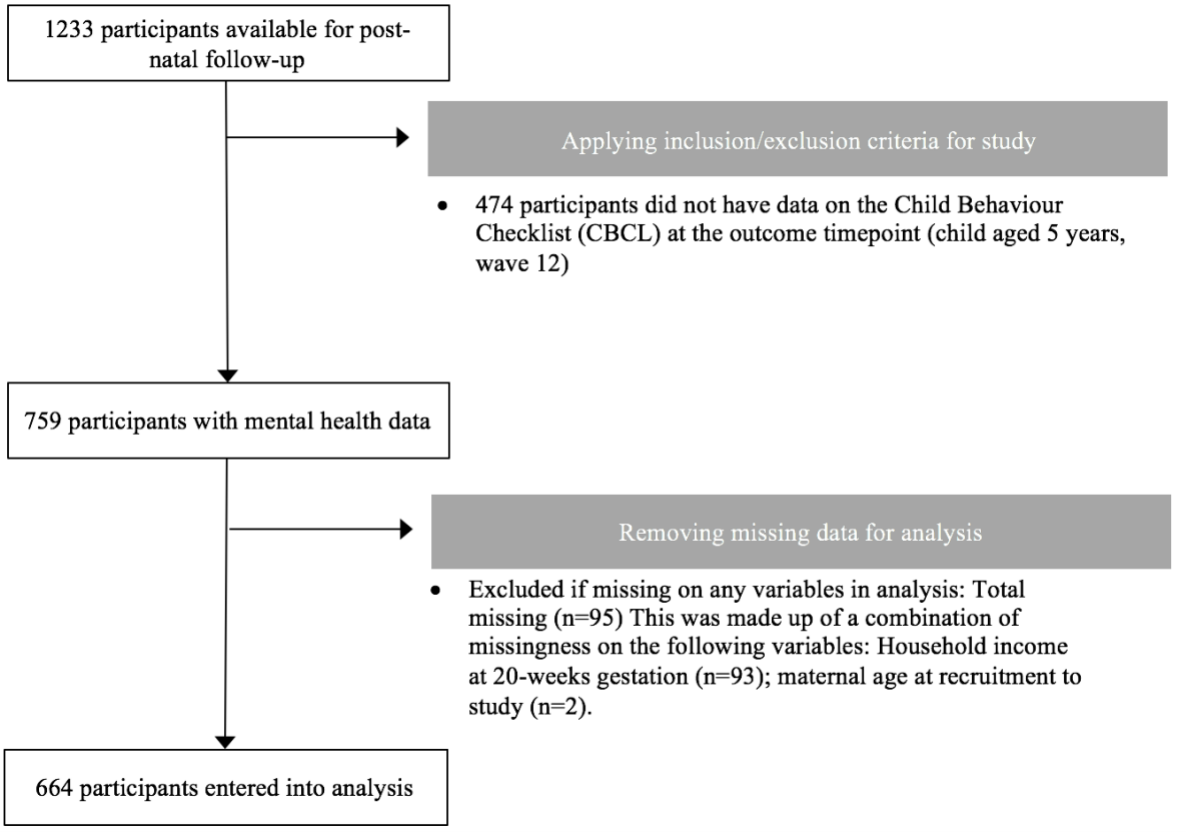


Table 6.1 shows sample characteristics stratified by household income. There were differences in mean scores for externalising and internalising behaviour problems by household income. As household income increases, mean scores for internalising and externalising behaviour problems decrease. Scores ranged from 9.9 (8.1 SD) in the lowest income households to 6.3 (6.3 SD) in the highest income households for externalising problems and from 8.1 (5.6 SD) to 5 (4.2 SD) for internalising problems. For all measures of maternal depressive symptoms in the perinatal period, mothers from the lowest income households had higher mean scores. Higher maternal age (> 35 years) was more common in the higher household income groups.

Table 6.1: Characteristics of the study population by household income

	Total	Up to £10,000	£10-20,000	£21-30,000	£31-40,000	£41-50,000	£51-60,000	£61-70,000	Over £71,000	p-value#
Subjects n (%)	666 (100)	48 (7.2)	77(11.6)	97(14.6)	134(20.1)	110(16.5)	101(15.2)	46(6.9)	53(8.0)	
Externalising raw score	7.7 (6.8)	9.9 (8.1)	10.9 (8.9)	7 (6.5)	6 (5.4)	7.8 (6.7)	7.5 (6.4)	7.6 (5.3)	6.3 (6.3)	< 0.001
Internalising raw score	6.2 (5.5)	8.1 (5.6)	7.9 (6.7)	5.5 (5.8)	5.1 (4.9)	6.5 (4.9)	6.7 (5.7)	5.6 (5)	5 (4.2)	< 0.001
Log-Externalising raw score	1.8 (0.9)	2.1 (0.9)	2.2 (0.9)	1.7 (0.9)	1.6 (0.9)	1.8 (1)	1.8 (0.9)	2 (0.7)	1.6 (0.9)	< 0.001
Log-Internalising raw score	1.7 (0.8)	2 (0.7)	1.9 (0.8)	1.5 (0.9)	1.5 (0.8)	1.8 (0.8)	1.8 (0.7)	1.6 (0.8)	1.5 (0.8)	< 0.001
Maternal age years n (%)										
18-24	160 (24.1)	40 (83.3)	44 (57.1)	36 (37.1)	30 (22.6)	6 (5.5)	2 (2.0)	2 (4.3)	0 (0)	< 0.001
25-34	408 (61.4)	5 (10.4)	29 (37.7)	50 (51.5)	83 (62.4)	94 (85.5)	78 (78.0)	33 (71.7)	36 (67.9))	
35+	96 (14.5)	3 (6.3)	4 (5.2)	11 (11.3)	20 (15.0)	10 (9.0)	20 (20.0)	11 (24.0)	17 (32.1)	
Child age (months)	58.5 (3.6)	58.2 (4.5)	58.4 (3.9)	58.4 (3.1)	58.7 (4.2)	58.5 (3.3)	58.8 (3.3)	58.1 (2.6)	58.5 (3.6)	0.965
Child's sex: female (%)	349 (52.4)	28 (58.3)	47 (61.0)	54 (55.7)	66 (49.3)	53 (48.2)	54 (53.5)	15 (32.6)	32 (60.4)	0.064
Child's ethnicity: other (%)	19 (2.9)	1 (2.1)	3 (3.9)	3 (3.1)	4 (3.0)	4 (3.6)	2 (2.0)	1 (2.2)	1 (1.9)	0.996
Maternal depression										
20-weeks gestation	6.4 (4)	9.2 (4.8)	8.1 (4.2)	7.1 (4.4)	5.7 (3.5)	6.2 (3.7)	5.5 (3.8)	4.5 (3.2)	5.2 (3.2)	< 0.001
14 months	5.1 (4)	6.9 (5.1)	6 (4.4)	5.9 (4.5)	4.8 (3.6)	4.7 (3.3)	4.6 (3.8)	4.1 (3.2)	3.9 (3.1)	< 0.001
3.5 years	5 (3.9)	7.5 (6)	5.6 (4.4)	5.6 (3.7)	4.7 (3.7)	4.6 (3.4)	4.4 (3.2)	4.3 (3)	4.4 (3.3)	< 0.001

Data are presented as means (SD), unless otherwise stated. Item missingness: Maternal age 2 # F-test: externalising, internalising, maternal depression; Chi-squared: Maternal age, Child's sex; Fisher's Exact: Ethnicity

Associations between covariates and child behavioural and emotional problems

Lower household income was associated with higher scores for externalising problems (table 6.2) but there was no significant association with internalising problems. Boys had significantly higher scores for externalising problems, whilst there were no significant sex differences for internalising problems. Consequently, the multivariable analysis focuses on externalising problems. In the univariable analysis male sex, child's age and maternal depressive symptoms at 20-weeks gestation, 14 months and 3 ½ years postnatally were associated with increased externalising mental health scores. By contrast there was no association with maternal age and ethnicity. To address the assumptions of mediation, I established that household income was associated with increased scores on the EPDS, using linear regression. (20 weeks (ß 0.58 p <0.001); 14 months (ß 0.40, p <0.001) and at 3.5 years (ß 0.37, p<0.001)).

Association between exposure and outcome, adjusted for other early-life factors

Table 6.3 shows the results of the multivariable analysis for externalising problems (results for internalising problems are shown in the appendix (Appendix 6). In the unadjusted model (model 1), children in the most deprived households had scores 32% (95% CI 4, 69) higher for externalising problems, compared to children from the least deprived households. Adjusting for socio-demographic factors slightly increased the household income coefficient such that children in the most disadvantaged households had scores 45% (95% CI 9, 93) higher than those in the least disadvantaged.

Table 6.2: Univariable associations between exposure, confounder and mediator measures with outcome measure (n=664)

	Externalising Raw Scores				Internalising Raw Scores			
Variables (Reference group)	**Exp(ß)**	**95% LCI**	**95% UCI**	**p-value**	**Exp(ß)**	**95% LCI**	**95% UCI**	**p-value**
Primary Exposure								
Household Income	1.04	1.01	1.08	<0.05	1.03	1.00	1.06	0.068
SEC Gap*	1.32	1.04	1.69	<0.05	1.23	0.98	1.53	0.068
Socio-demographic								
Mat Age (ref: 35+)				0.642				0.614
18-24	1.11	0.88	1.39		1.1	0.89	1.35	
25-34	1.09	0.9	1.33		1.09	0.91	1.3	
Child Age (Months)	0.97	0.95	0.99	<0.01	0.97	0.95	0.99	<0.001
Sex (Male)	1.22	1.07	1.4	<0.01	1.05	0.92	1.18	0.473
Ethnicity (Other)	0.79	0.53	1.19	0.265	1.25	0.86	1.81	0.234
Maternal Depression								
20-weeks gestation	1.04	1.07	1.4	<0.001	1.05	1.03	1.06	<0.001
14 months postnatal	1.03	1.02	1.05	<0.001	1.04	1.02	1.06	<0.001
3.5 years postnatal	1.04	1.02	1.06	<0.001	1.06	1.04	1.08	<0.001

Note: Exp (ß) interpreted as geometric means. Maternal Age (Ref: 35+); Sex (Ref: female); Ethnicity (Ref: white British). *The socioeconomic (SEC) gap, the difference between the most and least deprived households.

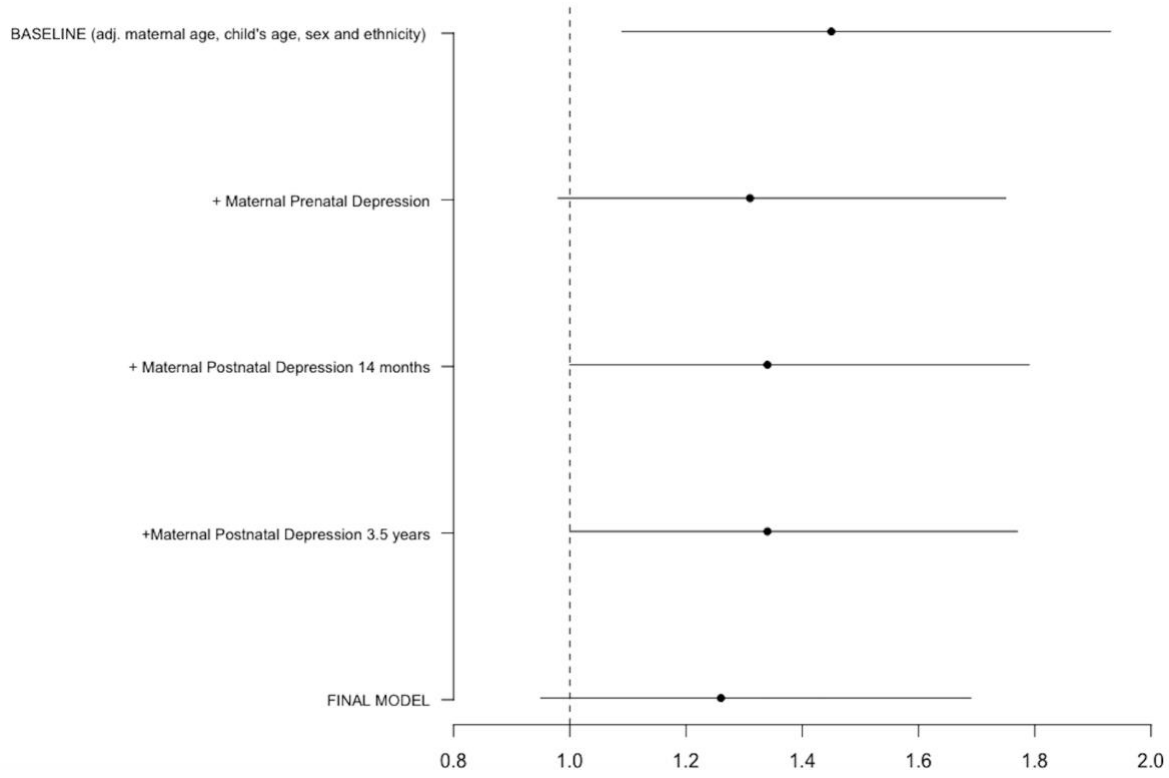
Table 6.3: Multivariable analysis of CBCL externalising behaviour problems life course models (n=664)

	Model I Exp (ß)	**Model II Exp (ß)**	**Model III Exp (ß)**	**Model IV Exp (ß)**	**Model V Exp (ß)**	**Model VI Exp (ß)**
Household Income	1.04* (1.01, 1.08)	1.06* (1.01, 1.10)	1.04 (0.99, 1.08)	1.04* (1.00, 1.09)	1.04* (1.00, 1.09)	1.03 (0.99, 1.80)
Household Income (SEC Gap)	1.32** (1.04, 1.69)	1.45** (1.09, 1.93)	1.31 (0.98, 1.75)	1.34* (1.00, 1.79)	1.34* (1.00, 1.77)	1.26 (0.95, 1.69)
Child Age		0.97** (0.95, 0.99)	0.97** (0.96, 0.99)	0.97** (0.95, 0.99)	0.97** (0.95, 0.99)	0.97** (0.96, 0.99)
Maternal Age (18-24)		0.95 (0.74, 1.22)	0.92 (0.72, 1.18)	0.96 (0.75, 1.23)	0.94 (0.74, 1.21)	0.93 (0.73, 1.19)
Maternal Age (25-34)		1.05 (0.86, 1.28)	1.04 (0.85, 1.26)	1.06 (0.87, 1.29)	1.05 (0.87, 1.28)	1.05 (0.87, 1.28)
Sex (Male)		1.24** (1.08, 1.42)	1.23*** (1.08, 1.40)	1.22** (1.07, 1.40)	1.24** (1.08, 1.41)	1.22** (1.07, 1.40)
Ethnicity (Other)		0.8 (0.53, 1.21)	0.8 (0.53, 1.21)	0.82 (0.54, 1.23)	0.85 (0.56, 1.28)	0.84 (0.56, 1.26)
Maternal Prenatal Depression			1.03*** (1.01, 1.05)			1.02 (0.99, 1.04)
Maternal Postnatal Depression (14 months)				1.03*** (1.01, 1.05)		1.01 (0.99, 1.03)
Maternal Postnatal Depression (3.5 Years)					1.04*** (1.02, 1.06)	1.02* (1.00, 1.05)

Note: Exp (ß) interpreted as geometric means. Maternal Age (Ref: 35+); Sex (Ref: female); Ethnicity (Ref: white British) *p<0.05; **p<0.01; ***p<0.001. The socioeconomic (SEC) gap, the difference between the most and least deprived households.

Figure 6.3 shows how independently adjusting for maternal depressive symptoms across the perinatal period attenuates the socioeconomic gap in child externalising behaviour problems. Adjusting for maternal prenatal depressive symptoms antenatally (model 3) the income gap coefficient is attenuated by 31% (Exp(ß**)** 1.31 [95% CI 0.98, 1.75]), from baseline (model 2), rendering the association with household income non-significant. Adjusting for either maternal depressive symptoms at 14 months or 3 ½ years postnatally (models 4 & 5) attenuated the socioeconomic gap in child externalising problems by 24% (Exp(ß**)** 1.34 [95% CI 1.00, 1.79]), from baseline, and the association with household income remained significant in both models. Finally, adjusting for maternal depressive symptoms at all three time points (model 6) attenuated the socioeconomic gap to non-significance, attenuating the SEC gap by 42% (Exp(ß**)** 1.26 [95% CI 0.95, 1.69]) compared to model 2.

Figure 6.3. Attenuation of the socioeconomic gap in child externalising behaviour problems independently adjusting for maternal depressive symptoms.



In the sequential models' maternal depressive symptoms entered at any timepoint (prenatal, 14 months and 3.5 years) was associated with an increased score for externalising problems. A one unit increase in EPDS score increased externalising scores by 3% (95% CI 1, 5) in the prenatal period and by 4% (95% CI 2, 6) in the postnatal period. Comparing the effect of depressive symptoms between mothers from the most deprived households to the least deprived (calculated as Exp (ß x difference in mean scores)), depressive symptoms in the prenatal period increased externalising scores by 13% (95% CI 6, 22) and by 9% (95% CI 3, 15) and 12% (95% CI 6, 18) for 14 months and 3.5 years postnatally. In our

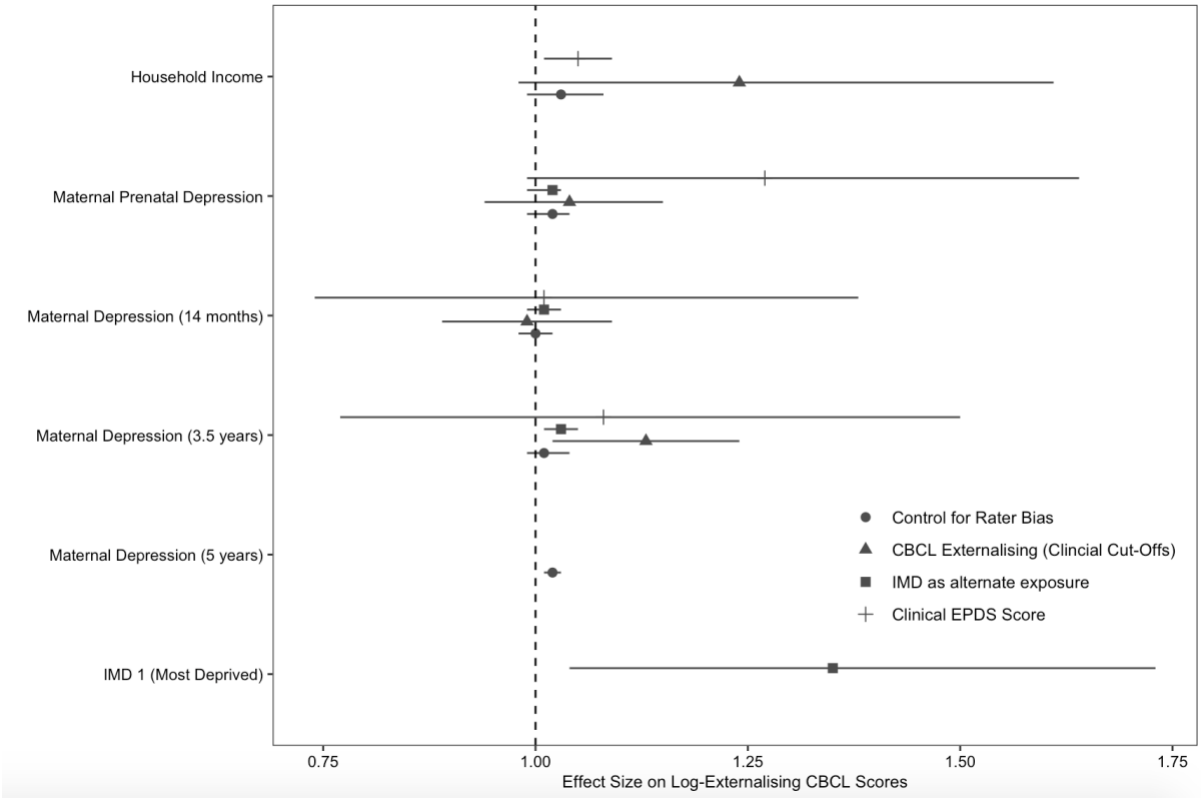
fully adjusted model (model 6), only maternal depressive symptoms at 3 ½ years postnatally, child's age and sex remained significant. Male sex increased scores for externalising problems by 22% (95% CI 7, 40).

Robustness tests

In this study I identified a gap in average CBCL scores across the socioeconomic spectrum of about 3 CBCL points at age 5 years, or one third of a z-score using the untransformed CBCL scores. To contextualise this difference, the effect size for the SEC gap on externalising behaviour problems is similar to the effect size of an evidence-based parenting intervention in a recent meta-analysis and larger than the gender/sex effect in the current analysis (Menting et al., 2013).

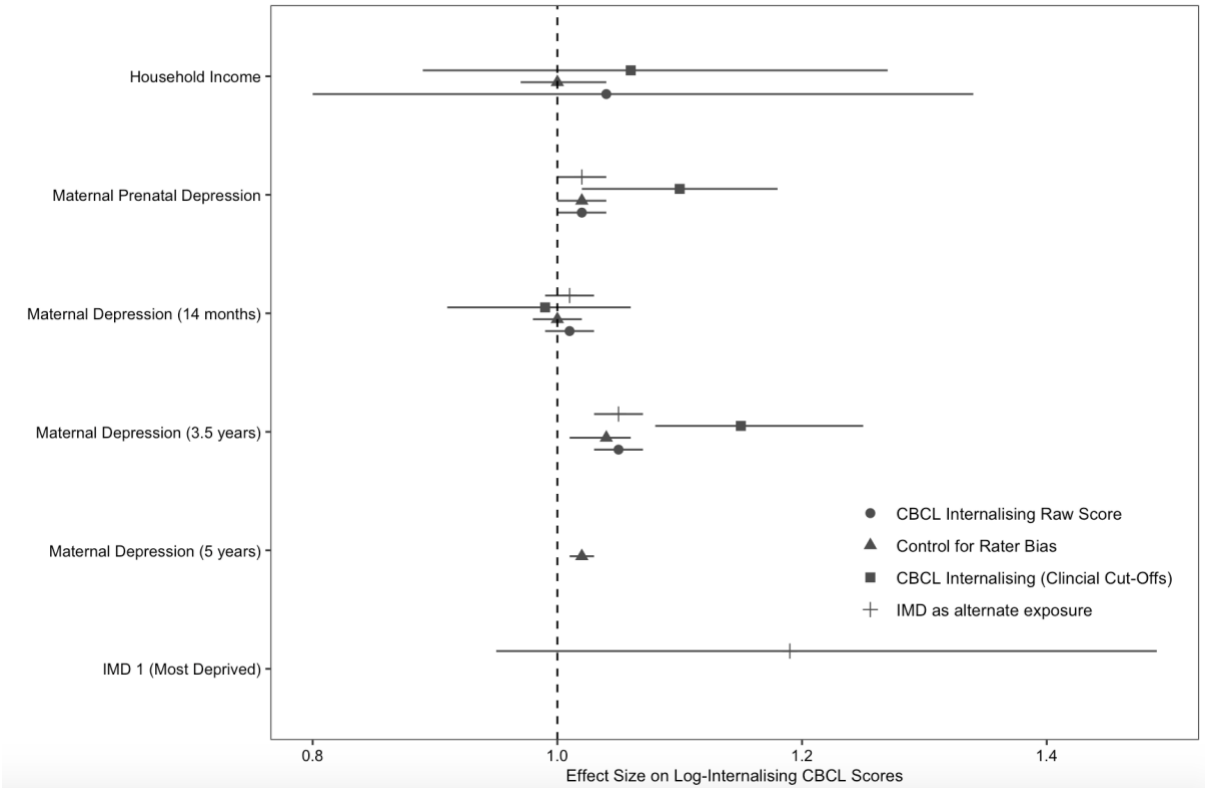
Figures 6.4 and 6.5 show the main parameters of interest, household income and maternal mental health, across the robustness models for both CBCL externalising and internalising behaviour problem scores. All coefficients are extracted from the final, fully adjusted model.

Figure 6.4: Exposure and mediator parameters across robustness models log-CBCL externalising problem scores.



Note: Coefficients extracted from final model which controls for child's age at outcome assessment, maternal age, child's sex and ethnicity. Maternal Age (Ref: 35+); Sex (Ref: female); Ethnicity (Ref: White British). Exp (ß) interpreted as geometric means.

Figure 6.5: Exposure and mediator parameters across robustness models for log-CBCL internalising problem scores.



Note: Coefficients extracted from final model which controls for child's age at outcome assessment, maternal age, child's sex and ethnicity. Maternal Age (Ref: 35+); Sex (Ref: female); Ethnicity (Ref: White British). Exp (ß) interpreted as geometric means.

Furthermore, I repeated the analysis using clinical cut-offs for internalising and externalising behaviour problems (0= no clinical level score, 1= borderline/clinical level score) to assess the association between SEC and clinical levels of child behavioural and emotional problems. This showed a social gradient in the proportion of children with behaviour problems and regression modelling using these dichotomised outcomes showed similar results to our main analysis using average values. In the age and sex baseline adjusted model there was an 18% increased risk of behaviour problems across the socioeconomic gap (Appendix 6).

Using IMD as an alternative measure of SECs, children in the most deprived quintile scored 39% higher (95% CI 8, 80) for externalising problems compared to the least deprived children. Adjusting for maternal depressive symptoms across the perinatal period slightly attenuated the effect to 35% (95% CI 4, 73) in the final model, a reduction of 11%. Male sex and maternal depressive symptoms at all time points significantly increased externalising problem scores (Appendix 6).

I found similar results using a counterfactual framework approach to mediation compared with the approach used in the main analysis (Appendix 6). I estimated the Natural Direct Effect (NDE), Natural

Indirect Effect (NIE) and Total Effect (TE) for the the relationship adjusting for maternal age at recruitment, ethnicity, child sex and maternal pre- and post-natal mental health, using the *medflex* package in R software. This package offers a flexible set of ready-made functions for fitting natural effect models, which is a novel class of causal models to directly parameterize the path-specific effects of interest, and can accommodate multiple correlated mediators (Steen et al., 2017). We calculated the proportion mediated via maternal mental health applying the formula NIE/(NDE+NIE) (VanderWeele, 2015).

Overall, 37% of the total effect of socioeconomic conditions (low versus high) on child mental health is mediated through maternal mental health (figure A.6.1), with a total effect of 1.055 (95% CI 1.013 to 1.098) and NIE of 1.020 (95%CI 1.009 to 1.031) (table A.6.1).

6.5: Discussion

Main findings

Using a prospective longitudinal study design with frequent early years measures of child and maternal mental health this study shows that low SECs in childhood, measured on the basis of household income at 20-weeks gestation, is associated with higher scores for externalising behaviour problems in children by age 5 years, but not for internalising problems. Children growing up in the most disadvantaged circumstances scored about 45% higher for externalising problems compared to children growing up in the least disadvantaged circumstances, with boys scoring significantly higher. About 40% of this association was explained by the increased prevalence of maternal mental health problems, particularly pre-natal mental health, in mothers of children growing up in disadvantaged circumstances. This analysis suggests that interventions that improve perinatal maternal mental health are likely to reduce social inequalities in child externalising behaviour problems.

Comparison with other findings

Our results corroborate previous studies suggesting that exposure to disadvantaged socioeconomic conditions increases the risk of later child mental health problems (Essex et al., 2006; Robinson et al., 2008; Bøe et al., 2012; Reiss 2013; Holmes & Kiernan, 2013). Socioeconomic disadvantage in the early years also has profound effects throughout the lifecourse. Longitudinal studies have shown that the SEC gap in child behavioural and emotional problems can be observed from infancy and that inequalities are maintained or increased throughout early childhood into adolescence (Mazza et al., 2016; McLeod & Shanahan, 1996).

Furthermore, results concur with studies that have shown that the relationship between SECs and behaviour problems is stronger for externalising symptoms (Bøe et al., 2012; Amone-P'Olak et al., 2009; Velez et al., 1989). Whilst this study only found a significant relationship between household income and externalising problems, the relationship with internalising problems did not quite reach significance, and this may be due to our relatively small sample size and sample age. However, this finding should not be overlooked, potential mechanisms of inequalities in internalising problems may differ compared to externalising problems and manifest later in the lifecourse.

The development and prevalence of internalising problems has been associated with increasing age (Allin & Stable, 2012). Although associations between SECs and internalising problems in children have been demonstrated in a number of other larger studies across childhood (Robinson et al., 2008; Fanti & Henrich, 2010; Kiernan & Huerta, 2008). Furthermore, this study found that child's age at time of CBCL assessment significantly decreases externalising problem scores (Exp(ß**)** 0.97 [95% CI 0.96, 0.99]). Studies have shown that the prevalence of externalising problems decline with age and this occurs across socioeconomic groups (Mazza et al., 2016; Strohschein, 2005).

Maternal psychopathology has been identified as risk factor that mediates the association between socioeconomic status and child and adolescent mental health problems at later ages (Reiss 2013; Carneiro et al., 2016; Fisher et al., 2013), with effects on child mental health well documented (Goodman et al., 2011). Kiernan et al. (2008) found that maternal depression mediated ~30% of the total economic effect on externalising problems, a similar figure to that found when we adjusted for postnatal measures of maternal depression in our study. This study extends the evidence base further, by showing how maternal mental health in the perinatal period impacts on the socioeconomic gap in very early measures of child behaviour problems at age 5 years. This study shows that low income is associated with higher scores of maternal depressive symptoms, and this is in turn related to higher externalising problem scores for children growing up in more disadvantaged SECs. Whilst I found that perinatal mental health is an important mediator of inequalities in child externalising behaviour problems, further studies should explore the mediating role of other perinatal factors such as birthweight and breastfeeding.

This study demonstrated clear sex differences, with boys at greater risk for externalising problems at age five, after adjustment for a range of covariates in the final model, corroborating previous studies (Carneiro et al., 2016; Goodman et al., 2011; Mäntymaa et al., 2012). There was no association between sex and internalising problems. Research suggests that the pathways and mechanisms for internalising and externalising problems may differ for boys and girls throughout development. Boys may be more susceptible to the impact of adverse environmental stresses, or their behaviour may be met by differing patterns of maternal response (Murray, 1992).

The main pathway (Figure 6.1) explored in this chapter is the effect of socioeconomic conditions on child mental health outcomes. In addition, the analysis also explores the mediating role of maternal mental health. I also assess the effect of SEC on maternal depressive symptomology in the perinatal period and subsequently, the effect of maternal depressive symptomology on child externalising behaviour problems. There may also be bi-directional effects in play which would suggest there may also be alternative pathways.

The pathways assessed in the analysis is based upon a social causation framework, whereby, the causal direction is from SECs to health. An alternative social selection framework suggests that the causal pathway is from health to socioeconomic status (West, 1991). My analysis supports the social causation framework as children are not in control of their social position. However, this may change through the lifecourse. Furthermore, in relation to mental health each framework may be dependent on type of mental health problem (Johnson et al., 1999; Hudson, 2005).

My analysis also supports a family stress model, whereby, the economic hardship and difficulties negatively affects the family-level indicators such as parental mental health which, in turn leads to difficulties for the child (Elder & Caspi, 1988). Parental, child and family risks are thought likely to work in a 'transactional, reciprocal manner.' (Mantymaa et al., 2012). For example, early externalising symptoms might contribute to the stability or continuity of parenting stress (Williford et al., 2007) which in turn may influence parenting. Additionally, studies have found that high levels of infant irritability predict the onset of depression in mothers already identified as at risk of postnatal depression (Murray, et al., 1996). This is in turn may further affect the influence on the child or the mother's on socioeconomic position.

Whilst not investigated in the current study, an alternative pathway in which parents' mental health contributes to their socioeconomic status and leads to negative effects on child mental health is plausible (Schuring et al., 2013). This would support a family investment model, which posits that a parent makes financial and social investments to support a child's development.

Studies have also suggested that health is influenced by individual characteristics and behaviours which can influence socioeconomic status. Behaviours are then intergenerationally transmitted, genetically (Rowe & Rodgers, 1997). Consequently, these genetic traits then influence behaviours and responses which contribute to negative socioeconomic and health outcomes (Rowe & Rodgers, 1997; Lerner, 2003).

Overall, my study found strong evidence of the association between SECs and child mental health, SECs and maternal depressive symptomology and between maternal perinatal depressive symptomology and child externalising problems.

Policy and practice implications

In the UK, the prevalence of child and adolescent mental health problems is increasing (Patalay & Fitzsimons, 2017; Gunnell et al., 2018). This study has shown that there are very early social inequalities in child behavioural problems. It is essential that policies to address inequalities focus on improving social conditions for all children, whilst also acting on maternal mental health in the perinatal period can potentially reduce the SEC gap in preschool-aged children's externalising behaviour problems.

This study also highlights the importance of maternal mental health in perinatal period for children across the lifecourse. This study has shown that maternal depressive symptomology across the perinatal period is associated with poorer child externalising behaviour problems. Furthermore, lower household income was associated with increased depressive symptomology at each of the time points assessed. Maternal mental health is a risk factor which can be targeted by policy and intervention. Addressing these issues can reduce the risk of later mental health problems for the mother and also the child.

In the UK, there has been increased recognition and awareness of the importance of perinatal mental health services (Ayers & Shakespeare, 2015). In 2014, the Maternal Mental Health Alliance (consisting of over 60 organisations) launched the 'Everyone's Business Campaign' which found significant variation in specialist perinatal maternal mental health provision, with 40% of the population having no specialist provision. Furthermore, variation exists in the level and type of provision available. For example, local authorities may have access to only one specialist nurse or complete community teams (Bauer et al., 2014). There is strong evidence that maternal mental health is associated with child health outcomes and supports targeting services and interventions to address these problems. Risk starts before birth and estimates suggest that approximately 122,000 babies (under 1) in the UK live with a parent with mental health problems (Marmot et al., 2010).

In the UK, the economic cost of maternal mental health problems in the perinatal period have been estimated to cost society £8.1 billion for each one-year cohort of births, with ~ 75% of the cost relating to impacts on the child (Bauer et al., 2014). Governmental policy has also shifted to address these issues with an All-Party Parliamentary Group recommending the prioritisation for perinatal services as a part of the 1001 critical days manifesto (APPG, 2013). Additionally, the government has committed to spending at least £2.3 billion per year by 2023/24 with explicit support for the expansion of specialist community perinatal teams (NHS, 2019). Action and investment to address maternal perinatal maternal

mental health services is welcomed, however, caution should be applied as to not widen inequalities in support.

Caution must be exercised in screening for maternal mental health at a population level. Screening measures such as the EPDS whilst recommended as a tool to identify individuals at risk possess variation in sensitivity and specificity which can be costly for healthcare providers. Screening tools should be used as part of a full assessment as recommended in NICE guidelines (NICE, 2014). Furthermore, as risk is higher in lower SES mothers, screening should not stigmatise and lead to further inequalities in uptake of existing support (Sills et al., 2007; Davidsen et al., 2021). Mothers and children with mental health problems require support, which is mindful of their needs, more so, in mothers from low SES who may feel stigmatised and isolated subsequently not reaching out for support (Hope et al., 2021b). Quickly addressing maternal perinatal mental health is vital, however, care should be exercised in ensuring fair access across the whole population. Targeted interventions aimed at specific population sub-groups should not increase inequalities.

Strengths and limitations

This study used data from a prospective longitudinal study with multiple measures of maternal mental health in the perinatal period. WCHADS is a rich dataset, with socio-demographic and environmental risk factors collected during pregnancy and the early-years. A limitation of this study is that the measure of child mental health is based upon maternal report and not a clinical diagnosis. However, I utilised the CBCL 1.5-5, a well-established and validated tool for screening at risk, preschool aged, children that can be used in clinical settings (Warnick et al., 2008). The aim of this study was to explore the effects of socioeconomic conditions on broad child behavioural and emotional problems and therefore treated CBCL scores as continuous. Although clinical cut offs are available, a dimensional approach better captures the development of behavioural problems, as sub-clinical difficulties are associated with potential clinical disorders over the lifecourse (Pike et al., 2006). Furthermore, repeating the analysis using clinical cut-offs led to similar conclusions.

Additionally, maternal mental health at the time of CBCL measurement can influence responses. I have not controlled for rater-bias in the main analysis at age 5 years, as maternal mental health at age 5 is likely to be on the causal pathway between SECs and child behaviour and emotional problems. Controlling for maternal depressive symptoms at the time of the outcome measure is likely to be an over-adjustment. However, in sensitivity analysis I controlled for maternal depressive symptomology at this timepoint using the Centre for Epidemiological Studies Depression scale (CES-D) and the results are similar (Appendix 6).

Another limitation of this study is that the measure of maternal mental health relies on a self-report and not a clinical diagnosis. Although, the EPDS is a validated measure of depressive symptomology in the perinatal period its use at 3.5 years postnatal may not fully capture the severity of depressive symptoms later in the lifecourse.

WCHADS retains a large sample size for a developmental study which allows for rich data to be collected on socio-demographic and child behavioural and emotional problems in the perinatal period and offers the potential to investigate causal pathways in the early years. However, as a consequence of cohort attrition this study used data available on 62% of children from the original sample population. Despite this, the socio-demographic composition of WCHADS participants permits analysis exploring the effect of SECs. Although, caution is needed as the measure of SECs relies on self-reported income and does not account for family size or resource allocation. There may not be sufficient statistical power to identify small effect estimates in this study, and effects may not necessarily generalisable to the UK population, though they are likely to be generalisable to similarly disadvantaged areas.

Whilst I have also conducted a counterfactual mediation to understand the potential causal pathway using variables that are temporally ordered, further research should explore the complex bi-directional relationship between family SECs and maternal and child behavioural and emotional problems over time. Reassuringly, sensitivity analysis using different outcome and exposure measures produced similar results and conclusions (Appendix 6).

Conclusion

More knowledge is needed for the earliest possible identification of children with behavioural and emotional problems. Whilst this study has shown that income and deprivation impact maternal mental health and child externalising behaviour problems, there may be threshold effects, and identifying these in future research may usefully inform public health and welfare policy. Further longitudinal investigation, with an early-years focus, is welcomed.

Currently, around 70% of children and adolescents with mental health problems have not had appropriate early intervention (Children's Society, 2015). Efforts to reduce inequalities in child behavioural and emotional problems should focus on reducing socioeconomic inequalities, with multi-dimensional strategies and prevention across the lifecourse. This analysis suggests targeting maternal mental health in the perinatal period is important, but that this alone will not address the increased risk in disadvantaged children.

Chapter 7

Discussion

7.1 Introduction

The overall aim of this thesis was to investigate socioeconomic inequalities in early years child mental health. In chapter 2 of this thesis, I presented an initial review of the literature which found evidence of a social gradient in child mental outcomes in high income countries. This chapter also revealed significant gaps in the evidence base on the emergence and development of inequalities in child mental health problems in the early years. The three studies presented in this thesis aimed to contribute and add to the existing literature discussed in Chapter 2, in order to expand on current evidence and understanding of social inequalities in child mental health outcomes. Significant contributions to the existing evidence base were made by investigating socioeconomic inequalities in mental health in preschool-aged children utilising a rich child developmental dataset, which had previously not been analysed from a health equities perspective.

In this final chapter, I provide an overview of my findings in relation to objectives 1-3 of this thesis and discuss the ways in which the work presented has made a unique and original contribution to the literature. The main findings of each study are presented and discussed individually within the results chapters. This chapter consolidates the findings across the three studies, in order to develop a greater understanding of the consequences of child mental health problems. The limitations of the research are considered alongside recommendations for future research. I also address objective 4 of the thesis with a section on the policy implications arising from the studies.

7.2 Overview of key findings

In this thesis, I have presented the results of three studies each addressing the objectives set out in Chapter 1. The results of the three studies suggest that across high income countries, there are socioeconomic inequalities in child mental health. These inequalities are present in the early-years, evident before the age of five years, and tend to widen through childhood. The key findings from these studies in relation to the overall objectives of the thesis are summarised below.

Objective 1 – To systematically review current evidence on the relationship between socioeconomic conditions and mental health outcomes in children up to five years of age, using data from prospective longitudinal studies conducted in high income countries.

Study 1 (Chapter 4) addressed the first objective of this thesis with a systematic review, which included 15 studies that investigated the association between early childhood SECs and preschool-aged child mental health outcomes in high income countries. The key findings were:

- Consistent evidence for an association between adverse childhood SECs and worse mental health outcomes in preschool-aged children (defined as 0-5 years) was identified.

- 12 out of the 15 included studies found an association between SECs and mental health problems, whereby, the most disadvantaged children had poorer mental health outcomes.
- 82% of the measures of association between SECs and child mental health outcomes were significant.
- The association between SECs and child mental health outcomes was observed across multiple measures of SECs and child mental health. Income and education were the most commonly used measure of SECs and, the CBCL and SDQ the most widely used outcome measures in a preschool-age population.
- Study methods were heterogenous, with variation in how SECs and mental health were assessed.

Objective 2 – To investigate the association between socioeconomic conditions and longitudinal trajectories of child mental health outcomes using data collected in the Wirral Child Health and Development Study.

Study 2 addressed the second objective of this thesis with a longitudinal analysis of data collected as part of a prospective longitudinal cohort study of children growing up on the Wirral in the UK. Data from 760 children between 3.5 to 9 years of age were analysed. The key findings were:

- Population average child mental health tended to improve over time, with scores for both externalising and internalising behaviour problems decreasing over time, with a greater decrease for externalising behaviour problems.
- Inequalities in mental health outcomes were not evident at age 3.5 years, when first measured. There was no significant difference in scores for both internalising and externalising problems by childhood SECs at age 3.5 years.
- Inequalities emerged over the subsequent follow up period, because mental health for disadvantaged children did not improve at the same rate as children growing up in more advantaged SECs. The rate of improvement for both externalising and internalising problem scores over time was slower for the most disadvantaged children compared to the least disadvantaged, leading to increasing inequalities over time.
- The emergence of inequalities in mental health outcomes did not vary by child sex. There was no significant association of sex with the rate of change for externalising or internalising score over time. Furthermore, there was no interaction between sex and SECs, indicating that the association of SECs and the rate of change in externalising and internalising scores did not differ by sex.

Objective 3 – To assess how maternal perinatal mental health mediates the association between childhood socioeconomic conditions at birth and subsequent child behavioural and emotional problems scores at 5 years of age.

Study 3 addressed the third objective of this thesis with analysis of mental health data on 664 children collected as part of the Wirral Child Health and Development Study. The key findings were:

- Children of mothers in more disadvantaged households had scores 45% higher for externalising behaviours scores at 5 years of age compared to the least disadvantaged children.
- The effect size for the inequality in externalising behaviour problems, contrasting children at the top and bottom of the income scale, is similar to the effect size of an evidence-based parenting intervention in a recent meta-analysis and larger than the well documented gender/sex effect in child mental health outcomes.
- Perinatal maternal mental health explains 40% of the inequality in externalising behaviour problem scores at age five.
- Boys scored significantly higher for externalising behaviour at 5 years of age.
- No significant association was found between socioeconomic conditions and internalising behaviour at 5 years of age. However, as shown in study 2, there is evidence of increasing inequalities in internalising behaviour scores by age 9.

In summary, disadvantaged children have worse mental health outcomes compared to their less disadvantaged counterparts across high income countries and in the Wirral study population. These socioeconomic inequalities are observable in the early years of a child's life, across multiple measures of SECs and child mental health. Furthermore, study 2 shows that these inequalities track and widen by 9 years of age. Study 3 also provided evidence that known risk factors such as pre- and post-natal maternal mental health are socially patterned and attenuate the SEC gap in child mental health outcomes. The next section will explore how these findings contribute and expand on the existing knowledge base.

7.3 Contribution to knowledge

As highlighted previously, the review of the literature (Chapter 2 and Chapter 4) revealed significant gaps in the current knowledge base and limitations in the design of previously conducted studies. In this section, I will examine how the three empirical studies have sought to address these limitations and how they have contributed to our current understanding of inequalities in child mental health. In this discussion, novel perspectives are offered by evaluating and synthesising the findings of the studies presented in this thesis and are situated within the context of relevant literature.

Contribution to the knowledge base on health inequalities

Exploring social inequalities in child mental health provides an opportunity to investigate the role of social, environmental and policy factors that can lead to differential outcomes in an area of health which is an increasing public health priority. Globally, mental health problems are an increasing burden of disease (Baranne & Falissard, 2018). The studies in this thesis have been guided by WHO Commission on Social Determinants of Health recommendation to measure and state the problem, expand and build upon the evidence base and develop more effective interventions (WHO, 2008).

Previously, research on child mental health has been undertaken from a psychological and/or psychiatric perspective. The studies in this thesis draw attention to an increase in literature exploring socioeconomic inequalities in child mental health. Whilst there has been an increase in early child mental health research from a health equity perspective, it is still in its early stages. Particularly, research assessing the early manifestations of child behaviour problems and their subsequent trajectories. The studies in this thesis have sought to address the research gap by assessing when and how inequalities in child mental health outcomes develop.

How do inequalities in child mental health outcomes develop?

The studies in this thesis have investigated the role of socioeconomic conditions in the early years in the development of child mental health problems. The results of the studies corroborate previous evidence suggesting that exposure to poorer socioeconomic conditions increases the risk of later child mental health problems (Essex et al., 2006; Tennant et al., 2007; Reiss, 2013). As evidenced and triangulated across the three studies in this thesis, there is consistent evidence supporting the importance of the social determinants to health, explicitly, socioeconomic disadvantage to child mental health outcomes. The studies in this thesis provide evidence of the effects of social stratification (socioeconomic conditions in the early years) and differential exposure (perinatal maternal mental health) on child mental health outcomes as outlined in the Diderichsen (2001) model. Whilst there is strong evidence for effects of disadvantage in the early years it is important to note that socioeconomic exposures are not temporally fixed, they are likely to be distributed over the life course and lead to subsequent health problems (Wickham et al., 2016; Wickham et al, 2017; Lai et al., 2019).

Study 1 synthesised evidence to assess the association between socioeconomic conditions and mental health outcomes in a preschool aged population. The review found robust evidence of the association between SECs and child mental health outcomes across OECD countries. Across the identified studies, 82% of the measures for SECs were significantly associated with poorer child mental health outcomes.

Furthermore, the association was found across both individual-level measures of SECs, for example, income and education and area-level measures of deprivation (Rijilarsdam, 2012; D'Souza, 2019; Flouri, 2010). This suggests that regardless of the construct and measure of SECs, disadvantage in the early years can lead to increased risk for the development of mental health problems later in life. Studies 2 and 3 utilised household income as the main measure of SECs in the early years but also utilised IMD as an alternative exposure measure. When using an area-level measure of deprivation, I found similar results whereby, the most disadvantaged children were more at risk for mental health problem scores.

This thesis provides strong evidence that the association between SECs and child mental health outcomes is evident across multiple validated measures of early child mental health. Furthermore, the effect of socioeconomic disadvantage may vary depending on the socio-emotional difficulty assessed. Previous studies exploring the association between low SECs and mental health outcomes have found mixed evidence. For example, (Gleason et al., 2011) found evidence of an increased risk to both internalising and externalising behaviour problems. Whereas (Paterson et al., 2013; Ciciolla et al., 2014) found that low SECs only increased the risk for internalising problems. Study 3 provides support with previous studies that have shown that the relationship between SECs and behaviour problems is stronger for externalising symptoms than for internalising symptoms (Bøe et al., 2012; Amone-P'Olak et al., 2009; Velez et al., 1989).

Whilst I only found a significant relationship between household income and externalising problems at five years of age in the Wirral population, the relationship between SECs and internalising problems should not be overlooked. Associations between SECs and internalising problems in children have been demonstrated in a number of other larger studies across childhood (Robinson et al., 2008; Fanti & Henrich, 2010; Kiernan & Huerta, 2008). Furthermore, the development and prevalence of internalising problems has been associated with increasing age (Allin & Stable, 2012). The studies in this thesis have demonstrated a clear association between SECs in the early years and poorer mental health outcomes in children.

When do inequalities in child mental health develop?

Currently, there is limited and mixed evidence as to when early inequalities in child mental health are established and whether inequalities widen or narrow across childhood. Adopting a life course approach to mental health helps researchers to understand how social, environmental and biological factors interplay in the development and subsequent consequences of mental health problems over the entire life span (Karestan et al., 2013).

Furthermore, it is important to understand any temporal relationships between factors in order to provide information on the developmental processes that are most pertinent in child mental health outcomes (Rutter et al., 2001). Assessing the timing of relationships between factors and outcomes (temporal relationships) is important in developmental psychopathology (Rutter et al., 2001). Prospective, epidemiological study designs (i.e., WCHADS birth-cohort) can help researchers understand the role of risk and protective factors across the lifecourse and how they may be receptive to policy and intervention in critical or sensitive periods (Barker et al., 2011).

A previous systematic review explored socioeconomic inequalities in child and adolescent mental health (5-18 years) and found that the most disadvantaged children were up to three times more likely to have a mental health problem compared to less disadvantaged children (Reiss, 2013). Study 1 built on this by focusing on a preschool aged population. I identified 15 studies using data from longitudinal cohort studies across OECD countries to explore and untangle when inequalities in child mental health develop.

The inclusion of only 15 studies in the review suggests that there is still a lack of evidence exploring the issue of social inequalities in early-years child mental health. Evidence of an association between SECs and child mental health was evident as early as one year of age, however, this finding was limited to one study (Palmer, 2013). However, the review provided robust evidence of an association by 5 years of age across both a variety of individual and area-level measures of SECs and measures of child mental health.

Presently, there are limited validated tools for assessing mental health in the early years with the BITSEA the earliest reliable measure at 12-18 months (Briggs-Gowan & Carter, 2002). To further understand how early inequalities manifest, where possible, future studies in the early years should aim to use validated measures of child mental health and report on the effect of socioeconomic conditions.

Longitudinal studies provide the best insight into understanding when inequalities can emerge. Longitudinal studies have shown that the SEC gap in child behavioural and emotional problems can be observed from infancy and that inequalities are maintained or increased throughout early childhood and into adolescence and adulthood (Viner et al., 2012; Arango et al., 2018). To investigate this, study 2 explored longitudinal trajectories of child mental health outcomes from 3.5 to 9 years of age. I found that whilst overall mental health problem scores decreased over time, the rate of decrease was slower for the most disadvantaged children. Similarly, Mazza et al., (2016) found that the gap in outcomes for mental health widened over time from 1.5 to 8 years of age for the most disadvantaged children. Furthermore, the timing of exposure to social disadvantage has been identified as important to developmental trajectories. Exposure to social disadvantage, in the early years, was found to have a

larger effect on mental health outcomes compared to exposure to poverty later in the lifecourse (Mazza et al., 2017).

Furthermore, there are likely to be varying trajectories for externalising and internalising behaviours over the lifecourse and these may vary by sex. Trajectories for externalising behaviours have been found to peak at 3 years of age before declining through childhood and subsequent transition into adolescence (Coie & Dodge, 1998). Contrastingly, trajectories for internalising problems tend to rise through middle-childhood and peak in adolescence (Bongers et al., 2003). My study identified that scores for both externalising and internalising CBCL scores decreased with age between 3.5 and 9 years, showing a general improvement in mental health over this age period and would support a 'childhood-limited' trajectory profile (Odgers et al., 2008). Similarly, Christensen et al., (2017) found improvement in mental health scores for boys and girls from 4 to 14 years of age.

Whilst I did not observe a significant interaction between age, SECs and sex, in the prediction of mental health trajectories from 3.5 to 9 years of age this has been shown to emerge later in life. For example, (Patalay & Fitzsimons, 2017) found that socioeconomic disadvantage was associated with only female mental health development in adolescence. There are likely to be varying trajectories for mental health problems that may vary by age, SECs, sex later in the lifecourse that are not presently identified in this thesis. Studies examining inequalities in mental health trajectories should look to explore the effect of SECs on the main developmental taxonomies in order to identify children most at risk of sub-optimal pathways (Moffit, 1993; Odgers et al., 2008). This will help target and focus interventions intended to reduce child mental health problems.

Study 3 further adds to the evidence to help our understanding of the temporal order of effects on the developmental pathway. The analysis was explicitly designed and informed by a lifecourse directed acyclic graph (see figure 3.9). Few studies have access to early measures of SECs. For example, the first measure of SECs in the Millennium Cohort Study is collected at six months postpartum. The analysis presented in Study 3 utilises an exposure measure captured during pregnancy (20 weeks gestation). Mental health measures were reported at 20 weeks' gestation, 14 months and 3.5 years postnatally with child mental health reported at 4.5 years of age. The temporal ordering of variables allows for causal interpretation. This study found evidence of an association between SECs and mental health at 4.5 years of age.

In summary, supporting the findings of the systematic review, there is evidence of inequalities in child mental health by five years of age. Whilst income was not associated with baseline mental health at 3.5 years in the trajectory analysis, inequalities emerged over time as the rate of improvement was much slower the most disadvantaged children.

Early life risk factors that explain inequalities in child mental health outcomes

This thesis has primarily focused on the role of the socioeconomic environment during pregnancy and maternal mental health as an important proximal factor for inequalities in child mental health outcomes. The World Health Organisation stated that children of mothers with mental health problems are up to five times more likely to develop a mental health problem in later life (WHO, 2014). Maternal psychopathology has been identified as risk factor that mediates the association between socioeconomic status and child and adolescent mental health problems at later ages (Bayer et al., 2005; Marmot et al., 2010) with effects on child mental health well documented (Cummings & Davies, 1994; Murray & Cooper, 1997).

Study 1 provided a review of the current literature on the association between SECs and mental health outcomes. The majority of included studies found that maternal mental attenuated or mediated the harmful effect of socioeconomic disadvantage on preschool-aged children's mental health outcomes (Bor et al., 1997; Najman et al., 2005; Rijilaarsdam et al., 2012; Palmer et al., 2013; Green et al., 2017; Hetherington et al., 2018; Palmer et al., 2018; Rutherford et al., 2019).

To examine the proposed pathway between SECs, maternal perinatal mental health and child mental health, Study 3 assessed the mediating role of maternal mental health in the perinatal period in explaining early inequalities in child mental health outcomes. I found that after adjusting for mental health at 20-weeks' gestation, 14 months and 3.5 years (postnatally), that 40% of the inequalities in child externalising behaviours could be explained. Similarly, Kiernan et al., (2013) found that maternal depression mediated ~30% of the effect of social disadvantage on child externalising behaviour problems.

Study 3 also identified that low income was associated with higher scores for maternal depressive symptoms, which in turn related to higher externalising problems scores in children. This is particularly, concerning given the high prevalence of mental health problems in the perinatal period. It is estimated that more than 1/3 of adults with a mental health problem are parents, consequently 2 million children live in households where at least one parent has a mental health problem (Tunnard, 2004).

Study 3 provides robust evidence of a causal mediation chain between socioeconomic environments during pregnancy, perinatal mental health and child mental health outcomes. The mediation analysis shows that maternal mental health has a significant indirect effect on mediating the role of wider social environments. Furthermore, this study expanded on previous literature by including multiple measures of maternal mental health across the perinatal period. This is consistent with developmental theory of

the transmission of risk of maternal mental health on a child's healthy development and supports Bronfenbrenner's (1979) bio-ecological theory. Explicitly, that wider social and environmental factors independently affect health outcomes but also exert influence on the inner layers. In turn, the inner layers operate through proximal factors (e.g., psychosocial factors) and affect children's behaviour (Pearce et al., 2019). Additionally, the findings also support Conger's (1992) family stress model which shows how social disadvantage (distal factors) can cause economic pressures, which in turn contributes to parents' mental health (proximal factors), which affects parenting style or quality of parenting, which in consequence leads to negative behavioural adjustment in children.

The studies in this thesis have exclusively assessed socioeconomic disadvantage and maternal mental health. Study 3 has shown that whilst maternal mental health in the perinatal period is important for subsequent child mental health problems, it does not fully explain the observed inequalities. Parental mental health is likely to negatively affect other important early-life risk factors that can compromise healthy child development such as parenting quality and parental warmth (Kawabata et al., 2011; Better Mental Health for All; 2016).

Genetic, social and wider environmental factors do not operate exclusively and can lead to increased susceptibility or further exposure to risk factors. There are many other risk factors across the lifecourse which may contribute or explain social inequalities in mental health outcomes (see Figure 2.5, Chapter 2). As evidenced in the systematic review, maternal stress, parenting quality, early parent-infant interactions and home environment are also associated with child mental health (Palmer et al., 2013; D'Souza et al., 2019b; Rijilaarsdam et al., 2012).

Evidence from the systematic review and mediation analyses provide strong support to previous research expressing not only the important role maternal mental health in children's development but also observed inequalities in preschool-age population. These studies support the developmental theories discussed above.

In summary, the studies in this thesis support the growing evidence base that inequalities in mental health outcomes start early in life and can be tracked through from early- to late- childhood. These inequalities also increase the risk for inequalities in other areas of health and social position later in the lifecourse. The principal message is that children who start behind are likely to stay behind (Kuh et al., 2004, Galobardes et al., 2008). This has important consequences for public health policy and more widely social policy. Early life experiences are likely to impact on a healthy developmental trajectory.

7.4 Critique of overall study design

The strengths and limitations of each study have been discussed in the individual results chapters (Chapters 4-6). In this section, I will provide an overview of the strengths and limitations of the overall thesis. The work presented in this thesis has made a unique and significant contribution to our current understanding of inequalities in child mental health. Examining inequalities in child mental health problems is a public health priority due to increasing prevalence and the associated burden on individuals, the healthcare sector and the wider economy. Original contributions to the evidence base have been made by through a systematic review of the current literature and novel analyses of a local child health and development study, utilising rigorous and advanced statistical methods to explore the association of SECs and child mental health in the early years.

Study 1 – Systematic review

Study 1 was a systematic review which aimed to investigate the association of socioeconomic conditions on preschool aged children's mental health for the first time. A key strength of employing systematic methods to searching and synthesising data increases the reliability and validity of the conclusions drawn. Therefore, systematic reviews can be used to help evidence policy decisions and develop theoretical understanding on a research topic (Ross, 2012). Furthermore, an explicit research question was developed under the PICO framework, with a clear inclusion and exclusion criteria applied to search results. An extensive search strategy was employed, with electronic database and grey literature searching to identify all relevant literature. Studies that met the inclusion criteria were also assessed for quality.

Combining and synthesising the results of multiple studies, on a research topic, can lead to determining a consistent effect size of an association (Greenhalgh, 2000). Owing to the variation in study populations, timing of exposure and outcome measures used, it was not feasible to pool effect estimates through a meta-analysis of the identified studies. However, findings were synthesised using harvest plots to clearly display the identified associations (Ogilvie et al., 2008).

Studies 2 & 3 – Dataset

Studies 2 and 3 utilise data collected as part of the Wirral Child Health and Development Study, a prospective epidemiological cohort study drawn from a community-based sample from a well-defined geographical area of the UK. In this section, I will explore the key strengths and limitations of the dataset, before outlining the strengths and limitations of the analytical methods.

The sample design of the study included sampling from a wider population, this helps to reduce potential biases that may arise from using data from a clinical sample. This approach increases the representativeness and generalisability of the results presented in the previous chapters. Furthermore, the study was designed specifically to identify the early biological, social and emotional risks of

childhood conduct problems (Sharp et al., 2012). Studies 2 & 3 take advantage of the rich data available, in the early years, to address the respective aims and objectives.

A key strength of the Wirral Child Health and Development Study is the high frequency of data collection assessments in the early years compared to other birth cohorts. Additionally, WCHADS retains a large sample size for a developmental study. By age 9 years (last wave of data used in this thesis), 908/1233 (73.6%) families in the sample were still retained in the study and eligible for follow-up. Consequently, this allowed for rich data to be collected on socio-demographic indicators and child mental health through early- to late childhood.

The study design and measures collected allows for investigation of potential causal pathways. A prospective design offers more advantages compared to a cross-sectional design by providing information about temporal sequences and the importance of timing of effects (Rutter, 2011). The studies in this thesis are able to explore the relationship between socioeconomic disadvantage during pregnancy, which has been identified as a key developmental period and later child mental health outcomes (Van de Bergh et al., 2020).

A limitation of the sample is that the Wirral study was not specifically designed with a health equity focus. Therefore, the studies in this thesis utilise the best available measures that capture socioeconomic conditions in the population. Owing to the socio-demographic composition of the Wirral, a large proportion of the sample (41.8%) are in the most deprived IMD quintile at recruitment into the study. Whilst this enables investigation into inequalities in health outcomes, the finding presented in this thesis are limited to the UK, particularly, areas with similarly high levels of social deprivation. Furthermore, only 3.6% of the sample identified with an ethnicity different to 'White British', meaning that there may not be the statistical power to explore any differences in outcomes by ethnicity.

Studies 2 & 3 – Analytical methods

A range of observational study designs were used in this thesis to address the objectives. With observational data, there is a risk of confounding due to unmeasured variables and residual confounding due to imprecise measurements of the covariates in the analytical models. Every effort has been made to adjust for potential confounding with the inclusion of appropriate covariates and a by utilising a clear modelling strategy.

Studies 2 and 3 utilised a hierarchical approach to modelling which was guided by logic models. These a priori logic models informed entry of independent variables in the analysis to help demonstrate how they may be causally related to the outcome measures (Malek et al., 2007). For example, a baseline model between SECs and child mental health were fitted first to establish the unadjusted independent

effect of the association before adjusting for factors such as maternal mental health. Hierarchical models are based on theoretical knowledge and therefore can provide informative and practical value (Malek et al., 2007; Field et al., 2012).

A key strength of both studies 2 and 3 was the use of an individual-level measure of socioeconomic conditions, measured during pregnancy (collected at recruitment to the study, 20-weeks gestation). Income and education are the most commonly used individual-level measures of SECs (Graham, 2007). The measure of SECs utilised in this thesis relied on self-reported household income. Mothers were asked "What is your approximate annual family income?", with responses collected in £10,000 incremental bands. Whilst this measure does not account for family size or resource allocation WCHADS recruited first-time mothers meaning the measure is likely to be more representative of income-to-need as it is a direct measure of material resources (Pizzi et al., 2020). A limitation of household income data is that it is often difficult to compare across studies and populations owing to the differing types of income, for example, gross or net household income (Pizzi et al., 2020).

Data on education was also collected in WCHADS. Respondents were asked to identify the highest level of education attained and by indicating the age at which they left full-time education. After assessing the distribution of this measure, it appeared that many respondents had potentially mis-interpreted the question, with participants appearing to state the age in which they may have entered or left education later on in life. For example, a respondent may have completed a qualification or returned to training later on in life. Consequently, I decided to use household income as the main individual-level measure of SEC in the analyses.

Area-level measures can also be used to measure socioeconomic conditions (Graham, 2007). In sensitivity analyses, IMD quintiles were used an alternative exposure measure. Whilst, respondents IMD score was also captured during pregnancy, area-level measures can lead to biased associations. Proxy measures are likely to underestimate the effect due to measurement error, arising from all individuals in an area having the same score regardless of how material resources may differ (Galobardes et al., 2007).

A key strength of the studies was the use of repeated measures of both maternal and child mental health in the early years. All measures of mental health collected are validated and widely used in clinical settings. Child mental health was measured by the internationally used Child Behaviour Checklist (Achenbach, 199; Ivanova et al., 2010) and maternal mental health measured using the Edinburgh Postnatal Depression Scale (Cox et al., 1987). Caution must be shown when utilising checklist measures compared to clinical diagnosis as these measures are likely to be influenced by the individual's own interpretation of their health and of their child's social and emotional behaviours.

Study 2 used modern longitudinal analysis approaches to explore trajectories of child mental health from 3.5 to 9 years of age. Linear mixed effects models allow for investigation of effects of interest between and within study individuals. Furthermore, these methods compensate for issues of cohort attrition by estimating the outcomes measure in a drop-out free population (Diggle, 2002). Whilst Study 2 used repeated outcome measurements at 4 different time points and assessed linear time trends, more frequent follow up would be needed to explore other time trends. Sensitivity analyses explored a possible quadratic time trend and a three-way interaction between variables of interest.

Study 3 used hierarchical linear models to assess the association between SECs and child mental health outcomes at five years of age. Additionally, two approaches to mediation analysis were used to investigate the role of maternal mental health as a potential mediator of the association between SECs and child mental health (Baron & Kenny, 1986; VanderWeele, 2015). Analyses used exposure data collected in the pre-natal period, measures of a validated maternal mental health across the perinatal period and a validated, widely used outcome measure of child mental health. This approach helped to investigate causal pathways and increased reliability and validity of observed effect estimates of this relationship.

Additionally, whilst every effort has been taken to limit the effects of confounding on the study results, the possibility of unobserved confounding explaining the results of Study 2 and 3 cannot be completely ruled out. Nevertheless, the results of Study 2 and 3 have been extensively evaluated within the context of previous literature, and the findings are broadly consistent with those of previous studies and plausible explanations for inequalities in child externalising behaviour problems have been identified.

To increase reliability in the study findings, I also conducted sensitivity analyses to test model assumptions (Appendix 5 & 6). I modelled an alternative exposure measure, for example, using an area-level measure of deprivation instead of an individual-measure. Furthermore, I used validated cut-offs of clinical mental health scores (study 3) (Achenbach & Rescorla, 2000) and also explored z-scores (Study 2) to assess reliability and validity of the main analyses. Reassuringly, similar associations were found across the sensitivity analyses.

The studies in this thesis have utilised robust and modern statistical methods to investigate socioeconomic inequalities in child mental health outcomes. I have utilised systematic review methods and data synthesis tools such as harvest plots. I have utilised cross-sectional and longitudinal statistical methods to investigate social inequalities in a dataset previously not analysed from a health equities perspective. Consequently, this allows for further investigation of inequalities in other child health and development outcomes utilising the rich measures available in the dataset.

7.5 Implications for Policy and Practice

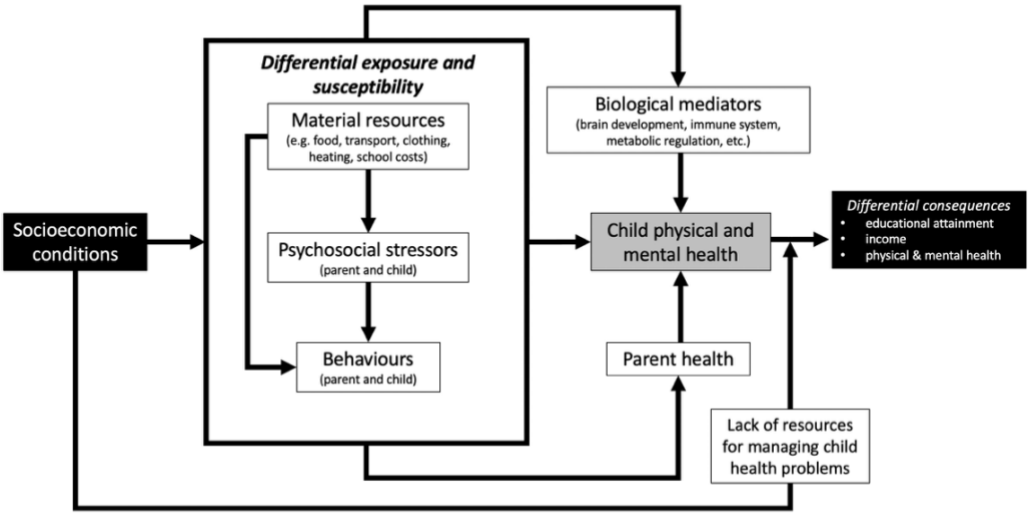
Having explored the findings of this thesis and critiqued the methods that have been used, I will evaluate the implications of the findings for current policy and practice in the UK.

The Diderichsen model helps to highlight potential policy and intervention entry points that can targeted to reduce inequalities in child mental health outcomes. Diderichsen's model of the mechanisms of health inequalities has provided a theoretical framework to the studies presented in this thesis (Diderichsen et al., 2001). Previously, there has been limited application of this model to child mental health. As discussed in Chapter 2, this model outlines the potential mechanisms, in which wider social and policy contexts and social position might influence health outcomes and subsequently, health inequalities. The model encapsulates how an individual's social position may determine their exposure to risks and vulnerability to ill health Furthermore, the model also outlines how the potential for differential consequences of ill health by SECs lead to further social disadvantage. For example, the consequences of poor mental health may be more detrimental for those already in disadvantaged social positions, with effects on education and employment later in the lifecourse (Hale & Viner, 2018).

The studies presented in this thesis have explored the mechanisms of health inequality proposed in Diderichsen's model, in the context of child mental health outcomes. All studies showed evidence of the harmful effects of social stratification, whereby, poorer social economic conditions in the perinatal period leads to increased risk of the development of mental health problems. Study 3 explicitly assessed the effect of differential exposure of maternal mental health on subsequent children's mental health at five years of age. The study found that poorer maternal mental health at any point in the perinatal period was associated with increased scores for externalising behaviour problems.

Figure (7.1) outlines the findings of this thesis as applied to the Diderichsen model. This model can also be viewed in relation to the "rainbow model" of the social determinants of health (discussed in Chapter 2). A range of exposures that can influence health outcomes are likely to be differentiated due to social stratification. Socioeconomic factors (from social and policy context) act "upstream" to influence the main social determinants of health, which influence "downstream" behaviours. For example, parental education and income might influence access to better health promotion behaviours such as seeking support from perinatal services.

Figure 7.1: Diderichsen model adapted to child mental and physical health outcomes (Mason et al., 2021).



The studies in this thesis have primarily explored the effects of social stratification (socioeconomic conditions in the early years) and differential exposure (perinatal maternal mental health) on child mental health outcomes. These exposures are also not temporally fixed, they are likely to be distributed over the life course. There remain key exposures and risks that are likely not captured in this thesis but also have adverse effects on child health outcomes. Children exposed to early life risk factors and adverse childhood experiences such as domestic violence, parental divorce, parental drug and alcohol misuse, physical and verbal maltreatment have been shown to have poorer health outcomes later in life (Hughes et al., 2017; Straatmann et al., 2019; Straatmann et al., 2020). Additionally, disadvantaged children are likely to be at greater risk of experiencing these detrimental risk factors (Walsh et al., 2019; Straatmann et al., 2020).

Although I have used this model explicitly to explore child outcomes, it is worth noting that these effects are not independent and are likely to be reciprocal with the caregiver. For example, Study 3 found that disadvantaged mothers had increased depressive symptomology across the perinatal period. This in turn, was associated with poorer child mental health scores and consequently, could lead to further problems for the caregiver.

This thesis has presented that exposures in the early years are particularly important, not only for healthy child development, but social position in later life. These effects may also interact with each other over the life course and it may be difficult to separate out their effects. Applying the Diderichsen model (Diderichsen et al., 2001) helps to highlight policy and intervention points that can be targeted to tackle

inequalities in child mental health outcomes. Next, I will explore policies and interventions that have been implemented to address these issues and provide recommendations.

Policies to address health inequalities and more specifically, child mental health, need to target three key areas:

1. Policies are needed "upstream" to address the wider social determinants of health and reduce social stratification
2. Policies and interventions are needed to decrease differential exposure and susceptibility of risk factors by supporting families in the perinatal and early-years periods
3. Prevent unequal consequences through the provision of key and effective services to tackle the burden of child mental health

Upstream policies to address the wider social determinants of health and reduce social stratification

The influential Strategic Review of Health Inequalities in England post 2010 "Fair Society, Healthy Lives" (also known as the Marmot Review 2010) suggests that in order to reduce health inequalities upstream action must be taken across all the social determinants of health (Marmot et al., 2010). The review placed particular emphasis on policies addressing inequalities in the early years of a child's life. For example, targeting early child development, educational outcomes and looking to skill acquisition and employment. Furthermore, policies should seek to improve neighbourhood conditions and invest in health and social services (Marmot et al., 2010; WHO, 2020). Furthermore, action is needed across the whole of society, not only to reduce the effects of poverty on health outcomes but to reduce social gradients (Marmot, 2013; WHO, 2020). The review proposes that health actions follow a 'proportionate universalism' approach whereby universal policies are delivered with a scale and intensity that is proportionate to the level of social disadvantage (Marmot et al., 2010). This "upstream" approach would likely help to tackle and reduce inequalities in child mental health, as show in this thesis, inequalities in mental health outcomes likely arise from wider socially patterned factors that compromise healthy child development.

As previously explored in this thesis (Chapter 2), there are concerns over the increased prevalence and widening inequalities of mental health problems in children and young people in the UK. This suggests that since 2010 there has been little progress in addressing the recommendation of the Strategic Review of Health Inequalities in England post 2010. An updated review was commissioned and published to assess any progress made over the previous ten years. The updated review "Health Equity in England: The Marot Review 10 Years On" highlights that there are worrying indications that there are widening social inequalities in mental wellbeing in the UK (Institute of Health Equity, 2020). The UK has one of the highest rates of child poverty in OECD. The rates of child poverty have risen, with approximately

four million children now living in poverty. These rates are projected to increase with current measures and have been described as 'systematic' and 'tragic' (OHCHR, 2019).

Additionally, in parallel to the rising rates of child poverty funding for children's services have fallen. Spending on services has fallen by £3 billion (30% reduction) across local authorities between 2010 and 2018. For example, spending on Sure Start was reduced by two-thirds in 2019 compared to 2010, with approximately 500 centres closing. Consequently, the levels of funding remain below the OECD and EU averages (Institute of Health Equity, 2020). This decline in funding has hit the most vulnerable and disadvantaged hardest with rates falling five times faster than in the least deprived local authorities. Therefore, Marmot (2020) report recommends that spending on children's services should at a minimum meet the OECD average and child poverty reduced to 10%, with a particular focus on providing and improving the availability of quality early years services (Institute of Health Equity, 2020).

Policies and interventions are needed to support families in the perinatal and early-years periods

Policies and investment to support families in the perinatal period and early-years are vital to address inequalities in child mental health outcomes. As shown in this thesis, policies targeting maternal mental health can help reduce inequalities in early child mental health outcomes but will not eradicate them solely.

Perinatal mental health problems cost the UK £8.1 billion for each one-year birth cohort (Bauer et al., 2014). The effects of poor maternal mental health are long lasting, with approximately three-quarters of this cost relating to adverse impacts on the child rather than the mother (Bauer et al., 2014). Furthermore, the prevalence of perinatal mental health problems is high with one in five women experiencing depression in the perinatal period (Schmeid et al., 2013). It is also estimated that around 60% of women are not currently detected or clinically diagnosed (Gavin et al., 2015). Action is needed to reduce the prevalence of mental health problems and reduce the economic and health burden.

Whilst a £365 million investment into perinatal services across England was welcomed, there is still wide variation in accessibility and quality of key services (NHS England, 2018). A landmark report exposed the lack of services across England to deliver specialised parent-infant support. Presently, there are only 27 specialised parent-infant relationship teams across the UK, meaning that there is a large gap in service provision, with potentially the families most in need of support currently not able to access these services (Parent Infant Partnership, 2020).

The report further highlights the need to invest in services delivered within the first 1001 days of a child's life. Bauer et al. (2022) further suggests that investment into a 'integrated model of care' which includes dedicated maternal mental health training for health visitors and midwives could lead to cost savings to the NHS of £490 million (£437 million in improvement to women's quality of life) over the next ten years.

The NHS Long Term Plan (2019) stated the intention to address the current provision gap in specialist perinatal mental health services. The plan outlines the commitment of a fixed spending of £2.3 billion per year to the overall mental health budget, with £239 million spend on specialist community perinatal mental health teams in 2023/24 (NHS, 2019). Furthermore, delivery of increased access to specialist services was noted as a fixed ambition. By introducing community care from pre-conception to 24 months it is hoped support will reach a further 66,000 women by 2023/24. Additionally, availability of evidence-based psychological therapies will be increased (NHS, 2019).

Identifying mothers at risk of perinatal mental health problems is pertinent to offer support and relevant therapies which provide a healthy environment for both mother and child. Population-level screening is one approach to this. However, caution must be exercised in employing screening measures on a large scale. NICE guidelines currently state that screening tools be used as part of full assessment of individuals suspected to be at risk (NICE, 2014). Furthermore, the choice of screening tool is important as even well validated and freely accessible tools such as the Edinburgh Postnatal Depression Scale possess variation in sensitivity and specificity which can be costly for healthcare providers.

A randomised control trial exploring the risks and benefits of web-based health e-screening compared to paper-based screening in pregnant women found that low income, previous treatment for depression or anxiety, or first pregnancy, were more likely to perceive greater risk in disclosing mental health concerns to a prenatal care provider (Kingston et al., 2017). Furthermore, as risk is higher in lower SES mothers, screening should not stigmatise and lead to further inequalities in uptake of existing support (Sills et al., 2007; Davidsen et al., 2021).

Mothers with mental health problems are less likely to take up preventative public health services (Osam et al., 2020). A systematic review of the barriers to accessing mental health services for women with perinatal mental illness found that there was often a complex interplay of individual (perceived stigma, poor awareness), cultural (language), organisational (service fragmentation) and wider structural barriers (unclear policy) (Smith et al., 2019). Stigma and victimisation may also prevent mothers with mental health problems reaching out for support. Shribman & Billingham (2009) found that mothers with severe mental health problems fail to access appropriate support when needed due to

fear that their child may be placed into care. Consequently, there are inequalities in the number of hurdles faced by mothers and that these barriers are likely to further exacerbate inequalities.

Barriers to support also increase economic pressures on the health system. Hope et al., (2021b) found that maternal mental health problems were associated with increased child healthcare used in both primary and secondary care settings. This resulted in an excess annual cost to the NHS of £656 million, with the majority of excess costs related to care in the first year of life. Multilevel strategies are needed to address existing barriers to support (Smith et al., 2019). This suggests that whilst additional funding is welcome, this alone will not reduce accessibility to required support and risks increasing inequalities.

Quickly addressing maternal perinatal mental health is vital, however, care should be exercised in ensuring fair access across the whole population. Targeted interventions aimed at specific population sub-groups should not increase inequalities. The inclusion of an offering of assessment of partners of women accessing specialist community care for their mental health and signposting to support is welcomed and signifies a step to providing care across the family and not just targeted at mothers (NHS, 2019).

Support and investment in the perinatal period should not be limited to parental mental health. Programmes that promote quality parent-child relationships will help aid healthy child development. Spending on interventions to improve early child development can bring returns of investment of as much as thirteen times the original investment (UNICEF, 2019). Parenting programmes offer a potential route to influence child health outcomes by promoting positive environments, health promotion behaviour and help families build resilience, which can reduce stresses in the family environment (McAvoy et al., 2013).

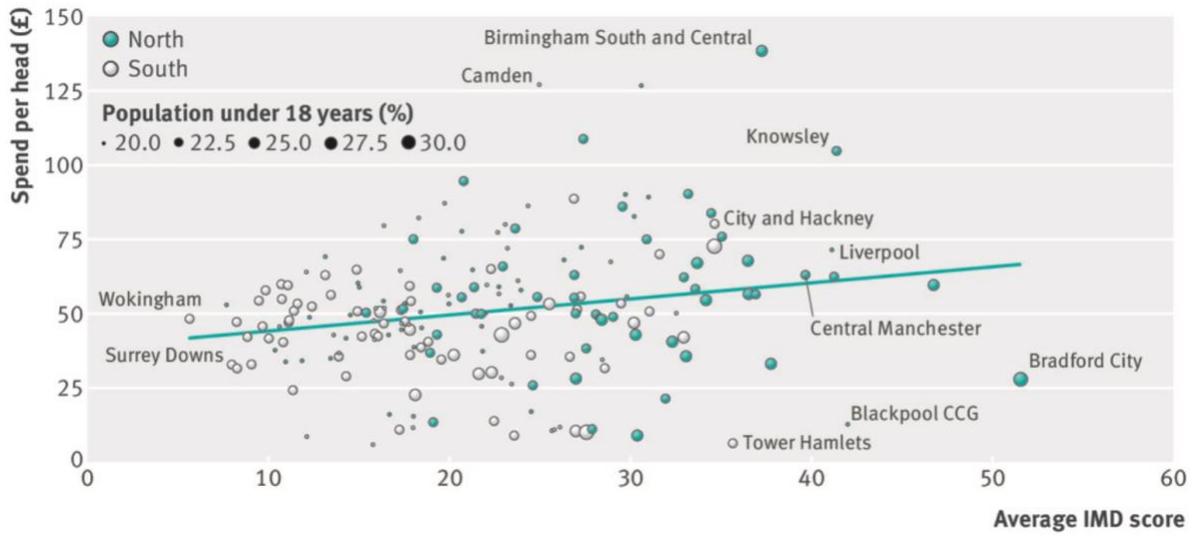
A review of 23 parenting interventions offered across Europe found that programmes that offered intensive psycho-education support and home visits to develop parent's and children's skills showed more favourable outcomes (Morrison et al., 2014). The review found that whilst delivering parenting programmes in disadvantaged areas can help reduce health inequalities in later life, only two of the programmes delivered a proportionate universalism approach. The authors therefore suggest that parenting interventions should be designed to address issues across the whole social gradient and to also address those most at risk (Morrison et al., 2014). Furthermore, a recent study using data from a UK birth cohort, found that implementing and scaling up, both universal non-intensive and targeted intensive parenting programmes can reduce inequalities in child mental health (Hope et al., 2021a).

Provision of key and effective services to tackle the burden of child mental health

To address inequalities in child mental health outcomes there also needs to be appropriate levels of service provision that offer high quality and accessible care. Much emphasis has been placed on the need for 'place based' health and care services. Whilst there have been repeated pledges for increased funding for mental health services, many services are struggling to meet the demand and cope the pressures placed on them. This particularly the case with child and adolescent mental health services since there have a rising number of mental health case referrals for children under the age of 18 years (Children's Commissioner, 2021). This is particularly problematic for services in more disadvantaged areas since social deprivation is strongly associated with child mental health outcomes.

As shown by an analysis I previously conducted, there is wide variation in spending by clinical commission groups on children and young people's mental health services (Rutherford & Taylor-Robinson, 2017). Figures (7.2 & 7.3) uses publicly accessible data to illustrate the extent of variation in forecasted CCG spend.

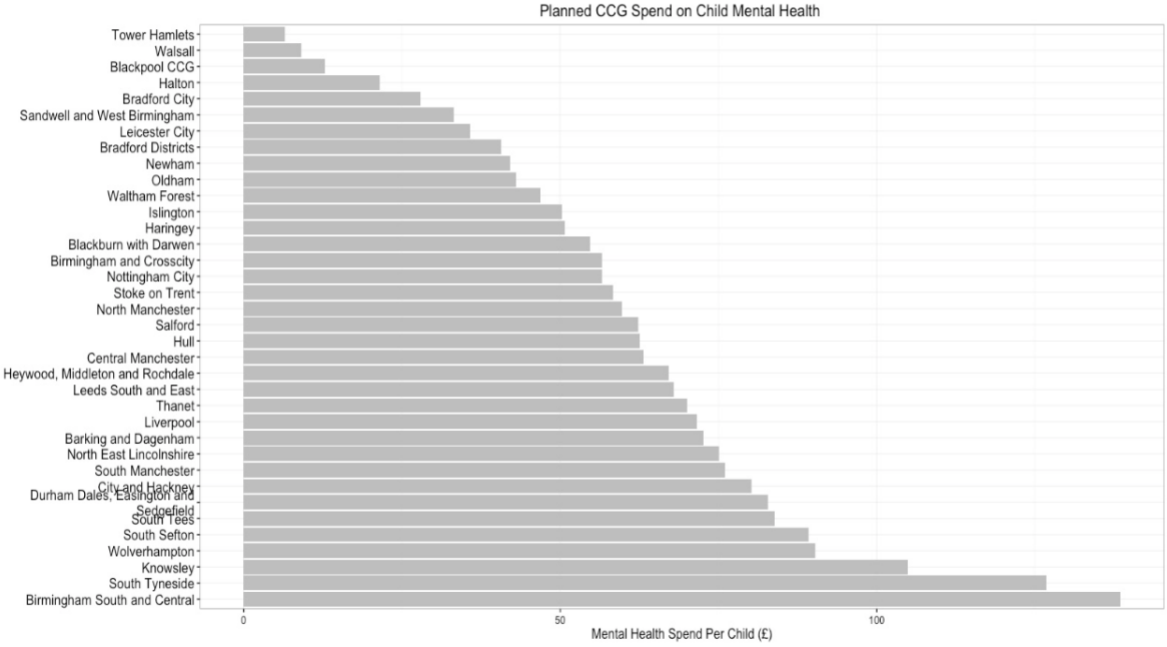
Figure (7.2) Association between social deprivation at the CCG level, measured by average IMD score and spend per head in child and adolescent mental health services (Rutherford & Taylor-Robinson, 2017).



Spend per head is only weakly associated with higher levels of deprivation. Whilst there is a positive linear relationship between social deprivation and spend per head, whereby more money is spent in more deprived areas, there remains stark unexplained variation. This suggests that there is a potential 'postcode lottery' in effect for service availability. Consequently, with high levels of unexplained variation, this suggests that there is not a current social determinant approach as the driving factor behind how money is distributed at a higher level and subsequently spent by CCGs. As the plot shows

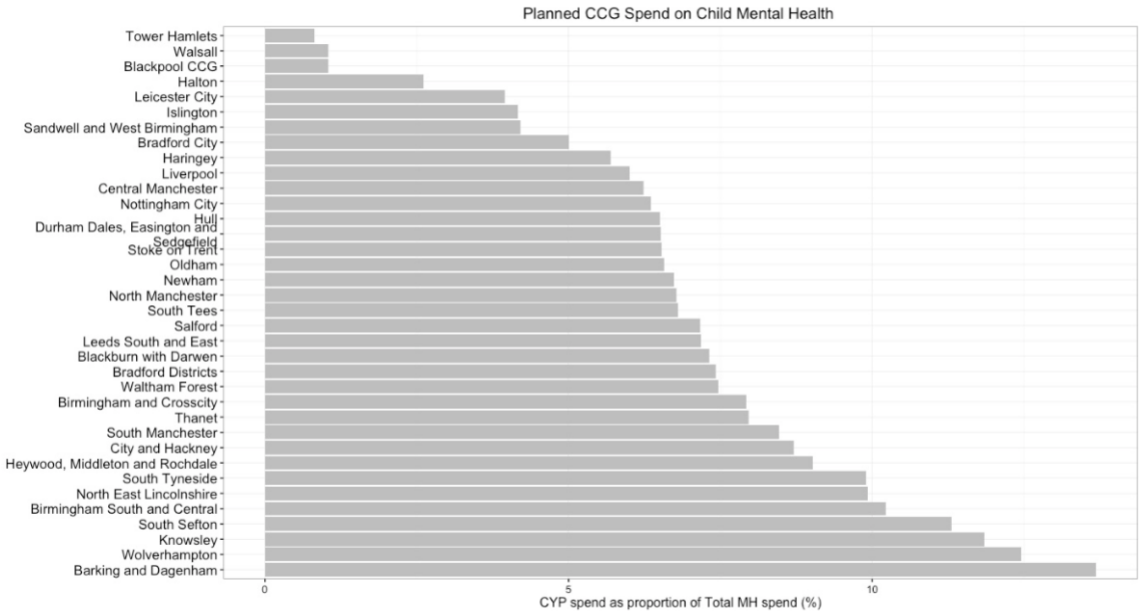
there is a stark difference in the levels of spending across areas with similar deprivation scores. This disjointed approach to spending and resource allocation is likely to increase mental health inequalities.

Figure (7.3) Distribution of mental health spend per child across a sub-sample of the most deprived CCGs in England.



The figure above is modelled on a sub-sample comprising of the most deprived local authorities. The distribution is highly skewed showing that despite the need for high levels of mental health funding in deprived areas there are stark differences. For example, Tower Hamlets forecasted a spend per head of £6.45 compared to Birmingham South and Central with a forecasted spend of £138.48. Despite similar levels of social deprivation, a child living within Birmingham South and Central CCG could access services spending over 20 times the amount on child mental health services compared to a child living in the Tower Hamlets. This huge gulf in variation only serves to widen already existing inequalities in mental health outcomes. This figure shows that there is a 'postcode lottery' in terms of service expenditure, therefore, large differences in quality and availability of service provision.

Figure (7.4) Distribution of spend on children and young people's mental health services as a proportion of spend on total mental health services. The data is a subsample of the most socially deprived CCGs determined by average IMD score.



Like the previous figure, there is stark variation among CCGs in how much money is allocated to children and young people's services. Despite evidence of the increasing need for investment in children's mental health, the figures above suggest that these services are not getting the required levels of investment. Despite the calls for a greater intervention needed in the early years, only a small proportion is being invested in crucial services. For example, Tower Hamlets CCG was forecasting to allocate just 0.85% of its mental health budget to children and young people's services. Consequently, the calls from researchers for decision makers to adopt a lifecourse and social determinants approach to health is not being adopted and driving decision making on child mental health spending.

Over the last five years there have been small improvements to address the issues of investment and accessibility of services. For example, the government planned a £300 million budget to invest in school-based mental health support (Department for Health & Department of Education 2017). However, large scale systemic challenges remain. Spending on specialist mental health services for children and young people have increased across 82% of CCGs, however, this investment translates to only a 4% increase in real terms (Children's Commissioner, 2022). Analysis of NHS data found that referrals to children's mental health services increased by 35% in 2019/20, whilst the number accessing treatment only increased by 4% (Children's Commissioner, 2021).

Despite Government announcements and pledges to address these issues here has been little improvement in children's mental health. Greater levels of investment are needed to tackle the increasing prevalence of mental health problems and subsequent pressures on NHS services. The NHS Long Term Plan (2019) set a benchmark of 1% of a CCGs budget on children and young people's

mental health services. Currently, only half of CCGs are meeting this target Furthermore, on average, CCGs spend fourteen-times more on adult mental health services (Children's Commissioner, 2022). The studies in this thesis have shown the importance of investing in the early years and propose that a benchmark spending of 1% is not adequate enough to address the growing burden of child mental health problems.

Worryingly, the demand on children has never been higher. In 2018/2019, there were approximately 400,000 children and young people referred to mental health services, with only one-fifth entering treatment within six weeks. Strikingly, a third of children and young people were still waiting on treatment by the end of the year (Children's Society, 2020). The long-term effects of the COVID-19 pandemic are yet to be seen, however, inequalities and demand on services are likely to be exacerbated, owing to increasing family stresses, financial difficulties and decreasing physical access to services (Morris & Fisher, 2022). As highlighted in the recent Child of the North: Building a fairer future after COVID-19 report (2021), the pandemic has been of particular difficulty to children in the North of England. Children spent more time in lockdown, were exposed to greater levels of household financial insecurity which has caused an increase in mental health problems, particularly in boys (Pickett et al., 2021).

Improving NHS specialist child services are only a part of the solution. A wider system approach is needed that incorporates schools and the voluntary sector (Picket et al., 2021). School-based interventions with policies that promote mental health and well-being are essential. Marmot (2010) promotes the important role schools have in children developing resilience to challenging and changing environments. The report suggested that in order to tackle inequalities and improve well-being of children and young people schools, families and communities needed to work together. NHS England announced that 400 mental health support teams to cover 3,000 schools in England in order to support 3 million pupils would be established by 2023 (NHS, 2021).

Mental health problems that emerge in early childhood are likely to persist if left untreated. With a focus on school-based approaches population-level screening of children to identify children at risk of developing mental health problems may offer insight for public health interventions and healthcare services.

Essex (2009) proposed a screening strategy as part of a larger public health approach to improving child mental health problems which aims to reduce the costs and maximise benefits of universal, targeted and clinic strategies (Offord et al., 1998). Using a sample of school-aged children in the USA found that universal school-based screening could improve detection of children who would likely benefit from support. Specifically, this approach could efficiently identify children at risk of comorbid symptoms

who would then qualify for clinical follow up to assess suitability for intervention (Essex et al., 2009). Whilst this approach may appeal to public health professionals and healthcare providers a population-level approach must be situated within the costs of operating (Offord et al., 1998). Screening at this level would also rely on high participation levels and participation may be lowest in population groups most at risk further increasing inequalities.

Furthermore, Najman et al. (2008) suggested caution is warranted when screening in early childhood for later mental health problems. In a longitudinal study of over 2500 young adults, screening at age 5 years performed poorly. The Child Behaviour Checklist was found to have sensitivities of 25% for major depression and 18% for anxiety disorders at 21 years of age.

Mental health screening in schools is a sensitive issue which has proven controversial, raising both ethical and practical concerns (Kratochwill, 2007; Dowdy et al., 2010). Concerns relate to consent for screening and how to adequately respond to any potential increases in demand for healthcare services and utilisation (Dowdy et al., 2010). Furthermore, screening could lead to further inequalities as interventions may focus only on specific cohorts of children deemed at risk and neglecting universal approaches to address the wider determinants of health. For example, the Troubled Families agenda adopted by many local authorities required interventions to place families at the centre, with family environment seen as the biggest anti-poverty measure (Lambert & Crossley, 2016). The most disadvantaged families were subsequently the main targets of the Troubled Families agenda and this led to further stigmatisation (Lambert & Crossley, 2016).

Screening for early mental health problems can be beneficial and highlight areas that require further support and investment. However, any population-level screening must be exercised cautiously as not to further marginalise population groups, create barriers to support and increase inequalities. For example, evidence from adult studies show that ethnic minority groups have an overwhelming negative experience of mental health services (Picket et al., 2021). Any approach to identifying children at risk of mental health should be guided by a proportionate universalism approach to ensure the wider social determinants of health are addressed.

In summary, the long-term solution to health inequalities is broader action on the social determinants of health. These are the conditions in which we are ‘born, grow up, work and live’ (Marmot, 2010). Unfortunately, limited progress has been made on reducing social inequalities in health outcomes and there is a very serious upcoming challenge in addressing increasing inequalities in child mental health. Reducing the consequences of social disadvantage by focusing on early years development is vital. As stated by the Chief Medical Officer (2012) “it makes sense to intervene early.” Policies that action on

the following would help achieve this (Marmot, 2010; Chief Medical Officer, 2012; Institute of Health Equity, 2020; Picket et al., 2021):

- Reduce the high rates of child poverty
- Adopt a proportionate universalism approach across all policies
- Monitor levels of child social disadvantage through quality routine data
- Increase surveillance of child and young people's mental health, particularly in the early years and with an emphasis on the longer-term impacts of COVID-19
- Increase and protect investment in the early years
- Shift expenditure towards the early years
- Provide high quality and accessible support and services for parents during pregnancy and in the first 1001 critical days
- Increase provision of high-quality universal services in childhood
- Improve access and provision of NHS specialist services for children and adolescent mental health

As Michael Marmot stated in 2010:

"Giving every child the best start in life, is our highest priority".

7.6 Conclusions

This thesis has assessed the association of SECs and child mental health problems in the early years and has explored potential explanations for the inequalities identified. Firstly, a systematic review of the literature identified strong evidence of the association between SECs and mental health problems in preschool aged children across high income countries. Furthermore, the review highlighted this association is observable across multiple measures of SECs and mental health. The results showed that the strength of association varied across populations, age and measures, suggesting that pathways to inequalities in mental health outcomes are not simple, with complex mechanisms at play.

Analysis of the WCHADS study revealed that social inequalities in mental health problems are evident in preschool-aged children. Furthermore, longitudinal analysis showed that these inequalities widen over time. Additionally, maternal depressive symptomology, particularly in the prenatal period partially mediated this association, suggesting that action to reduce inequalities in child mental health should start before birth but cannot be achieved by solely focusing on maternal mental health.

Important consequences of child mental health problems such as mental health problems later in the life course, educational attainment and potential earning power will incur heavy economic burden for individual and societies. Evidence from this thesis suggests that these outcomes disproportionately

affect disadvantaged groups, and that disadvantage starts before birth. Worryingly, an increasing proportion of children in the UK are born into less optimum environments for healthy development. Inequalities in important developmental outcomes are likely to have adverse effects on health that are maintained through the life course.

Inequalities in child health outcomes are likely to arise from socially patterned environmental, psychological and material factors that compromise a healthy child development, such as exposure to parental mental health problems. This suggests that a broad and targeted approach is needed to tackle inequalities in child mental health. Current policies and interventions that are designed to reduce child mental health problems are unlikely to address the unequal consequences observed. The work in this thesis suggest that policies need to be informed by a social determinants of health approach, with interventions needed across all the social determinants of health.

7.7 Future Research

The studies in this thesis have highlighted a number of areas requiring further research. More knowledge is needed to better understand the mechanisms at play behind inequalities in mental health outcomes, particularly, in the early years. Additionally, more research is needed into unpicking the specific pathways for different child behavioural and emotional outcomes. The methods employed in this thesis could also be more widely applied to child mental health literature. Studies should proactively employ a health equity approach, by explicitly reporting on the differences in outcomes by socioeconomic conditions. If more studies adopted this approach, particularly, in early-years literature, there would be a greater weight of evidence to help create more appropriate policies and more effective interventions.

The work presented in this thesis has been conducted as part of a wider research programme. The NIHR CLAHRC NWC has been committed to reducing inequalities in health. The network has explored inequalities in mental health and public health outcomes with an emphasis on knowledge exchange, service delivery and implementation. It is hoped that work in this research programme will provide a greater understanding of mechanisms driving health inequalities not only across the North West of England but across the UK.

This thesis and the studies conducted within it have enhanced my knowledge and understanding of inequalities in health and child mental health problems. I have gained a valuable skill set in performing systematic reviews, analysing data and writing for publication. I will continue to use these skills and expand on them in my future work tackling the issue of health inequalities. I would like to expand on studies in this thesis with an emphasis on exploring potential pathways to inequalities in child mental health outcomes, for example, parenting quality and paternal mental health, an area that is currently overlooked.

Additionally, I intend to continue disseminating the work of this thesis through conferences and publications. Furthermore, communicating this research and engaging with a wider audience is an important aspect of the overall research project. With the growing body of evidence on health inequalities and the further understanding of social inequalities in child mental health, added by the studies in this thesis, it is vital, to advocate for actions to reduce these social inequalities. Publications that have arisen from this thesis are presented in the appendix.

7.8 Reflections on the PhD experience

Undertaking this research has been an invaluable experience. I have developed skills and experience in conducting rigorous and robust academic research in the field of public health. I have developed a wide range of research and statistical skills, from conducting a systematic review to using longitudinal methods such as linear mixed effects. I have had the opportunity to develop analytical skills in statistical software packages, such as R.

Furthermore, I had the opportunity to be a part of the Wirral Child Health and Development Study research team and help with data collection. This was a particularly memorable experience, providing an insight in to how a community birth cohort study is conducted and to understand where, and how, the data utilised in this thesis are generated. This was a special experience as the study and its participants are situated within my local community.

Supported by a PhD studentship from NIHR CLAHRC, I was actively involved in a large collaborative research network with a common aim to tackle health inequalities. This network provided vast opportunities to develop my research, collaborative working and networking skills. Furthermore, the guidance and encouragement of fellow PhD students, academics and clinicians enhanced my research and PhD experience.

If I were to undertake this PhD again, I would have liked to have analysed data from multiple longitudinal studies and conduct comparative research across birth cohort studies. Although, this was not possible, I was able to support and engage with fellow PhD students and academics on other projects using other child health datasets.

Following on from this research, I plan to utilise established research networks to share findings and promote collaborative learning and research on socioeconomic inequalities in early years child mental health. Furthermore, I will expand on the findings of this thesis and explore the role of potential modifiable risk and protective factors. I will continue to advocate for children's health and well-being as well as for policies to tackle health inequalities.

References

Achenbach TM, McConaughy SH, Howell CT, et al. (1987). Child and Adolescent Behavioral and Emotional Problems - Implications of Cross-Informant Correlations for Situational Specificity. *Psychological Bulletin;* 101(2):213–232.

Achenbach, T. M., & Rescorla, L. A. (2000). Manual for the ASEBA preschool forms & profiles. Burlington, VT: University of Vermont.

Achenbach TM, Rescorla LA (2001). Manual for the ASEBA School-Age Forms & Profiles. Burlington, VT: University of Vermont, Research Centre for Children, Youth, and Families; 2001.

Adams NL, Rose TC, Hawker J, et al. (2018) Relationship between socioeconomic status and gastrointestinal infections in developed countries: A systematic review and meta-analysis. *PLoS ONE* 13(1): e0191633.

Aiken CE, & Ozanne, S. E. (2013): Transgenerational developmental programming. *Human Reproduction Update*. 20(1): 63-75.

Aked (2007). Child Poverty in Perspective: An Overview of Child Well-Being in Rich Countries. UNICEF Innocenti Research Centre, Innocenti Report Card.

Allen, G. (2011). Early intervention: the next steps. *London: HM Government*.

Allen, J., Balfour, R., Bell, R., & Marmot, M. (2014). Social determinants of mental health. *International Review of Psychiatry*, *26*(4), 392-407.

Allin S, Stabile M. (2012). Socioeconomic status and child health: what is the role of health care, health conditions, injuries and maternal health? *Heal Econ Policy Law* 7: 227–242.

All-Party Parliamentary Group (APPG) for Conception to Age 2. 2013: The 1001 critical days: the importance of the conception to age two period. Accessible: http://www.1001criticaldays.co.uk/UserFiles/files/1001_days_jan28_15_final.pdf

Amone-P'Olak, K., Burger, H., Ormel, J., et al (2009). Socioeconomic position and mental health problems in pre-and early-adolescents. *Social Psychiatry and Psychiatric Epidemiology*, *44*(3), 231-238.

Angold, A., & Costello, E. J. (1996). The relative diagnostic utility of child and parent reports of oppositional defiant behaviours. *International Journal of Methods in Psychiatric Research*, *6*(4), 253–259.

Angold, A., Costello, E., Farmer, E. M., Burns, B. J., & Erkanli, A. (1999). Impaired but undiagnosed. *Journal of the American Academy of Child & Adolescent Psychiatry*, *38*(2), 129-137.

Angold & Egger (2006). Common emotional and behavioural disorders in preschool children: presentation, nosology and epidemiology. *Child Psychology & Psychiatry* 47: 313-337.

Arango, C., Díaz-Caneja, C, McGorry, P. et al. (2018). Preventive strategies for mental health. *The Lancet Psychiatry*, *5*(7), 591-604.

Arcaya MC, Arcaya AL, Subramanian S (2015). Inequalities in health: definitions, concepts, and theories. *Global Health Action* 8:27106.

Asaria M, Doran T, Cookson R. (2016). The costs of inequality: whole-population modelling study of lifetime inpatient hospital costs in the English National Health Service by level of neighbourhood deprivation, *JECH:* doi:10.1136/jech-2016-207447.

Awasthi, P., Das, A., Sen, R., et al. (2021). On the benefits of maximum likelihood estimation for Regression and Forecasting. *arXiv preprint arXiv:2106.10370*.

Badri M, Al Qubaisi A, Al Rashedi A et al. (2014). The causal relationship between parental involvement and children's behavioural adjustment to KG-1 schooling. *International Journal of Child Care and Education Policy* 8(1):3

Bandoli, G., Palmsten, K., Chambers, C (2018) Revisiting the Table 2 fallacy A motivating examining preeclampsia and preterm birth. *Paediatric and Perinatal Epidemiology* 32: 390-397.

Baranne ML, Falissard B. (2018). Global burden of mental disorders among children aged 5-14 years. *Child & Adolescent Psychiatry Mental Health.*12:12:19.

Barican JL, Yung D, Schwartz C, et al., (2022) Prevalence of childhood mental disorders in high-income countries: a systematic review and meta-analysis to inform policymaking. *Evidence-Based Mental Health*; 25:36-44.

Barker, E. D., Jaffee, S. R., Uher, R., & Maughan, B. (2011). The contribution of prenatal and postnatal maternal anxiety and depression to child maladjustment. *Depression and Anxiety*, *28*(8), 696-702. doi:10.1002/da.20856; 10.1002/da.20856

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*(6), 1173–1182.

Batty GD, Der G, Macintyre S, Deary IJ. (2006). Does IQ explain socioeconomic inequalities in health? Evidence from a population-based cohort study in the west of Scotland. *Journal* of *British Medicine*, 332:580–584.

Bauer A, Parsonage M, Knapp M, et al, (2014). The costs of perinatal mental health problems. Centre Mental Health.

Bayer, J. K., Hiscock, H., Ukoumunne, O. C., et al. (2008). Early childhood aetiology of mental health problems: a longitudinal population-based study. *Journal of Child Psychology and Psychiatry*, *49*(11), 1166-1174.

Beijersbergen MD, Juffer F, Bakermans-Kranenburg MJ, et al. (2012). Remaining or becoming secure: parental sensitive support predicts attachment continuity from infancy to adolescence in a longitudinal adoption study. *Developmental Psychology* 48(5):1277.

Belsky, J. (1984). The determinants of parenting: A process model. *Child Development*, 83- 96.

Belsky, J., Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2007). For better and for worse: Differential susceptibility to environmental influences. *Current directions in psychological science*, *16*(6), 300-304.

Black D, Morris JN, Smith C, et al. (1980) Inequalities in Health: Report of a Research Working Group (The Black Report). London: Department of Health and Social Security.

Blakely, T. (2002). Commentary: estimating direct and indirect effects—fallible in theory, but in the real world?. *International Journal of Epidemiology*, *31*(1), 166-167.

Blakely T, Disney G, Atkinson J., et al. (2017). A typology for charting socioeconomic mortality gradients: "go southwest". *Epidemiology*. 28(4):594–603.

Blaxter L, Hughes C, Tight M (2010) How to Research (4th edition). Maidenhead: Open University Press/McGraw-Hill Education.

Bøe T, Skogen JC, Sivertsen B., et al. (2017) Economic volatility in childhood and subsequent adolescent mental health problems: a longitudinal population-based study of adolescents. *BMJ Open* 2017;**7:**e017030.

Boland, A., Cherry, G. & Dickinson, R. (2014) Doing a systematic review: a student's guide. SAGE: London.

Bongers, I. L., Koot, H. M., van der Ende, J., & Verhulst, F. C. (2003). The normative development of child and adolescent problem behavior. *Journal of Abnormal Psychology, 112*(2), 179–192.

Bor, W et al. (1997). "The Relationship between Low Family Income and Psychological Disturbance in Young Children: An Australian Longitudinal Study." *The Australian and New Zealand Journal of Psychiatry* 31(5): 664–75.

Bowlby J. (1973) Attachment and loss: separation. New York: Basic Books; 1973.

Bowlby J. (1988). Attachment, communication, and the therapeutic process. A secure base: Parent-child attachment and healthy human development 137–157.

Braithwaite EC, Pickles A, Sharp H, Glover V, O'Donnel KJ, Tibu F. (2017): Maternal prenatal cortisol predicts infant negative emotionality in a sex-dependent manner. *Physiol Behav*. 175: 31-36.

Braveman P, Gottlieb L (2014) The Social Determinants of Health: It's Time to Consider the Causes of the Causes. *Public Health Reports*, 129 (Supplementary 2):19–31.

Briggs-Gowan MJ, Carter AS. (2002). *Brief Infant-Toddler Social and Emotional Assessment (BITSEA) manual, version 2.0.* New Haven, CT: Yale University.

Bronfenbrenner U. (1979). The ecology of human development: Experiments by nature and design. Cambridge, MA: Harvard University Press.

Bronfenbrenner U (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology* 22(6):723

Brooks-Gunn, J., & Duncan, G. J. (1997). The Effects of Poverty on Children. *The Future of Children, 7*(2), 55–71. https://doi.org/10.2307/1602387

Brunner E, Marmot M. (2005) 'Social organization, stress, and health', in Marmot M, Wilkinson RG (eds.) Social determinants of health (2nd edition). New York: Oxford University Press: 6–31.

Carneiro A, Dias P, Soares I. (2016) Risk Factors for Internalizing and Externalizing Problems in the Preschool Years: Systematic Literature Review Based on the Child Behavior Checklist 1½–5. *J Child Fam Stud.*

Caspi A**,** McClay J, Moffitt TE, et al. (2002). Role of genotype in the cycle of violence in maltreated children. *Science,* 297:851–854.

Caspi, A., Hariri, A. R., Holmes, A., Uher, R., & Moffitt, T. E. (2010). Genetic sensitivity to the environment: The case of the serotonin transporter gene and its implications for studying complex diseases and traits. *The American Journal of Psychiatry, 167*(5), 509-527.

Centre for Disease Control (2022). What is child mental health? Available here: https://www.cdc.gov/childrensmentalhealth/basics.html (Accessed: 15/04/2022).

Centre for Reviews and Dissemination (2008). Guidance for undertaking reviews in health care. Available here: https://www.york.ac.uk/media/crd/Systematic_Reviews.pdf (Accessed: 15/01/2016).

Chen CY. (2017) Effects of parental chronic illness on children's psychosocial and educational functioning: A literature review. *Contemporary School Psychology*. 21(2):166-76.

Chief Medical Officer (2013) Annual Report: Public mental health priorities investing in evidence. Available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/413196/CMO_web_doc.pdf

Child Poverty Act (2010). Child Poverty Act Legislation. Available here: https://www.legislation.gov.uk/ukpga/2010/9/pdfs/ukpga_20100009_en.pdf (Accessed: 18/05/2016).

Children's Commissioner (2021) The state of children's mental health services 2019/20. Available here: https://www.childrenscommissioner.gov.uk/wp-content/uploads/2021/01/occ-the-state-of-childrens-mental-health-services-2019-20.pdf (Accessed: 12/05/22)

Children's Commissioner (2022) 1 year as Children's Commissioner March 2021 to March 2022. Available here: https://www.childrenscommissioner.gov.uk/wp-content/uploads/2022/03/cco-1-year-as-childrens-commissioner.pdf

Children's Society (2015). The Good Childhood Report 2015. Available here: http://www.childrenssociety.org.uk/sites/default/files/tcs/good_childhood_report_2012_final_0.pdf

Children's Society (2020). Waiting in Line Report. Available here: https://www.childrenssociety.org.uk/information/professionals/resources/waiting-line

Chittleborough CR, Baum FE, Taylor. A, et al., (2006) Life-course approach to measuring socioeconomic position in population health surveillance systems. *Journal of Epidemiology & Community Health*. 60(11):981-92.

Christensen, D., Fahey, M. T., Giallo, R., & Hancock, K. J. (2017). Longitudinal trajectories of mental health in Australian children aged 4-5 to 14-15 years. *PLoS One*, *12*(11), e0187974.

Ciciolla, L., Gerstein, E. D., & Crnic, K. A. (2014). Reciprocity among maternal distress, child behavior, and parenting: transactional processes and early childhood risk. *Journal of clinical child and adolescent psychology: the official journal for the Society of Clinical Child and Adolescent Psychology, American Psychological Association, Division 53*, *43*(5), 751–764.

Coie, J. D., & Dodge, K. A. (1998). Social, emotional, and personality development. In W. Damon, & N. Eisenberg (Eds.) Handbook of child psychology (5th ed., pp. 779-862). Vol. 3 Hoboken, NJ: John Wiley & Sons.

Collishaw, S., & Sellers, R. (2020). Trends in child and adolescent mental health prevalence, outcomes, and inequalities. *Mental health and illness of children and adolescents*, 63-73.

Comeau J, Boyle MH (2017). Patterns of poverty exposure and children's trajectories of externalizing and internalizing behaviors. *SSM Population Health.* 2017 Dec 7;4:86-94.

Conger RD, Conger KJ, Elder Jr GH, et al. (1992). A family process model of economic hardship and adjustment of early adolescent boys. *Child Development* 63(3):526-41.

Cooper K, Stewart K. Does Money Affect Children's Outcomes? A Systematic Review. York: Joseph Rowntree Foundation, 2013.

Cox JL, Holden JM, Sagovsky R. (1987). Detection of postnatal depression: Development of the 10-item Edinburgh Postnatal Depression Scale. *Br J Psychiatry*. 150: 782–786.

Cummings, E. M., & Davies, P. (1994). Children and marital conflict: The impact of family dispute and resolution. Guilford Press.

Dahlgren, G. & Whitehead, M. (2007). European strategies for tackling social inequities in health: Levelling up Part 2. *Copenhagen: World Health Organization*.

Davidsen, KA, Christiansen, E, Haubek, D, et al. (2021). Parental mental illness, attendance at preventive child healthcare and dental caries in the offspring: a nation-wide population-based cohort study. *Social Psychiatry Epidemiology;* 56(4): 583–92.

Davies P, & Windle, M. (1997) Gender specific pathways between maternal depressive symptoms, family discord, and adolescent adjustment. *Developmental Psychology* 33(4): 657-668.

Davis EP, Glynn LM, Schetter CD, Hobel C, Chicz-Demet A, Sandman CA. (2007): Prenatal exposure to maternal depression and cortisol influences infant temperament. *J Am Acad Child Adolesc Psychiatry*. 46(6):7 37-746.

Davis, E. et al. (2010). "Socioeconomic Risk Factors for Mental Health Problems in 4-5-Year-Old Children: Australian Population Study." *Academic Paediatrics* 10(1): 41–47.

Dean K, Stevens H, Mortensen PB. et al. (2010). Full spectrum of psychiatric outcomes among offspring with parental history of mental disorder. *Archives of General Psychiatry*. 67(8):822-9.

Deighton J, Lereya ST, Casey P, et al (2019). Prevalence of mental health problems in schools: poverty and other risk factors among 28 000 adolescents in England. *Br J Psychiatry.* 30;215(3):1-3.

de Lijster, J. M., van den Dries, M. A., van der Ende, J., et al. (2019). Developmental trajectories of anxiety and depression symptoms from early to middle childhood: A population-based cohort study in the Netherlands. *Journal of Abnormal Child Psychology*, 47(11), 1785-1798.

Department of Education & Skills (2003). Every Child Matters. London: Department of Education and Skills. Available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/272064/5860.pdf (Accessed: 17/06/2016).

Department of Health (1998). Independent inquiry into inequalities in health (the Acheson Report) Available here: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4097582 (Accessed: 14/06/2016).

Department of Health (1999). Reducing Health Inequalities: An Action Report. London: Department of Health.

Department of Health (2007) Wirral Health Profile 2007. Available here: https://www.wirralintelligenceservice.org/media/2245/health-profile-for-wirral-2007.pdf .

Department of Health (2011). No Health without Mental Health; A cross-government mental health outcomes strategy for people of all ages. London: Department for Health.

Department of Health (2014). Closing the Gap: Priorities for essential change in mental health. London: Department for Health.

Department of Health (2015). Future in Mind: promoting, protecting and improving our children and young people's mental health and wellbeing. London: Department of Health.

Department of Health and Social Care (2013). The best start for life: a vision for the 1001 critical days. London: Department of Health and Social Care. Available here: https://www.gov.uk/government/publications/the-best-start-for-life-a-vision-for-the-1001-critical-days

Department of Health and Social Care & Department for Education (2017). Transforming children and young people's mental health provision: a green paper. London: Department of Health and Social Care.

Department for Work and Pensions (2018). Households Below Average Income: 1994/95 to 2016/17. Available here: https://www.gov.uk/government/statistics/households-below-average- income-199495-to-201617.

Department for Work and Pensions (2020). Households below average income (HBAI) statistics. Available here: https://www.gov.uk/government/collections/households-below-average-income-hbai--2

Diderichsen, F., Evans, T. & Whitehead, M. (2001). The social origins of disparities in health. *Challenging inequities in health.* New York: Oxford University Press.

Diderichsen F, Hallqvist J, Whitehead M. (2018) Differential vulnerability and susceptibility: how to make use of recent development in our understanding of mediation and interaction to tackle health inequalities. *International Journal of Epidemiology*. 268–274.

Diggle, P., Heagerty, P., Liang K.-Y, et al. (2002). Analysis of Longitudinal Data (second edition), Oxford, Oxford University Press.

Dowdy, E., Ritchey, K. & Kamphaus, R.W (2010) School-Based Screening: A Population-Based Approach to Inform and Monitor Children's Mental Health Needs. *School Mental Health* 2, 166–176

D'Souza, S., Underwood, L., Peterson, E. et al. (2019). Determinants of persistence and change in early childhood behavioural problems: The roles of parenting and maternal mental health. *Journal of Child and Family Studies*, *28*(7), 1826-1842.

D'Souza, Stephanie et al. (2019b). "Persistence and Change in Behavioural Problems during Early Childhood." *BMC Paediatrics* 19(1): 1–10.

Ebesutani, C., Bernstein, A., Nakamura, B., et al. (2010). Concurrent validity of the Child Behavior Checklist *DSM*-oriented scales: correspondence with *DSM* diagnoses and comparison to syndrome scales. *Journal of Psychopathology and Behavioral Assessment, 32*, 373–384.

Elder, G., Caspi A. (1988) Economic stress in lives – Developmental Perspectives. *Journal Social Issues*; 44(4): 25-45.

Elsenburg, L., Rieckmann, A., Nguyen, T-L., et al., (2022). Mediation of the parental education gradient in early adult mortality by childhood adversity: a population-based cohort study of more than 1 million children. *Lancet Public Health.* 7(2):e146-155.

Erskine HE, Baxter AJ, Patton G, et al., (2017) The global coverage of prevalence data for mental disorders in children and adolescents. *Epidemiology and Psychiatric Sci*ences 26: 395–402.

Essex, M. J., Kraemer, H., Armstrong, J. et al. (2006). Exploring risk factors for the emergence of children's mental health problems. *Archives of General Psychiatry, 63*(11), 1246-1256.

Essex, M. J., Kraemer, H. C., Slattery, M. J., et al., (2009). Screening for childhood mental health problems: outcomes and early identification. *Journal of child psychology and psychiatry, and allied disciplines*, 50(5), 562–570.

Fanti KA, Henrich CC (2010). Trajectories of pure and co-occurring internalizing and externalizing problems from age 2 to age 12: findings from the National Institute of Child Health and Human Development Study of Early Child Care. *Developmental Psychology*. 46(5):1159-75.

Field A, Miles J, Field Z (2012) Discovering Statistics Using R. London: Sage.

Field, F. (2010). *The Foundation Years: preventing poor children becoming poor adults*, The Stationery Office/Tso.

Fisher SD, Brock RL, O'Hara MW, Kopelman R, Stuart S (2013). Longitudinal contribution of maternal and paternal depression to toddler behaviors: Interparental conflict and later depression as mediators. *Couple Fam Psychol Res Pract.* 4: 61–73.

Fitzmaurice, G. & Ravichandran, C. (2008). A primer in longitudinal data analysis. *Circulation*, 118, 2005-10.

Fitzsimons, E., Goodman, A., Kelly, E., & Smith, J. P. (2017). Poverty dynamics and parental mental health: Determinants of childhood mental health in the UK. *Social Science & Medicine*, *175*, 43-51.

Flouri, E., Mavroveli, S and Tzavidis, N (2010.) Modelling Risks: Effects of Area Deprivation, Family Socioeconomic Disadvantage and Adverse Life Events on Young Children's Psychopathology." *Social Psychiatry and Psychiatric Epidemiology* 45(6): 611–19.

Flouri, E., Mavroveli, S and Tzavidis, N (2012). Cognitive Ability, Neighborhood Deprivation, and Young Children's Emotional and Behavioral Problems. *Social Psychiatry and Psychiatric Epidemiology* 47(6): 985–92.

Flouri E, Midouhas E, Joshi H. (2014). Family poverty and trajectories of children's emotional and behavioural problems: the moderating roles of self-regulation and verbal cognitive ability. *Journal of Abnormal Child Psychology*. 42(6):1043-56.

Flouri, E., & Ioakeimidi, S. (2018). Maternal depressive symptoms in childhood and risky behaviours in early adolescence. *European Child & Adolescent Psychiatry*, *27*(3), 301-308.

Foresight Mental Capital and Wellbeing Project (2008). Final Project report. The Government Office for Science, London.

Galobardes B., Lynch, J. & Smith, G. (2007). Measuring socioeconomic position in health research. *British Medical Bulletin*, 81-82, 21-37.

Garratt, K, Laing, J, Long, R. (2022). Support for children and young people's mental health (England). London: House of Commons Library.

Gavin NI, Meltzer-Brody S, Glover V, Gaynes BN. (2015) Is Population-Based Identification of Perinatal Depression and Anxiety Desirable? [Internet]. Identifying Perinatal Depression and Anxiety.

GBD 2019 Mental Disorders Collaborators (2019). Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Psychiatry* 9(2): 137-150.

Gelfand DM, Teti DM. (1990). The effects of maternal depression on children. *Clinical psychology review.* 10(3):329-53.

Gelfand LA, Mensinger JL, Tenhave T. (2009) Mediation analysis: a retrospective snapshot of practice and more recent directions. J Gen Psychol. Apr;136(2):153-76.

Gibson, J, McKenzie-McHarg, K, Shakespeare, J, et al., (2009). A systematic review of studies validating the Edinburgh Postnatal Depression Scale in antepartum and postpartum women. *Acta Psychiatrica Scandinavica* 119(5): 350-364)

Goodman R. (1997) The Strengths and Difficulties Questionnaire: A Research Note. *Journal of Child Psychology and Psychiatry*, 38:581-586.

Goodman SH, Rouse MH, Connell AM et al. (2011). Maternal Depression and Child Psychopathology: A Meta-Analytic Review. *Clinical Child & Family Psychology Review*.14: 1–27.

Gotlib, I. H., Lewinsohn, P. M., & Seeley, J. R. (1995). Symptoms versus a diagnosis of depression: Differences in psychosocial functioning. *Journal of Consulting and Clinical Psychology*, *63*(1), 90-100.

Graham H (2004) Social determinants and their unequal distribution: clarifying policy understandings. Milbank Q, 82(1):101–24.

Graham H (2007) Unequal Lives: Health and Socioeconomic Inequalities. Maidenhead: Open University Press/McGraw-Hill Education.

Green H., McGinnity, A., Meltzer, H. (2005) Mental health of children and young people in Great Britain, 2004. Office for National Statistics. Available here: http://www.northlanmindsetorg.uk/documents/Mental%20Health%20of%20Children%20and%20Young%20People%20in%20Great%20Britain_2004.pdf (Accessed: 16/03/2017).

Green, M. (2018) Latent Profiles of Early Developmental Vulnerabilities in a New South Wales Child Population at Age 5 Years. *The Australian and New Zealand Journal of Psychiatry* 52(6): 530–41.

Greenhalgh T (2010) How to Read a Paper: The basics of evidence-based medicine (4th edition). Chichester: Wiley-Blackwell/BMJ Books.

Gridley, N., Blower, S., Dunn, A. et al. (2019) Psychometric Properties of Child (0–5 Years) Outcome Measures as used in Randomized Controlled Trials of Parent Programs: A Systematic Review. *Clinical Child &Family Psychology Review* 22**,** 388–405

Gross, H. E., Shaw, D. S., Burwell, R. A., & Nagin, D. S. (2009). Transactional processes in child disruptive behavior and maternal depression: A longitudinal study from early childhood to adolescence. *Development and Psychopathology, 21*(1), 139-156.

Gunnell, D., Kidger, J., & Elvidge, H. (2018). Adolescent mental health in crisis. *BMJ 361*.

Hafeman, D. M. (2011). Confounding of indirect effects: a sensitivity analysis exploring the range of bias due to a cause common to both the mediator and the outcome. *American Journal of Epidemiology*, *174*(6), 710-717.

Hale, D. R., & Viner, R. M. (2018). How adolescent health influences education and employment: investigating longitudinal associations and mechanisms. *Journal of Epidemiology and Community Health*, *72*(6), 465–470. https://doi.org/10.1136/jech-2017-209605

Halfon, N & Hochstein, M. (2003). Life course health development: An integrated framework for developing health, policy and research. *Milbank Quarterly* 80:433-479.

Halle et al., (2018) Measuring social and emotional development in children from birth to age 3. San Francisco: WestEd.

Hartman CA, Rhee SH, et al. (2007). Modelling rater disagreement for ADHD: are parents or teachers biased? *J Abnorm Child Psychology*; 35(4):536–542.

Hernández-Alava M, Popli G (2017). Children's development and parental input: evidence from the UK millennium cohort study. *Demography*. 54(2):485-511.

Hetherington, E. McDonald, S. Racine, N, et al., Risk and Protective Factors for Externalizing Behavior at 3 Years: Results from the All Our Families Pregnancy Cohort." *Journal of Developmental and Behavioral Pediatrics* 39(7): 547–54.

Hicks BM**,** South SC**,** DiRago AC**,** Iacono WG**,** McGue M (2009). Environmental adversity and increasing genetic risk for externalizing disorders. *Arch Gen Psychiatry* 2009; **66**:640–648.

Hill, C. (2010) *An evaluation of screening for postnatal depression against NSC criteria.* National Screening Committee.

Hill, J., Harrington, R., Fudge, H., Rutter, M., & Pickles, A. (1989). Adult personality functioning assessment (APFA). an investigator-based standardised interview. *The British Journal of Psychiatry, 155*(1), 24-35.

Hill, J., Fudge, H., Harrington, R., Pickles, A., & Rutter, M. (2000). Complementary approaches to the assessment of personality disorder: The personality assessment schedule and adult personality functioning assessment compared. *The British Journal of Psychiatry, 176*, 434-439.

Hill, J. (2002). Biological, psychological and social processes in the conduct disorders. *Journal of Child Psychology and Psychiatry, 43*(1), 133-164.

Hoff, E, Laursen, B & Tardif, T (2002) Socioeconomic Status and Parenting. In: Bornstein M, ed. *Handbook of Parenting: Biology and Ecology of Parenting.* Vol 2. 2nd ed. New Jersey: Lawrence Erlbaum Associates: 231-252.

Holmes J, Kiernan K (2013). Persistent poverty and children's development in the early years of childhood. *Policy Polit.* 41: 19–42.

Hood A, Waters T. (2017). Living standards, poverty and inequality in the UK: 2017–18 to 2021–22.

Hope, H., Osam, C., Kontopantelis, E., et al. (2021b). The healthcare resource impact of maternal mental illness on children and adolescents: UK retrospective cohort study. *The British Journal of Psychiatry, 219*(3), 515-522.

Hope, S., Rougeaux, E., Deighton, J., et al (2018). Mental health competence at age 11 and its association with risk taking behaviours at age 14. doi:10.1136/jech-2018-SSMabstracts.64

Hope, S., Pearce, A., Cortina-Borja, M. et al. (2021) Modelling the potential for parenting skills interventions to reduce inequalities and population prevalence of children's mental health problems: Evidence from the Millennium Cohort Study. *SSM Population Health* 14:100817

Hudson G (2005). Socioeconomic status and mental illness: tests of the social causation and selection hypotheses. *Am J Orthopsychiatry*; 75(1): 3-18.

Hughes K, Bellis MA, Hardcastle KA, et al., (2017). The effect of multiple adverse childhood experiences on health: a systematic review and meta-analysis. *Lancet Public Health.* 2(8):e356-e366.

Institute of Health Equity (2020) Health equity in England: The Marmot Review 10 years on. Available here: https://www.health.org.uk/sites/default/files/upload/publications/2020/Health%20Equity%20in%20England_The%20Marmot%20Review%2010%20Years%20On_full%20report.pdf (Accessed: 17/06/2020).

Ivanova MY, Achenbach TM, Rescorla LA, et al (2010). Preschool psychopathology reported by parents in 23 societies: Testing the seven-syndrome model of the child behavior checklist for ages 1.55. *Journal of American Child Adolescent Psychiatry*. 49: 1215–1224.

Jaffee, S. R., Strait, L. B., & Odgers, C. L. (2012). From correlates to causes: Can quasi- experimental studies and statistical innovations bring us closer to identifying the causes of antisocial behavior? *Psychological Bulletin, 138*(2), 272-295.

Joffres, M, Jaramillo, A, Dickinson, J, et al., (2013). Recommendations on screening for depression in adults. CMAJ; 185:775-82. doi:10.1503/cmaj.130403.

Johnson, JG., Cohen, P, Dohrenwend BP, et al., (1999). A longitudinal investigation of social causation and social selection process involved in the association between socioeconomic status and psychiatric disorders. *Journal of Abnormal Psychology*; 108(3): 490-499.

Judge, L. (2012). Ending Child Poverty by 2020: Progress made, and lessons learned.

Kaplan GA, Pamuk ER, Lynch JW, et al. (1996) Inequality in income and mortality in the United States: analysis of mortality and potential pathways. *Journal of British Medicine*, 312:999–1003.

Kawabata Y, Alink LR, Tseng WL, et al. (2011). Maternal and paternal parenting styles associated with relational aggression in children and adolescents: A conceptual analysis and meta-analytic review. *Developmental Review* (4):240-78

Keenan, B. M., Newman, L. K., Gray, K. M. et al. (2016). Parents of children with ASD experience more psychological distress, parenting stress, and attachment-related anxiety. *Journal of Autism and Developmental Disorders*, *46*(9), 2979-2991.

Kendler KS**,** Kessler RC**,** Walters EE**,** et al. (1995). Stressful life events, genetic liability, and onset of an episode of major depression in women. *Am J Psychiatry* 1995;152(6):833–842.

Kerr DCR, Lunkenheimer ES, et al. (2007). Assessment of child problem behaviors by multiple informants: a longitudinal study from preschool to school entry. *Journal of Child Psychology and Psychiatry;* ;48(10):967–975.

Kessler, RC., Berglund, P., Demler, O, et al. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, *62*(6), 593-602.

Kessler RC, Amminger GP, Aguilar-Gaxiola S, et al. (2007) Age of onset of mental disorders: a review of recent literature. *Current Opinion Psychiatry* 20:359–64

Kessler RC, McLaughlin KA, Green JG. et al. (2010) Childhood adversities and adult psychopathology in the WHO World Mental Health Surveys. *British Journal of Psychiatry.* 197(5):378-85.

Khan KS, Kunz R, Kleijnen J, et al. (2003) Five steps to conducting a systematic review. J R Soc Med, 96(3):118–21.

Kieling C, Baker-Henningham H, Belfer M, Conti G, Ertem I, Omigbodun O, Rohde LA, Srinath S, Ulkuer N, Rahman A. Child and adolescent mental health worldwide: evidence for action. Lancet 2011 Oct 22;378(9801):1515-25.

Kiernan KE, Huerta MC. (2008). Economic deprivation, maternal depression, parenting and children's cognitive and emotional development in early childhood. *British Journal of Sociology* 59: 783–806.

Kim-Cohen J**,** Caspi A**,** Taylor A**,** et al. (2006). MAOA, maltreatment, and gene–environment interaction predicting children's mental health: new evidence and a meta-analysis. *Mol Psychiatry* 11:903–913.

Kingston D, Tough S, Whitfield H. (2012). Prenatal and postpartum maternal psychological distress and infant development: a systematic review. *Child Psychiatry & Human Development.* 43(5):683-714.

Kingston D, Biringer A, Veldhuyzen van Zanten S, et al., (2017). Pregnant Women's Perceptions of the Risks and Benefits of Disclosure During Web-Based Mental Health E-Screening Versus Paper-Based Screening: Randomized Controlled Trial. *JMIR Ment Health*; 4(4):e42

Knapp, M., McDaid, D., & Parsonage, M. (2011). Mental health promotion and mental illness prevention: The economic case.

Kochanska, G., Friesenborg, A. E., Lange, L. A, et al., (2004). Parents' personality and infants' temperament as contributors to their emerging relationship. *Journal of Personality and Social Psychology, 86*(5), 744-759.

Konold TR, Walthall JC, et al. (2004). The behavior of child behavior ratings: Measurement structure of the child behavior checklist across time, informants, and child gender. *Behavioral Disorders*; 29(4):372–383.

Kratochwill, T. R. (2007). Preparing psychologists for evidence-based school practice: Lessons learned and challenges ahead. *American Psychologist, 62*, 829–843.

Krieger N. (2001). A glossary for social epidemiology: part II. *Journal of Epidemiology & Community Health*. 55:693–700.

Krieger N. (2011). Epidemiology and the people's health: theory and context. New York: Oxford University Press.

Kuh, D., Power, C., Blane, D. (2004). A life course approach to chronic disease epidemiology. In: Kuh, D., Power, C., Blane, D. & Bartley, M. (eds.) A life course approach to chronic disease epidemiology. Oxford University Press.

Kumsta, R., Rutter, M., Stevens, S., & Sonuga-Barke, E. J. (2010). IX: Risk, causation, mediation, and moderation. *Monographs of the Society for Research in Child Development, 75*(1), 187-211. doi:10.1111/j.1540-5834.2010.00556.x; 10.1111/j.1540- 5834.2010.00556.x

Kumsta, R., Kreppner, J., Rutter, M., et al. (2011). III. Deprivation-specific psychological patterns. *Monographs of the Society for Research in Child Development*, *75*(1), 48.

Lai E., Wickham S, Law C, et al. (2019). Poverty dynamics and health in late childhood in the UK: evidence from the Millennium Cohort Study. *Archives of Disease in Childhood;* 104**:**1049-1055.

Lai, E., Schluter, D., Lange, T., et al. (2020). Understanding pathways to inequalities in child mental health: a counterfactual mediation analysis in two national birth cohorts in the UK and Denmark. *BMJ OPEN*, 10(10). doi:10.1136/bmjopen-2020-040056

Lambert, M., & Crossley, S. (2017). 'Getting with the (troubled families) programme': A review. *Social Policy and Society, 16*(1), 87-97.

Lancaster CA, Gold KJ, Flynn HA. et al. (2010). Risk factors for depressive symptoms during pregnancy: a systematic review. *American Journal of Obstetrics & Gyn*a*ecology*. 202: 5–14.

Legerstee, Jeroen S et al. (2013). Gender-Specific Developmental Trajectories of Anxiety during Adolescence: Determinants and Outcomes. The TRAILS Study. *Journal of the Canadian Academy of Child and Adolescent Psychiatry* 22,1:26-34.

Lerner, R. (2003) What are SES effect of? A developmental systems perspective. In: Bornstein M & Bradley, R eds. *Socioeconomic status, parenting, and child development.* New Jersey: Lawrence Erlbaum Associates.

Levis B, Negeri Z, Sun Y, Benedetti A, Thombs B D (2020). Accuracy of the Edinburgh Postnatal Depression Scale (EPDS) for screening to detect major depression among pregnant and postpartum women: systematic review and meta-analysis of individual participant data. *BMJ*; 371 :m4022 doi:10.1136/bmj.m4022

Link BG, Phelan J. (1995). Social conditions as fundamental causes of disease. *Journal of Health Social Behavior* 35:80–94.

Lovejoy MC, Graczyk PA, O'Hare E, et al. (2000). Maternal depression and parenting behavior: A meta-analytic review. *Clinical Psychology Review.* 20(5):561-92.

Lupien SJ**,** King S**,** Meaney MJ**,** et al., (2000) Child's stress hormone levels correlate with mother's socioeconomic status and depressive state. *Biol Psychiatry*; 48(10):976–980

Lynch, J. W., & Kaplan, G. A. (1997). Understanding How Inequality in the Distribution of Income Affects Health. *Journal of Health Psychology*, 3:297–314.

Lynch J**,** Smith GD**,** Hillemeier M**,** et al., (2001). Income inequality, the psychosocial environment, and health: comparisons of wealthy nations. *Lancet*; 358(9277):194–200.

Mackenbach, J. (2011). Can we reduce health inequalities? An analysis of the English strategy (1997-2010). *Journal of Epidemiology & Community Health,* 65**,** 568-75.

MacKinnon DP, Fairchild AJ, Fritz MS. (2007) Mediation analysis. Annual Review Psychology. 58:593-614.

Malek MH, Berger DE, Coburn JW (2007) On the inappropriateness of stepwise regression analysis for model building and testing. *European Journal of Applied Physiology,* 101(2):263–4.

Mäntymaa M, Puura K, Luoma I, et al. (2012). Predicting internalizing and externalizing problems at five years by child and parental factors in infancy and toddlerhood. *Child Psychiatry Human Development.* 43(2):153-70.

Markon, K. E., Chmielewski, M., & Miller, C. J. (2011). The reliability and validity of discrete and continuous measures of psychopathology: A quantitative review. *Psychological Bulletin, 137*(5), 856-879.

Marmot, M., Shipley, M., Rose, G. (1984). Inequalities in death--specific explanations of a general pattern? *Lancet,* 1**,** 1003-6.

Marmot, M, SMITH, G., Stansfeld, S. et al. (1991). Health inequalities among British civil servants: the Whitehall II study. *Lancet, 337,* 1387-93.

Marmot M (2005) 'Introduction', in Marmot M, Wilkinson RG (eds.) Social determinants of health (2nd edition). New York: Oxford University Press: 1–6.

Marmot M., Allen, J., Goldblatt, P., et al. (2010). Fair society, healthy lives: Strategic review of health inequalities in England post-2010. The Marmot Review: London UK. 2010.

Marryat L, Thompson L, Minnis H, Wilson P (2017). Primary schools and the amplification of social differences in child mental health: a population-based cohort study. *Journal of Epidemiology & Community Health*. 1–7.

Mason KE, Alexiou A, Bennett DL, et al., (2021). Impact of cuts to local government spending on Sure Start children's centres on childhood obesity in England: a longitudinal ecological study. *Journal of Epidemiology & Community Health* 75:860-866.

Maughan, B. (2005). Developmental trajectory modeling: A view from developmental psychopathology. *The Annals of the American Academy of Political and Social Science, 602*(1), 118-130.

Mazza, J., Boivin, M., Tremblay, R., et al. (2016). Poverty and behavior problems trajectories from 1.5 to 8 years of age: Is the gap widening between poor and non-poor children? *Social Psychiatry and Psychiatric Epidemiology, 51*(8), 1083-1092.

McAvoy, H., Purdy, J., Sneddon, H., & Mac Evilly, C. (2013). Prevention and early intervention in children and young people's services: Child health and development.

McCartney, G., Popham, F., McMaster, R., & Cumbers, A. (2019). Defining health and health inequalities. *Public Health,* 172, 22–30.

McCrae, J. S., & Brown, S. M. (2018). Systematic Review of Social–Emotional Screening Instruments for Young Children in Child Welfare. *Research on Social Work Practice*, *28*(7), 767–788Medical Research Council (2017). MRC strategy for lifelong mental health research 2017. Available here: https://www.ukri.org/publications/mrc-strategy-for-lifelong-mental-health-research/

McLaughlin, K. A., & King, K. (2015). Developmental trajectories of anxiety and depression in early adolescence. *Journal of Abnormal Child Psychology*, *43*(2), 311-323.

McLearn KT, Minkovitz CS, Strobino DM., et al. (2006) The timing of maternal depressive symptoms and mothers' parenting practices with young children: implications for paediatric practice. *Pediatrics.* 118(1):e174-82.

Mcleod JD, Shanahan MJ. (1996). Trajectories of Poverty and Children's Mental Health. 37: 207–220.

Mind (2020). What is mental health? Available here: https://www.mind.org.uk/information-support/for-children-and-young-people/understanding-mental-health/ (Accessed: 10/04/2022).

Mitjans M**,** Arias B. (2012). The genetics of depression: what information can new methodologic aproaches provide? *Actas españolas de psiquiatría;* 40(2):70–83.

Moffitt, T. E. (1993). Adolescence-limited and life-course-persistent antisocial behavior: A developmental taxonomy. *Psychological Review, 100*(4), 674–701

Morgan, A. (2006). 'Determinants of Health', in Davies M, Macdowall W (eds.) Health Promotion Theory. Maidenhead: Oxford University Press: 49–63.

Morris, J & Fisher, E. (2022). Growing problems, in depth: The impact of COVID-19 on health care for children and young people in England. Available here: https://www.nuffieldtrust.org.uk/resource/growing-problems-in-detail-covid-19-s-impact-on-health-care-for-children-and-young-people-in-england

Morrison, J., Pikhart, H., Ruiz, M. et al. (2014). Systematic review of parenting interventions in European countries aiming to reduce social inequalities in children's health and development. *BMC Public Health* 14**,** 1040

Murray, L., Stanley, C., Hooper, R., King, F., & Fiori-Cowley, A. (1996). The role of infant factors in postnatal depression and mother-infant interactions. *Developmental Medicine & Child Neurology, 38*(2), 109-119.

Murray, L., & Cooper, P. (1997). Effects of postnatal depression on infant development. *Archives of Disease in Childhood, 77*(2), 99–101.

Murray L, Cooper PJ. (2002) Editorial: Postpartum depression and child development. *Psychology & Medicine.* 27: 253–260.

Murray L, Arteche A, Fearon P, et al. (2011). Maternal postnatal depression and the development of depression in offspring Up to 16 years of age. *Journal of American Child & Adolescent Psychiatry*. 50: 460–470.

Murray, A.L., Eisner, M., Nagin, D. *et al.* (2020) A multi-trajectory analysis of commonly co-occurring mental health issues across childhood and adolescence. *European Child Adolescent Psychiatry* 31**,** 145–159.

Murray, A. L., Ushakova, A., Speyer, L., et al. (2022). Sex/gender differences in individual and joint trajectories of common mental health symptoms in early to middle adolescence. *JCPP Advances, 2*(1), e12057.

Najman, J. et al. (2005). Predictors of Depression in Very Young Children-a Prospective Study. *Social Psychiatry and Psychiatric Epidemiology* 40(5): 367–74.

Najman, J., Heron, M, Hayatbakhshm M, et al., (2008) Screening in early childhood for risk of later mental health problems: A longitiudinal study. *Jounral of Psychiatric Research*; 42(8): 694-700.

National Institute for Health and Care Excellence (2014). *Antenatal and postnatal mental health: Clinical management and service guidance.* British Psychological Society.

NHS Digital (2017). Mental health of Children and Young People in England 2017. Available here: https://files.digital.nhs.uk/A6/EA7D58/MHCYP%202017%20Summary.pdf (Accessed: 14/03/2022).

NHS Digital (2020). Mental health of Children and Young People in England 2021. Available here: https://files.digital.nhs.uk/97/B09EF8/mhcyp_2021_rep.pdf (Accessed: 14/03/2022).

NHS England (2019) NHS Mental Health Implementation Plan 2019/20 – 2023/24. Accessible: https://www.longtermplan.nhs.uk/wp-content/uploads/2019/07/nhs-mental-health-implementation-plan-2019-20-2023-24.pdf

NHS England (2021). More than a million children given access to NHS mental health support at school. 2021; published online May 8. https://www.england.nhs. uk/2021/05/more-than-a-million-children-given-access-to-nhs-mental-health-support- at-school/.

Noble M, Wright G, Dibben C, et al. (2004) The English Indices of Deprivation 2004 (revised) Report to the Office of the Deputy Prime Minister. London: Neighbourhood Renewal Unit. Available here: http://webarchive.nationalarchives.gov.uk/20100410180038/http://www.communities.gov.uk/archived/publications/communities/indicesdeprivation

Odgers CL, Moffitt TE, Broadbent JM, et al. (2008). Female and male antisocial trajectories: from childhood origins to adult outcomes. *Developmental. Psychopathology* 20(2):673-716.

Office of High Commissioner on Human Rights (2020) United Nations Human Rights Report 2019. Available here: https://www.ohchr.org/sites/default/files/Documents/Publications/OHCHRreport2019.pdf

Offord DR, Kraemer HC, Kazdin AE, et al., (1998). Lowering the burden of suffering from child psychiatric disorder: Trade-offs among clinical, targeted, and universal interventions. *Journal of the American Academy of Child and Adolescent Psychiatry*; 37(7):686–694.

Ogilvie D, Fayter D, Petticrew M, et al. (2008) The harvest plot: A method for synthesising evidence about the differential effects of interventions. *BMC Medical Research Methodology*, 8:8.

Osam, CS, Matthias, P, Hope, H, Ashcroft, DM, Abel, KM. The influence of maternal mental illness on vaccination uptake in children: a UK population-based cohort study. *Eur J Epidemiol* 2020; 35: 879–89.10.1007/s10654-020-00632-5.

Palmer, F. et al. (2013). Early Adversity, Socioemotional Development, and Stress in Urban 1-Year-Old Children." *Journal of Pediatrics* 163(6): 1733-U291.

Palmer, F. et al. (2018). Socio-Demographic, Maternal, and Child Indicators of Socioemotional Problems in 2-Year-Old Children: A Cohort Study. *Medicine* 97(28): e11468.

Parent Infant Partnership UK (2020) Rare Jewels: Specialised parent-infant partnership teams in the UK. Available here: https://parentinfantfoundation.org.uk/our-work/campaigning/rare-jewels/#fullreport

Patalay, P; Fitzsimons, E; (2018) Development and predictors of mental ill-health and wellbeing from childhood to adolescence. *Social Psychiatry and Psychiatric Epidemiology*, 53 (12) 1311-1323.

Patterson, G, & Stouthamer-Loeber, M. (1984). The correlation of family management practices and delinquency. *Child Development* 55(4): 1299-1307.

Pearce A, Dundas R, Whitehead M, et al. (2019) Pathways to inequalities in child health. *Archives of Disease in Childhood* 104:998-1003.

Pearce A, Mason K, Fleming K, et al., (2020) WHO. Reducing inequities in health across the life-course: Early years, childhood and adolescence. Available here: https://www.euro.who.int/__data/assets/pdf_file/0008/457289/Reducing-inequities-in-health-across-the-life-course.pdf. 2020. (Accessed 17/03/2022).

Pickett, K. E., & Wilkinson, R. G. (2015). Income inequality and health: a causal review. *Social Science & Medicine*, *128*, 316-326.

Pickett K., Taylor-Robinson D., et al (2021) The Child of the North: Building a fairer future after COVID-19, the Northern Health Science Alliance and N8 Research Partnership.

Pickles, A., & Angold, A. (2003). Natural categories or fundamental dimensions: On carving nature at the joints and the rearticulation of psychopathology. *Development and Psychopathology*, *15*(3), 529-551

Pike A, Lervolino AC, Eley TC, et al. (2006) Environmental risk and young children's cognitive and behavioral development. *International Journal of Behavioral Development*. ;30: 55–66.

Pizzi, C., Richiardi, M., Charles, M. et al., (2020). Measuring Child Socioeconomic Position in Birth Cohort Research: The Development of a Novel Standardized Household Income Indicator. *International Journal of Environmental Research and Public Health*, *17*(5), 1700.

Pryor, L., Strandberg-Larsen, K., Nybo Andersen, A.-M., Hulvej Rod, N., & Melchior, M. (2019). Trajectories of family poverty and children's mental health: Results from the Danish National Birth Cohort. *Social Science & Medicine, 220,* 371–378.

Public Health England (2017) Wirral Health Profile 2017. Available here: https://www.wirralintelligenceservice.org/media/1442/wirral-health-profile-2017.pdf

Public Health England (2019) Wirral Health Profile 2019. Available here: https://fingertips.phe.org.uk/static-reports/health-profiles/2019/e08000015.html?area-name=wirral

Public Health England (2021) Wirral Child Health Profile 2021. Available here: https://www.wirralintelligenceservice.org/media/3341/child-health-profiles-wirral-march-2021.pdf

Radloff, L. S (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurements* 1:385-401.

Ravens-Sieberer, U., Wille, N., Erhart, M., et al. (2008). Prevalence of mental health problems among children and adolescents in Germany: results of the BELLA study within the National Health Interview and Examination Survey. *European Child & Adolescent Psychiatry*, *17*(1), 22-33.

Reiss F. (2013). Socioeconomic inequalities and mental health problems in children and adolescents: a systematic review. *Social Science & Medicine* 90:24-31.

Repetti R., Taylor, S, Seeman, T. (2002). Risk families: family social environments and the mental and physical health of offspring. *Psychology Bulletin*. 128(2): 330-336.

Reuben JD., Shaw DS, Neiderhiser JM, et al. (2016). Warm parenting an effortful control in toddlerhood: Independent and interactive predictors of school-age externalizing behavior. *Journal of Abnormal Child Psychology* (6):1083-96.

Richardson WS, Wilson MC, Nishikawa J, et al. (1995) The well-built clinical question: a key to evidence-based decisions [Editorial]. *ACP J Club*, 123(3):A12–3.

Richiardi L, Bellocco R, Zugna D (2013). Mediation analysis in epidemiology: Methods, interpretation and bias. *International Journal of Epidemiology*. 42: 1511–1519.

Rijlaarsdam, J. et al. (2013). Home Environments of Infants: Relations with Child Development through Age 3. *Journal of Epidemiology and Community Health* 67(1): 14–20.

Rivenbark, J. G., Odgers, C. L., Caspi, A., et al. (2018). The high societal costs of childhood conduct problems: evidence from administrative records up to age 38 in a longitudinal birth cohort. *Journal of Child Psychology and Psychiatry*, *59*(6), 703-710.

Robinson M, Oddy WH, Li J, Kendall GE, De Klerk NH, Silburn SR, et al. (2008) Pre- and postnatal influences on preschool mental health: A large-scale cohort study. *Journal of Child Psychology Psychiatry Allied Disciplines.* 49: 1118–1128.

Ross T (2012) A survival guide for health research methods. Maidenhead: Open University Press/McGraw-Hill Education.

Rowe D & Rodgers, J, (1997) Poverty and behavior: Are environmental measures nature and nurture? *Developmental Review;* 17(3): 358-375.

Rowe R**,** Maughan B**,** Worthman CM, et al., (2004). Antisocial behavior, and social dominance in boys: pubertal development and biosocial interaction. *Biol Psychiatry* **55**:546–552.

Rutherford, C. & Taylor-Robinson, D. (2017). Wide variation in child mental health spend in England. *BMJ (Clinical research ed.),* 356, j451.

Rutherford, C., Sharp, H., Hill, J., et al. (2019). How Does Perinatal Maternal Mental Health Explain Early Social Inequalities in Child Behavioural and Emotional Problems? Findings from the Wirral Child Health and Development Study." *PloS One* 14(5): e0217342.

Rutter, M., Pickles, A., Murray, R. et al. (2001). Testing hypotheses on specific environmental causal effects on behavior. *Psychological Bulletin*, *127*(3), 291.

Rutter, M. (2011). Research Review: Child psychiatric diagnosis and classification: concepts, findings, challenges and potential, *Journal of Child Psychology & Psychiatry* 52(6): 647-660.

Schmied V, Johnson M, Naidoo N, et al. (2013) Maternal mental health in Australia and New Zealand: A review of longitudinal studies. *Women and Birth*. Australian College of Midwives; 26: 167–178.

Schuring, M., Robroek, S. J., Otten, F. W., et al. (2013). The effect of ill health and socioeconomic status on labor force exit and re-employment: a prospective study with ten years follow-up in the Netherlands. *Scandinavian Journal of Work, Environment & Health*, *39*(2), 134–143.

Sentse M, Kretschmer T, de Haan A, et al. (2017). Conduct problem trajectories between age 4 and 17 and their association with behavioral adjustment in emerging adulthood. *Journal of Youth and Adolescence*. 46(8):1633-42.

Sharp, H., Pickles, A., Meaney, M., et al. (2012) Frequency of Infant Stroking Reported by Mothers Moderates the Effect of Prenatal Depression on Infant Behavioural and Physiological Outcomes. *PLoS ONE* 7(10):e45446.

Shaw, D. S., Lacourse, E., & Nagin, D. S. (2005). Developmental trajectories of conduct problems and hyperactivity from ages 2 to 10. *Journal of Child Psychology and Psychiatry*, *46*(9), 931-942.

Shribman, S., & Billingham, K. (2009). Healthy Child Programme: Pregnancy and the first five years of life. Department of Health.

Siegrist J, Marmot M (2006) 'Introduction', in Siegrist J, Marmot M (eds.) Social Inequalities in Health: New evidence and policy implications. New York: Oxford University Press: 1–27.

Sills, MR, Shetterly, S, Xu, S, et al. (2007). Association between parental depression and children's health care use. *Pediatrics*; 119(4): e829–36.

Singer, J. D. & Willet, J. B. (2003). Applied longitudinal data analysis: modeling change and event occurrence: modeling change and event occurrence, Oxford University Press, USA.

Smith KE, Bambra C, Hill S (2016) 'Background and introduction: UK experiences of health inequalities', in Smith KE, Bambra C, Hill S (eds.) Health Inequalities: Critical Perspectives. New York: Oxford University Press: 1–22.

Smith M, Lawrence V, Sadler E, et al. (2019). Barriers to accessing mental health services for women with perinatal mental illness: systematic review and meta-synthesis of qualitative studies in the UK *BMJ Open*; 9:e024803

Social Mobility & Child Poverty Commission (2014). State of the Nation 2014: Social mobility and child poverty in Great Britain. Available here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/367461/State_of_the_Nation_-_summary_document.pdf (Accessed: 13/07/2018).

Stone SL, Speltz ML, Collett B, Werler, MM. (2013). Socioeconomic Factors in Relation to Discrepancy in Parent versus Teacher Ratings of Child Behavior. *Journal Psychopathology Behavioral Assessment*. Sep 1;35(3):314-320.

Straatmann, V.S., Lai E, Lange T, et al. (2019). How do early-life factors explain social inequalities in adolescent mental health? Findings from the UK Millennium Cohort Study. *Journal of Epidemiology & Community Health.* 73(11):1049-1060.

Straatmann, V. S., Lai, E., Law, C., Whitehead, M., Strandberg-Larsen, K., & Taylor-Robinson, D. (2020). How do early-life adverse childhood experiences mediate the relationship between childhood socioeconomic conditions and adolescent health outcomes in the UK?. *Journal of Epidemiology & Community Health*, *74*(11), 969-975.

Strohschein L (2005). Household Income Histories and Child Mental Health Trajectories. *Journal of Health & Social Behaviors.* 46: 359–375.

Stuckler D, Reeves A, Loopstra R, et al., (2017). Austerity and health: the impact in the UK and Europe. *European Journal of Public Health*. 27(suppl_4):18-21.

Sullivan PF**,** Neale MC**,** Kendler KS (2000). Genetic epidemiology of major depression: review and meta-analysis. *Am J Psychiatry*; 157(10):1552–1562.

Sweeting H, Hunt K (2014). Adolescent socioeconomic and school-based social status, health and well-being. *Social Science & Medicine* 121:39–47.

Taylor-Robinson D, Whitehead M, Barr B. (2014). Great leap backwards. *BMJ* 349: g7350.

Taylor-Robinson, D., Pearce, A., Whitehead, et al. (2016). Social inequalities in wheezing in children: findings from the UK Millennium Cohort Study. *European Respiratory Journal*, 47(3), 818-828.

Taylor-Robinson D, Barr B (2017). Death rate now rising in UKs poorest infants. *BMJ* 2017; 357. DOI:10.1136/bmj.j2258

Taylor-Robinson D, Lai E, Bradshaw J, et al. (2018). Rise in mortality in England and Wales in first seven weeks of 2018: Death rate continues to rise for poorest infants in England and Wales. *BMJ*: 360

Tennant, R., Goens, C., Barlow, J., et al. (2007). A systematic review of reviews of interventions to promote mental health and prevent mental health problems in children and young people. *Journal of Public Mental Health*.

Thomson, Kimberly C et al. (2017). Profiles of Children's Social-Emotional Health at School Entry and Associated Income, Gender and Language Inequalities: A Cross-Sectional Population-Based Study in British Columbia, Canada. *BMJ Open* 7(7): e015353.

Thompson, R., Tabone, J., LitrowniK, A. et al., (2011) Early adolescent risk behaviour outcomes of child externalising behavioural trajectories. *Journal of Early Adolescence* 31(2): 234-257.

Tibu F, Hill J, Sharp H, Marshall K, Glover V, Pickles A. (2014): Evidence for sex differences in fetal programming of physiological stress reactivity in infancy. *Developmental Psychopathology;* 26(4): 879-888.

Tremblay, R., Boulerice, B, Harden, P. et al. (1996). Do children in Canada become more aggressive as they approach adolescence? In Human Resources Development Canada and Statistics Canada (Eds.), Growing up in Canada: National longitudinal survey of children and youth (pp. 127–137). Ottawa: Statistics Canada.

UNICEF (2019) World Bank and World Health Organisation Nurturing Care Framework.

United Nations (2008). UN Convention on the Rights of the Child (UNCRC). Unicef UK. Available here: https://www. unicef.org.uk/what-we-do/un-convention-child-rights/ (Accessed 12/05/2022).

Uphoff E, Cabieses B, Pinart M, et al. (2015). A systematic review of socioeconomic position in relation to asthma and allergic diseases. *European Respiratory Journal.* 46(2):364-74.

Van den Bergh B., Van Calster B, Smits T, Van Huffel S, Lagae L. (2008): Antenatal maternal anxiety is related to HPA-axis dysregulation and self-reported depressive symptoms in adolescence: A prospective study on the fetal origins of depressed mood. *Neuropsychopharmacology.* 33(9): 2301-2301.

Van den Bergh, B., van den Heuvel, M., Lahti, M. et al. (2020) Parental developmental origins of behaviour and mental health: the influence of maternal stress in pregnancy. *Neuroscience & Biobehavioural Reviews* 117:26-64.

Vanderbilt, D., & Gleason, M. M. (2011). Mental health concerns of the premature infant through the lifespan. *Pediatric Clinics, 58*(4), 815-832.

VanderWeele, T. (2015). Explanation in Causal Inference: Methods for Mediation and Interaction. Oxford.

VanderWeele, T. (2016) Mediation Analysis: A practitioner's Guide. *Annual Review of Public Health* 37: 17-32.

Vella SA, Gardner LA, Swann C. et al. (2019). Trajectories and predictors of risk for mental health problems throughout childhood. *Child and Adolescent Mental Health* 24(2):142-8.

Viner, R. M., Ozer, E. M., Denny, S., et al. (2012). Adolescence and the social determinants of health. *Lancet, 379*(9826), 1641-1652.

Walsh D, McCartney G, Smith M, et al. (2019). Relationship between childhood socioeconomic position and adverse childhood experiences (ACEs): a systematic review. *Journal of Epidemiology & Community Health* 73:1087-1093.

Warnick EM, Bracken MB, Kasl S (2008). Screening Efficiency of the Child Behavior Checklist and Strengths and Difficulties Questionnaire: A Systematic Review. *Child Adolescent Mental Health* 13: 140–147.

Webster-Stratton, C. H., & Reid, M. J. (2010). The incredible years program for children from infancy to pre-adolescence: Prevention and treatment of behavior problems. In R. C. Murrihy, A. D. Kidman, & T. H. Ollendick (Eds.), *Clinical handbook of assessing and treating conduct problems in youth* (pp. 117–138). Springer Science &Business Media.

Weinstock, M. (2007): Gender differences in the effects of prenatal stress on brain development and behaviour. *Neurochem Res. 32*(10): 1730-1740.

Wells GA, Shea B, O'Connel D, et al (2018). The Newcastle-Ottawa scale (NOS) for assessing the quailty of nonrandomised studies in meta-analyses. Available here: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. (Accessed 26/05/17).

West, B. T., Welch, K. B., & Gałlechki, A. T. (2007). Linear mixed models. A practical guide using statistical software. Boca Raton: Chapman & Hall/CRC.

West, P. (1991). Rethinking the selection explanation for health inequalities. *Social Science & Medicine*; 32: 373-384

West, P. (1997). Health inequalities in the early years: is there equalisation in youth?. *Social Science & Medicine*, *44*(6), 833-858.

Westreich D, Greenland S. The table 2 fallacy: presenting and interpreting confounder and modifier coefficients. *American Journal of Epidemiology*. 2013 Feb 15;177(4):292-8.

Whitehead, M. 1990. *The concepts and principles of equity and health. WHO 1990,* Regional Office for Europe: Copenhagen, WHO.

Whitehead, M. & Popay, J. (2010). Swimming upstream? Taking action on the social determinants of health inequalities. *Social Sci & Medicine,* 71**,** 1234-6; discussion 1254-8.

Whittle S, Simmons JG, Dennison M. et al. (2014). Positive parenting predicts the development of adolescent brain structure: a longitudinal study. *Developmental Cognitive Neuroscience.* 8:7-17.

Wickham S, Anwar E, Barr B, et al. (2016). Poverty and child health in the UK: using evidence for action *Archives of Disease in Childhood*; 101**:**759-766.

Wickham S, Whitehead M, Taylor-Robinson D, et al. (2017). The effect of a transition into poverty on child and maternal mental health: a longitudinal analysis of the UK Millennium Cohort Study. *Lancet Public Health* 2:e141–e148.

Wilkinson RG, Marmot M (2003) Social Determinants of Health: The Solid Facts (2nd edition). Copenhagen: World Health Organization. Available at http://www.euro.who.int/__data/assets/pdf_file/0005/98438/e81384.pdf (Accessed at: 14/02/2016)

Wilkinson RG (2005) 'Ourselves and others – for better or worse: social vulnerability and inequality', in Marmot M, Wilkinson RG (eds.) Social determinants of health (2nd edition). New York: Oxford University Press: 341–59.

Wilkinson R, Pickett K. (2009). The Spirit Level: why more equal societies almost always do better. London: Penguin.

Williford, A. P., Calkins, S. D., & Keane, S. P. (2007). Predicting change in parenting stress across early childhood: Child and maternal factors. *Journal of Abnormal Child Psychology*, *35*(2), 251-263.

World Health Organisation (2004) Climate change and human health: risks and responses. Geneva: World Health Organisation.

World Health Organisation (2004b) Commission on Social Determinants of Health. Geneva. World Health Organisation. Available here: http://apps.who.int/iris/bitstream/handle/10665/20230/B115_35-en.pdf?sequence=1 (Accessed: 12/05/2022).

World Health Organisation (2008) Commission on Social Determinants of Health: Closing the gap in a generation: health equity through action on the social determinants of health. Geneva: World Health Organisation. Available here: https://www.who.int/publications/i/item/WHO-IER-CSDH-08.1 (Accessed: 26/03/2017).

World Health Organisation (2014). Mental health atlas 2014. World Health Organization. Available here: https://apps.who.int/iris/handle/10665/178879. (Accessed 17/08/2017).

Wright, N., Hill, J., Pickles, A., & Sharp, H. (2019). Callous unemotional traits, low cortisol reactivity and physical aggression in children: findings from the Wirral Child Health and Development Study. *Translational Psychiatry*, 9(1), 79.

Appendices to Chapter 4

The appendix for Chapter 4 features supplementary material to support the information provided within the main chapters relevant to the systematic literature review.

A.4.1 PROSPERO Protocol

UNIVERSITY of York
Centre for Reviews and Dissemination

NHS
National Institute for Health Research

PROSPERO International prospective register of systematic reviews

Relationship between socioeconomic conditions and preschool-aged children's mental health: a systematic review

Callum Rutherford, David Taylor-Robinson, Helen Sharp

Citation
Callum Rutherford, David Taylor-Robinson, Helen Sharp. Relationship between socioeconomic conditions and preschool-aged children's mental health: a systematic review. PROSPERO 2017:CRD42017071705 Available from http://www.crd.york.ac.uk/PROSPERO_REBRANDING/display_record.asp?ID=CRD42017071705

Review question(s)
Is exposure to lower socioeconomic conditions (SECs) compared to higher SECs associated with the emergence/development of mental health problems in preschool children?

Searches
Utilising multiple systematic approaches to identify as much literature as possible. Searching electronic databases, grey literature and reference list searching.

[1] Electronic Databases

Electronic searching of 3 databases will be performed; MEDLINE, PsycINFO and Web of Science. Databases most relevant to the research question and subject area were selected as they are likely to yield the highest number of relevant papers.

Search terms were identified from scoping searches and comprise of broad mental health outcomes and socioeconomic terms. Relevant synonyms for SECs and child mental health outcomes were identified from systematic reviews focussed on health inequalities and child mental health. Ultimately, terms were selected to represent current clinical and policy discourse. While not exhaustive, the outcome terms are intended to provide a broad spectrum of children's mental health outcomes.

Database search functions will also be utilised. Where possible, search terms will be exploded to broaden the search. Truncation and proximity operators will also be applied, as necessary. Terms will be combined using Boolean operators. To ensure optimal searching, the final search strategy will be piloted and refined in one database.

To ensure rigor the same search terms will be used for each database query. The design and functionality differs with each database; thus, searches will be adapted when necessary. Careful attention will be paid to the variation of search functions within each database.

[2] Grey Literature

A Search of the grey literature will be conducted by entering the terms; "mental health" "psychopathology", "internalising", "externalising", "socioeconomic", "income", "deprivation" into the Google/Google scholar search engine. The first 100 results will be assessed.

[3] Reference lists

Reference lists of included studies will be searched to identify any relevant articles not stored on electronic databases.

Restrictions:

Database filters will be utilised to restrict results. Results will be limited to publications available in English

language. Where available additional filters such as age constraints (e.g., "infant", "preschool"), document type and "human subjects" will be applied. All filters directly relate to inclusion criteria.

Types of study to be included

Inclusion:

Longitudinal observational studies (longitudinal, cohort, case-control), written or translated into English, reporting quantitative results assessing the association of SECs in the perinatal period and subsequent preschool mental health outcomes. Socioeconomic conditions can be measured by occupation, income, education, employment or deprivation at the individual or aggregate level. Studies must be conducted in high-income countries, defined as being a member of the Organisation for Economic Co-operation and Development (OECD).

Exclusion:

Studies that do not specify the age of the sample, include non-validated outcome measures or where the primary outcome measure is not stated will be excluded. Literature reviews and case studies will be excluded.

Condition or domain being studied

The impact of SECs on the development of child mental health outcomes in high-income countries.

A systematic review has already established an association between SECs and child and adolescent mental health outcomes (Reiss, 2013). However, it is not yet known how early these inequalities develop. Reducing inequalities in mental health outcomes is a public health priority (Marmot, 2010). There is increasing recognition that the early-years of a child's life are critical periods in which inequalities can develop ("1001 Critical Days"). To design effective policy interventions, we need to know how and at what stage in the early-years health inequalities are established.

In the UK, prevalence rates of behavioural and emotional problems in children and adolescents have been estimated at 6% and 4%, respectively (Green et al., 2005). There is still limited understanding of the aetiology of mental health outcomes in children but there are many identified risk factors, including pre-natal, genetic and environmental factors. Low family socio-economic position is particularly important risk factor for the mental health of children, since many of the previously identified risk factors cluster with low SECs (Whiteford et al., 2013).There is a need to better understand the interplay and social patterning of these risk factors and their impact on preschool child mental health.

This review therefore aims to explore the relationship between SECs and preschool-aged children's mental health in high-income countries, and to and investigate possible explanations for any differences in the risk across socioeconomic groups.

Participants/ population

Any preschool-aged child from a high-income country defined as being a member of the Organisation for Economic Co-Operation and Development (OECD).

Intervention(s), exposure(s)

The exposure of interest is lower SECs measured at the individual or aggregate level by income, education, occupation, employment, or deprivation of area of residence.

Comparator(s)/ control

The comparator of interest is higher SECs measured at the individual or aggregate level by income, education, occupation, employment, or deprivation of area of residence.

Context

Studies consisting of a broadly representative sample at individual or population level will be included. Studies that exclusively use a sub-group of the population, for example children in care, will be excluded.

Outcome(s)

Primary outcomes

Primary outcome of interest will be any validated measure of mental health in preschool-aged children. For example,

internalising and externalising problems as measured by the Child Behaviour Checklist.

Secondary outcomes
None.

Data extraction, (selection and coding)
Searches will be carried out by the lead author (CR). Titles and abstracts will be screened by CR and a random sample will be screened by a second independent reviewer, to check agreement. Any discrepancies will be discussed and re-examined until an agreement is reached.

Full text for studies that are deemed to meet the inclusion criteria, from screening titles and abstracts, will be retrieved, collated and reviewed in the same way. Resources not available will be pursued through institutional sharing agreements.

To organise and facilitate data comparison, tables will be created by extracting data from each study into an Excel spreadsheet. Data to be extracted will include the following: aim/hypothesis, study design, level of analysis, country, sample size, age range/mean, mental health outcome, method of measurement, measure of SECs, covariates, statistically significant results, non-significant results and conclusions. Data extraction form will be piloted to test its efficiency and accuracy.

Risk of bias (quality) assessment
Risk of bias and quality assessment of the identified studies will be conducted by the lead author. A suitable tool for observational studies, for example, the Newcastle-Ottawa Scale or Liverpool Quality Assessment Tools will be used.

Strategy for data synthesis
Owing to the broad structure of this review, heterogeneity between studies design, populations, exposure and outcome measurements is expected. Data synthesis will be dictated by the data available. Key concepts and trends that emerge will be explored through narrative synthesis. Data permitting, results will be visualised through harvest plots and pooled in a meta-analysis.

Analysis of subgroups or subsets
To explore the relationship between SECs and child mental health outcomes, a subgroup analysis is anticipated on study design factors and potential moderating/mediating factors on the relationship between SECs and mental health outcomes. These may include: internalising and externalising problems, sex, methods of measurement (based on parent report), methods used to measure SECs, and level of analysis (aggregate or individual). Tables will be created to allow for within and between sub-group comparison.

Dissemination plans
Review will be submitted for publication. Findings of the review will be presented at conferences and will contribute to the author's PhD project as part of the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care North West Coast (NIHR CLAHRC NWC).

Contact details for further information
Callum Rutherford

Department of Public Health and Policy, Institute of Psychology, Health & Society, The Farr Institute @ HeRC, F208 (Block F, 2nd Floor), Waterhouse Building, Brownlow Street, University of Liverpool, L69 3GL.

C.Rutherford@liverpool.ac.uk

Organisational affiliation of the review
University of Liverpool; Department of Public Health & Policy; Department of Psychological Sciences.

Review team
Mr Callum Rutherford, Department of Public Health & Policy, University of Liverpool

Professor David Taylor-Robinson, Department of Public Health & Policy, University of Liverpool
Dr Helen Sharp, Department of Psychological Sciences, University of Liverpool

Anticipated or actual start date
10 July 2017

Anticipated completion date
30 September 2019

Funding sources/sponsors
National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care North West Coast (NIHR CLAHRC NWC)

Conflicts of interest
None known

Language
English

Country
England

Subject index terms status
Subject indexing assigned by CRD

Subject index terms
Child; Humans; Mental Health; Social Class

Stage of review
Ongoing

Date of registration in PROSPERO
08 August 2017

Date of publication of this revision
08 August 2017

Stage of review at time of this submission	Started	Completed
Preliminary searches	Yes	No
Piloting of the study selection process	No	No
Formal screening of search results against eligibility criteria	No	No
Data extraction	No	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

A.4.2 Database Search Terms

MEDLINE (OVID)
1. exp socioeconomic Factors/
2. Education*.mp.
3. exp Employment/
4. Income*.mp.
5. Occupation*.mp.
6. Poverty.mp
7. Poorest.mp.
8. exp Social Class/
9. Inequalit*.mp.
10. Socioeconomic*.mp.
11. Depriv*.mp.
12. Disadvantag*.mp.
13. Underprivileged.mp.
14. Social determinant*.mp.
15. (Social adj1 factor*).mp
16. Socio*.mp.
17. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16
18. mental health.mp.
19. mental disorder*.mp.
20. psychopatholog*.mp.
21. internal*.mp.
22. external*.mp.
23. 18 or 19 or 20 or 21 or 22
24. preschool.mp.
25. infan*.mp.
26. toddler*.mp.
27. "early years".mp.
28. "early life".mp.
29. 24 or 25 or 26 or 27 or 28
30. exp cohort studies/
31. cohort*.mp.
32. exp case-control studies/
33. exp longitudinal study/
34. exp prospective study/
35. exp follow up/
36. 30 or 31 or 32 or 33 or 34 or 35
37. exp Australia/
38. exp Austria/
39. exp Belgium/
40. exp Canada/
41. exp Chile/
42. exp Czech Republic/
43. exp Denmark/
44. exp Estonia/
45. exp Finland/
46. exp France/
47. exp Germany/
48. exp Greece/
49. exp Hungary/
50. exp Iceland/
51. exp Ireland/

52. exp Israel/
53. exp Italy/
54. exp Japan/
55. exp Korea/
56. exp Latvia/
57. exp Luxembourg/
58. exp Mexico/
59. exp Netherlands/
60. exp New Zealand/
61. exp Norway/
62. exp Poland/
63. exp Portugal/
64. exp Slovak Republic/
65. exp Slovenia/
66. exp Spain/
67. exp Sweden/
68. exp Switzerland/
69. exp Turkey/
70. exp United Kingdom/
71. exp United States/
72. 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64 or 65 or 66 or 67 or 68 or 69 or 70 or 7
73. 17 and 23 and 29 and 36 and 72
74. limit 73 to ("all infant (birth to 23 months)" or "newborn infant (birth to 1 month)" or "infant (1 to 23 months)" or "preschool child (2 to 5 years)")
75. limit 74 to English language
76. limit 75 to humans

A.4.3 PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol

Section and topic	Item No	Checklist item
ADMINISTRATIVE INFORMATION		
Title:		
Identification	1a	Identify the report as a protocol of a systematic review
Update	1b	If the protocol is for an update of a previous systematic review, identify as such (not applicable)
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number
Authors:		
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments (not applicable)
Support:		
Sources	5a	Indicate sources of financial or other support for the review
Sponsor	5b	Provide name for the review funder and/or sponsor

Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol
INTRODUCTION		
Rationale	6	Describe the rationale for the review in the context of what is already known
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)
METHODS		
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated
Study records:		
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall's τ)
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015 Jan 2;349(jan02 1):g7647.

Demonstrated

Not applicable
Not Demonstrated

A.4.4 Newcastle – Ottawa Quality Assessment Scale (Cohort Studies) used for quality appraisal

NEWCASTLE - OTTAWA QUALITY ASSESSMENT SCALE
COHORT STUDIES

Note: A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. A maximum of two stars can be given for Comparability

Selection

1) Representativeness of the exposed cohort
   a) truly representative of the average _____ (describe) in the community ✱
   b) somewhat representative of the average _____ in the community ✱
   c) selected group of users eg nurses, volunteers
   d) no description of the derivation of the cohort

2) Selection of the non exposed cohort
   a) drawn from the same community as the exposed cohort ✱
   b) drawn from a different source
   c) no description of the derivation of the non exposed cohort

3) Ascertainment of exposure
   a) secure record (eg surgical records) ✱
   b) structured interview ✱
   c) written self report
   d) no description

4) Demonstration that outcome of interest was not present at start of study
   a) yes ✱
   b) no

Comparability

1) Comparability of cohorts on the basis of the design or analysis
   a) study controls for _____ (select the most important factor) ✱
   b) study controls for any additional factor ✱ (This criteria could be modified to indicate specific control for a second important factor.)

Outcome

1) Assessment of outcome
   a) independent blind assessment ✱
   b) record linkage ✱
   c) self report
   d) no description

2) Was follow-up long enough for outcomes to occur
   a) yes (select an adequate follow up period for outcome of interest) ✱
   b) no

3) Adequacy of follow up of cohorts
   a) complete follow up - all subjects accounted for ✱
   b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) ✱
   c) follow up rate < ____% (select an adequate %) and no description of those lost
   d) no statement

Table A.4.5 Bibliography of included studies

1	Bayer, Jordana K et al. 2008. "Early Childhood Aetiology of Mental Health Problems: A Longitudinal Population-Based Study." *Journal of Child Psychology and Psychiatry, and Allied Disciplines* 49(11): 1166–74.
2	Bor, W et al. 1997. "The Relationship between Low Family Income and Psychological Disturbance in Young Children: An Australian Longitudinal Study." *The Australian and New Zealand Journal of Psychiatry* 31(5): 664–75.
3	Davis, Elise et al. 2010. "Socioeconomic Risk Factors for Mental Health Problems in 4-5-Year-Old Children: Australian Population Study." *Academic Pediatrics* 10(1): 41–47.
4	D'Souza, Stephanie et al. 2019. "Antenatal and Postnatal Determinants of Behavioural Difficulties in Early Childhood: Evidence from Growing Up in New Zealand." *Child Psychiatry & Human Development* 50(1): 45–60.
5	D'Souza, Stephanie et al. 2019. "Persistence and Change in Behavioural Problems during Early Childhood." *BMC Pediatrics* 19(1): 1–10.
6	Flouri, Eirini, Stella Mavroveli, and Nikos Tzavidis. 2010. "Modeling Risks: Effects of Area Deprivation, Family Socio-Economic Disadvantage and Adverse Life Events on Young Children's Psychopathology." *Social Psychiatry and Psychiatric Epidemiology* 45(6): 611–19.
7	Flouri, Eirini, Stella Mavroveli, and Nikos Tzavidis. 2012. "Cognitive Ability, Neighborhood Deprivation, and Young Children's Emotional and Behavioral Problems." *Social Psychiatry and Psychiatric Epidemiology* 47(6): 985–92.
8	Green, Melissa J et al. 2018. "Latent Profiles of Early Developmental Vulnerabilities in a New South Wales Child Population at Age 5 Years." *The Australian and New Zealand Journal of Psychiatry* 52(6): 530–41.
9	Hetherington, Erin, Sheila McDonald, Nicole Racine, and Suzanne Tough. 2018. "Risk and Protective Factors for Externalizing Behavior at 3 Years: Results from the All Our Families Pregnancy Cohort." *Journal of Developmental and Behavioral Pediatrics* 39(7): 547–54.
10	Najman, Jake M et al. 2005. "Predictors of Depression in Very Young Children-a Prospective Study." *Social Psychiatry and Psychiatric Epidemiology* 40(5): 367–74.
11	Palmer, Frederick B et al. 2013. "Early Adversity, Socioemotional Development, and Stress in Urban 1-Year-Old Children." *Journal of Pediatrics* 163(6): 1733-U291.
12	Palmer, Frederick B et al. 2018. "Socio-Demographic, Maternal, and Child Indicators of Socioemotional Problems in 2-Year-Old Children: A Cohort Study." *Medicine* 97(28): e11468.
13	Rijlaarsdam, Jolien et al. 2013. "Home Environments of Infants: Relations with Child Development through Age 3." *Journal of Epidemiology and Community Health* 67(1): 14–20.
14	Rutherford, Callum et al. 2019. "How Does Perinatal Maternal Mental Health Explain Early Social Inequalities in Child Behavioural and Emotional Problems? Findings from the Wirral Child Health and Development Study." *Plos One* 14(5): e0217342.
15	Thomson, Kimberly C et al. 2017. "Profiles of Children's Social-Emotional Health at School Entry and Associated Income, Gender and Language Inequalities: A Cross-Sectional Population-Based Study in British Columbia, Canada." *BMJ Open* 7(7): e015353.

Table A.4.6 Characteristics of included studies

Ref	First Author	Year	Quality	Country	Level of Analysis	Sample size	Study Design	Outcome Measure	Outcome Tool	SEC Measure
1	Bayer	2008	Medium	Australia	Individual, Area	<1000	Intervention	Internalising, Externalising, Total Problem Scores	CBCL	Multiple
2	Bor	1997	Medium	Australia	Individual	5001-10,000	Cohort	Internalising, Externalising, Social/Attentional/Thought (SAT) subscale	CBCL - Short Version	Income
3	Davis	2000	High	Australia	Individual	1001-5000	Cohort	Emotional, Conduct, Hyperactivity, Peer Problems, Total Difficulties	SDQ 2-4 Years	Multiple
4	D'Souza	2019	Medium	New Zealand	Individual, Area	5001-10,000	Cohort	Emotional, Conduct, Hyperactivity, Peer Problems, Total Difficulties	SDQ Preschool	Multiple
5	D'Souza	2019	Medium	New Zealand	Individual, Area	5001-10,000	Cohort	Emotional, Conduct, Hyperactivity, Peer Problems, Total Difficulties	SDQ Preschool SDQ standard	Multiple
6	Flouri	2010	Medium	United Kingdom	Individual, Area	5001-10,000	Cohort	Emotional, Conduct, Hyperactivity, Peer Problems, Total Difficulties	SDQ	Multiple
7	Flouri	2012	Medium	United Kingdom	Individual, Area	5001-10,000	Cohort	Emotional, Conduct, Hyperactivity, Peer Problems, Prosocial, Total Difficulties	SDQ	Multiple
8	Green	2018	Medium	Australia	Area	>10,000	Population	Latent Class Profiles, "At Risk" Social, Emotional, Physical, Cognitive, Communication	AEDC	Deprivation
9	Hetherington	2018	Medium	Canada	Individual	1001-5,000	Cohort	Externalising Behaviour Scores	CBCL - Short Version	Income
10	Najman	2005	Medium	Australia	Individual	5001-10,000	Cohort	Depression Scale	CBCL - Short Version	Education
11	Palmer	2013	Medium	United States	Individual	1001-5,000	Cohort	Social Emotional Problems	BITSEA	Income
12	Palmer	2018	Medium	United States	Individual	1001-5,000	Cohort	Social Emotional Problems	BITSEA	Income
13	Rijilarsdam	2012	Medium	Netherland	Individual	5001-10,000	Cohort	Internalising, Externalising Problem Scores	CBCL	Multiple
14	Rutherford	2019	High	United Kingdom	Individual, Area	<1000	Cohort	Internalising, Externalising Problem Scores	CBCL	Multiple
15	Thomson	2017	High	Canada	Individual	>10,000	Population	Social Emotional Development Profiles	EDI	Income

Appendices to Chapter 5

The appendix for Chapter 5 features exploratory analysis, investigations of model assumptions and sensitivity analyses that were conducted to assess the robustness of the main results from the analysis of WCHADS data presented in Chapter 5.

A.5.1 Model selection

First, I fitted a random intercept and slope to the data to assess whether a linear mixed effects approach was best suited to the data. I found that adding a random slope to the data significantly improved model fit (table A.5.1). A reduction in the Akaike Information Criterion (AIC), a method of assessing model fit, was observed. An AIC of 7577.3 was reduced to 6463.0 between a fixed effects model and model with fixed effects and random slope. This model was used as the baseline model to build a set of hierarchical models. Next, I determined whether it was best to model the exposure measure, household income, as a continuous or categorical variable. Although modelling income as categorical statistically significantly improved the model. I decided to retain household income as a continuous measure to preserve statistical power in the models.

Table A.5.1: Analysis of variance (ANOVA) modelling random intercept and random slope.

.	Df	AIC	BIC	-2 Log Likelihood	Deviance	Chi-Square	p-value
Random Intercept	4	7577.30	7601.40	-3784.60	7569.30		
+ **Random Slope**	6	7463.00	7499.10	-3725.50	7451.00	118.33	<0.001

Df: degrees of freedom; AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion.

I then proceeded to test whether it was appropriate to model an interaction term between the exposure measure and age. This would test whether any differences in the exposure measure (modelled as the slope) varied over time. This addressed the aim of assessing whether any social inequalities in child behavioural and socio-emotional problems widen or narrow throughout early childhood. Adding an interaction term significantly improved our model fit (AIC: 6138.1). After adding baseline confounders to the model (model fit AIC: 6132.9), I tested whether it was appropriate to model a confounder interaction within the model. Adding an interaction term did not statistically significantly improve model fit (table A.5.2).

Table A.5.2: Analysis of variance (ANOVA) modelling confounder interaction

	Df	AIC	BIC	-2 Log Likelihood	Deviance	Chi-Square	p-value
Model IV	12	6433.40	6504.00	-3204.70	6409.40		
+ Confounder Interaction	16	6433.80	6527.90	-3200.90	6401.80	7.61	0.1069

Df: degrees of freedom; AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion.

This approach to hierarchical model building was repeated for total CBCL internalising problem scores. I found that it was appropriate to fit a random slope and model an interaction term with the exposure measure, household income.

A.5.2 Logarithmic transformation of outcome measure

I formally tested whether a logarithmic transformation was best suited to the data by modelling a simple random intercept model using both untransformed and log-transformed outcomes. I plotted the distribution of the model residuals using a Quantile-Quantile plot to assess whether there is a normal distribution of model residuals (figures A.5.1, A.5.2). After fitting a simple random intercept model and comparing model fit, using a log-transformed outcome variable was best suited to the data.

Figure A.5.1: Distribution of a random intercept model residuals fitting the untransformed outcome variable alongside a Quantile-Quantile plot.

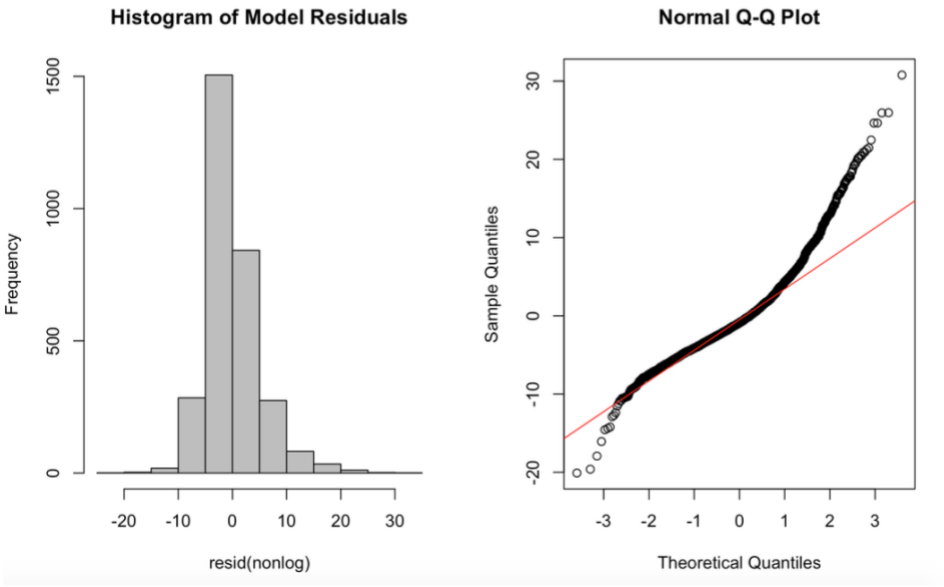
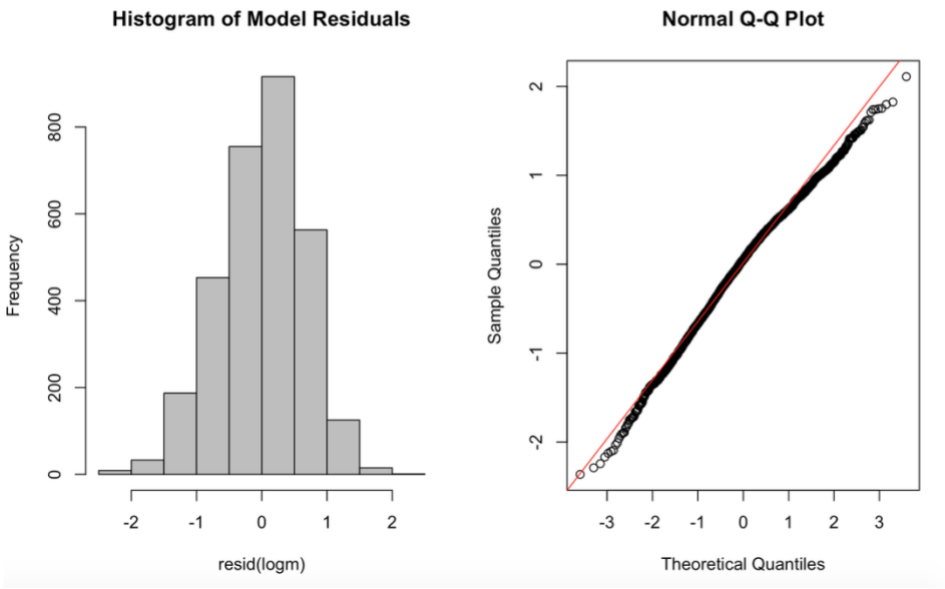


Figure A.5.2: Distribution of a random intercept model residuals fitting the log-transformed outcome variable alongside a Quantile-Quantile plot.

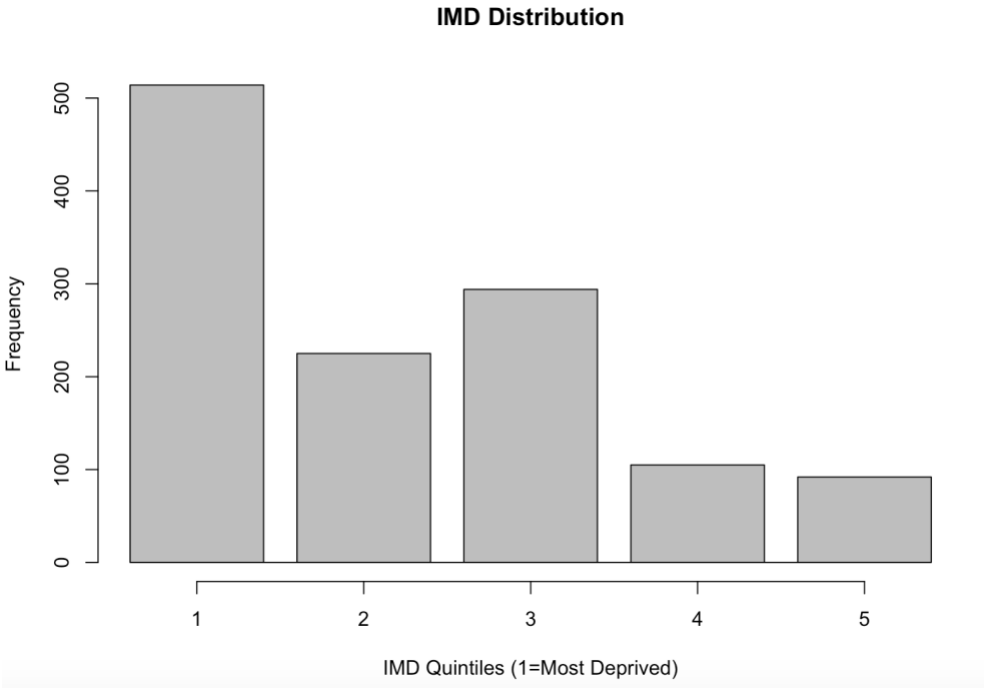


A.5.3 Models testing alternative exposure measures.

Index of Multiple Deprivation (IMD) as an alternative exposure measure

I repeated the main analysis using the English version of the Index of Multiple Deprivation (IMD), an area-level measure of deprivation as an alternative measure of socioeconomic conditions (SECs). These indices combine economic, social and housing indicators measures at the census into a composite deprivation score for small areas in England. IMD raw scores generated from postcodes at recruitment into the study were used derive IMD quintiles. Owing to the socio-demographic composition of the Wirral, 42% of the sample were in the most deprived quintile of deprivation at recruitment into the study. Figure (A.5.3) shows the distribution of the exposure measure, IMD. The analyses below use quintiles and compare individuals from the most deprived quintile to the least deprived quintile to explore any social inequalities in child mental health outcomes.

Figure (A.5.3) Distribution of study participants by Indices of Multiple Deprivation Quintiles at 20 weeks-gestation.



Tables (A.5.3, A.5.4) display coefficients for log-internalising and log-externalising behaviour problem scores. Results are shown for each of the four models in a sequential, hierarchical order with 95% confidence intervals. Model summary statistics are also provided.

In the fully adjusted model (*model IV*), scores for log-externalising and log-internalising behaviours decreased with age (Externalising βage = -0.173 [95% CI -0.221, -0.124); Internalising βage = -0.63 [95% CI -0.108, -0.017]). For log-externalising problems there was a significant time by exposure interaction, whereby, the rate of decline was slower for most deprived children compared to the least deprived children (βage*IMD = 0.066 [95% CI 0.012, 0.120]). There was no significant age by exposure interaction for log-internalising problem scores (βage*IMD = 0.037 [95% CI -0.013, 0.087]).

I found a sex effect only for log-externalising behaviour problems, whereby boys scored higher (βsex = 0.128 95% CI [0.045, 0.211]). Children with mothers aged 18-24 also scored higher for log-externalising scores compared with children from mothers aged 35+ (βmaternal age = 0.164 95% CI 0.022, 0.306]). There was no significant maternal age effect on log-internalising behaviour scores.

Table A.5.3: Nested models: CBCL externalising behaviour problem scores modelling IMD as an alternative exposure.

	Model 1			Model II			Model III			Model IV		
	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI
Fixed Effects												
Intercept	2.486			2.313			2.519			2.417		
Age	-0.130	-0.144	-0.117	-0.130	-0.144	-0.116	-0.173	-0.221	-0.125	-0.173	-0.221	-0.124
Deprivation												
IMD 1 (Most Deprived)				0.257	0.099	0.412	-0.061	-0.361	0.238	-0.110	-0.413	0.193
IMD 2				0.100	-0.072	0.271	-0.121	-0.446	0.203	-0.137	-0.464	0.189
IMD 3				0.171	0.007	0.335	0.015	-0.296	0.325	0.005	-0.309	0.318
IMD 4				0.163	-0.037	0.363	0.130	-0.251	0.512	0.117	-0.267	0.501
Age x Deprivation												
Age x IMD 1							0.066	0.013	0.119	0.066	0.012	0.120
Age x IMD 2							0.046	-0.011	0.103	0.046	-0.013	0.103
Age x IMD 3							0.033	-0.022	0.088	0.032	-0.023	0.087
Age x IMD 4							0.007	-0.060	0.075	0.007	-0.060	0.075
Maternal Age 18-24										0.164	0.022	0.306
Maternal Age 25-34										0.027	-0.102	0.156
Sex (Male)										0.128	0.045	0.211
Ethnicity (Other)										-0.057	-0.277	0.162
Random Effects												
Residual Variance	0.448			0.448			0.447			0.447		
Intercept Variance	0.233			0.239			0.229			0.244		
Slope Variance	0.011			0.011			0.011			0.011		
-2 Log Likelihood	-3725.500			-3696.800			-3691.900			-3670.400		
Deviance	7451.000			7393.600			7383.700			7340.800		

AIC	7463.000			7413.600			7411.700			7376.800		
BIC	7499.100			7473.800			7496.000			7485.100		

Note: IMD (Ref: 5 (Least Deprived); Maternal Age (Ref: 35+); Sex (Ref: female); Ethnicity (Ref: White British)
AIC: Akaike information criterion; BIC: Bayesian information criterion

Table A.5.4: Nested models: CBCL internalising behaviour problem scores modelling IMD as an alternative exposure.

	Model 1			**Model II**			**Model III**			**Model IV**		
	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI
Fixed Effects												
Intercept	1.869			1.841			1.962			1.941		
Age	-0.038	-0.051	-0.025	-0.038	-0.051	-0.025	-0.062	-0.108	-0.017	-0.063	-0.108	-0.017
Deprivation												
IMD 1 (Most Deprived)				0.084	-0.051	0.225	-0.096	-0.383	0.191	-0.127	-0.417	0.163
IMD 2				-0.048	-0.202	0.105	-0.203	-0.515	0.108	-0.212	-0.525	0.100
IMD 3				0.027	-0.120	0.174	-0.094	-0.393	0.203	-0.098	-0.397	0.202
IMD 4				-0.012	-0.191	0.168	0.083	-0.283	0.448	0.086	-0.281	0.453
Age x Deprivation												
Age x IMD 1							0.036	-0.142	0.087	0.037	-0.013	0.087
Age x IMD 2							0.031	-0.023	0.085	0.031	-0.023	0.086
Age x IMD 3							0.025	-0.028	0.077	0.026	-0.027	0.078
Age x IMD 4							-0.019	-0.083	0.045	-0.018	-0.082	0.046
Maternal Age 18-24										0.106	-0.021	0.233
Maternal Age 25-34										0.006	-0.110	0.122

Sex (Male)										-0.159	-0.090	0.059
Ethnicity (Other)										0.108	-0.091	0.306
Random Effects												
Residual Variance	0.421			0.420			0.420			0.421		
Intercept Variance	0.196			0.201			0.195			0.199		
Slope Variance	0.009			0.009			0.009			0.009		
-2 Log Likelihood	-3540.100			-3517.600			-3514.600			-3502.300		
Deviance	7080.100			7035.300			7029.300			7004.700		
AIC	7092.100			7055.300			7057.300			7040.700		
BIC	7128.300			7115.500			7141.500			7149.000		

Note: β coefficients presented on log-scale. IMD (Ref: 5 (Least Deprived); Maternal Age (Ref: 35+); Sex (Ref: Female); Ethnicity (Ref: White British) AIC: Akaike information criterion; BIC: Bayesian information criterion.

Household income as a linear or categorical function

The main analyses treat the exposure measure, household income as a linear function. In order to test this assumption, I also conducted the analyses with the exposure measure modelled as a categorical variable. I performed an analysis of variance (ANOVAs) test to compare nested models to decide which approach would be best suited to the data (table A.5.5).

Table A.5.5: Analysis of Variance modelling household income as linear or categorical

	df	**AIC**	**BIC**	**-2 Log Likelihood**	**Deviance**	x^2	**Chi Df**	**P-Value**
Externalising								
Income as Linear	7	6454.9	6496.1	-3220.5	6440.9			
Income as Categorical	13	6455.5	6532.1	-3214.8	6429.5	11.379	6	0.077
Internalising								
Income as Linear	7	6141.1	6182.3	-3063.5	6127.1			
Income as Categorical	13	6138.1	6214.7	-3056.1	6112.1	14.942	6	0.021

Tested on the same nested sample, modelling household income as a categorical variable only significantly improved the model fit for internalising behaviour models only. The model fit marginally improved (x^2 = 11.379, p <0.05). Owing to such a small difference, it was justified to use income as a linear function in the main analyses to preserve statistical power.

Tables (A.5.6, A.5.7) display the coefficients for internalising and externalising behaviour problem scores with income modelled as a categorical variable. The highest income group (Over £70,000) is used as the reference group in the analysis. All estimates are compared to the reference category. Results are shown for each of the four models in a sequential, hierarchical order with 95% confidence intervals. Model summary statistics are also provided.

Table A.5.6: Nested models: CBCL externalising behaviour problem scores modelling income as categorical

	Model 1			Model II			Model III			Model IV		
	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI
Fixed Effects												
Intercept	2.486			2.436			2.622			2.560		
Age	-0.130	-0.144	-0.117	-0.129	-0.153	-0.124	-0.176	-0.228	-0.125	-0.176	-0.228	-0.124
Income												
Up to £10,000				0.241	0.017	0.465	-0.355	-0.793	0.083	-0.321	-0.771	0.128
£10-20,000				0.220	0.021	0.420	0.011	-0.375	0.398	0.042	-0.352	0.436
£21-30,000				0.027	-0.163	0.218	-0.248	-0.616	-0.120	-0.232	-0.604	0.141
£31-40,000				-0.043	-0.226	0.140	-0.164	-0.517	0.190	-0.164	-0.520	0.192
£41-50,000				0.023	-0.165	0.211	-0.245	-0.608	0.118	-0.253	-0.618	0.112
£51-60,000				0.042	-0.150	0.234	-0.029	-0.399	0.342	-0.038	-0.410	0.335
£61-70,000				0.069	-0.161	0.298	0.068	-0.374	0.510	0.043	-0.401	0.487
Age x Income												
Age x Up to £10,000							0.121	0.045	0.198	0.122	0.045	0.198
Age x £10-20,000							0.042	-0.024	0.108	0.042	-0.025	0.108
Age x £21-30,000							0.055	-0.008	0.119	0.055	-0.008	0.119
Age x £31-40,000							0.024	-0.036	0.085	0.024	-0.037	0.084
Age x £41-50,000							0.054	-0.009	0.116	0.053	-0.009	0.116
Age x £51-60,000							0.014	-0.050	0.078	0.013	-0.051	0.078
Age x £61-70,000							-0.000	-0.374	0.510	-0.000	-0.078	0.078
Maternal Age 18-24										-0.022	-0.196	0.130
Maternal Age 25-34										0.014	-0.116	0.145
Sex (Male)										0.119	0.031	0.207
Ethnicity (Other)										0.000	-0.241	0.243
Random Effects												

Residual Variance	0.448			0.446			0.447			0.446		
Intercept Variance	0.233			0.256			0.232			0.239		
Slope Variance	0.011			0.011			0.010			0.010		
-2 Log Likelihood	-3725.500			-3214.800			-3206.800			-3195.000		
Deviance	7451.000			6429.500			6413.500			6390.000		
AIC	7463.000			6455.500			6453.500			6438.000		
BIC	7499.100			6532.100			6571.300			6579.300		

Note: β coefficients presented on log-scale Income (Ref: Over £71,000); Maternal Age (Ref: 35+); Sex (Ref: Female); Ethnicity (Ref: White British)

AIC: Akaike information criterion; BIC: Bayesian information criterion

Table A.5.7: Nested models: CBCL internalising behaviour problem scores modelling income as categorical

	Model 1			**Model II**			**Model III**			**Model IV**		
	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI	β	LCI	UCI
Fixed Effects												
Intercept	1.869			1.776			2.035			2.061		
Age	-0.038	-0.051	-0.025	-0.041	-0.055	-0.0267	-0.091	-0.141	-0.041	-0.091	-0.141	-0.041
Income												
Up to £10,000				0.269	0.070	0.467	-0.200	-0.623	0.223	-0.182	-0.615	0.251
£10-20,000				0.184	0.006	0.361	-0.156	-0.529	0.217	-0.141	-0.521	0.239
£21-30,000				0.040	-0.129	0.209	-0.208	-0.564	0.148	-0.196	-0.556	0.163
£31-40,000				-0.012	-0.175	0.150	-0.239	-0.580	0.103	-0.232	-0.576	0.111
£41-50,000				0.134	-0.033	0.301	-0.207	-0.558	0.144	-0.201	-0.554	0.152
£51-60,000				0.127	-0.043	0.298	-0.100	-0.459	0.258	-0.110	-0.465	0.255

£61-70,000				-0.014	-0.218	0.190	-0.204	-0.632	0.223	-0.197	-0.626	0.232
Age x Income												
Age x Up to £10,000							0.092	0.018	0.166	0.092	0.018	0.166
Age x £10-20,000							0.066	0.002	0.130	0.066	0.002	0.129
Age x £21-30,000							0.048	-0.013	0.110	0.048	-0.013	0.109
Age x £31-40,000							0.044	-0.014	0.103	0.043	-0.015	0.102
Age x £41-50,000							0.067	0.006	0.127	0.066	0.006	0.127
Age x £51-60,000							0.045	-0.017	0.106	0.046	-0.016	0.108
Age x £61-70,000							0.037	-0.037	0.111	0.037	-0.037	0.111
Maternal Age 18-24										-0.049	-0.194	0.097
Maternal Age 25-34										-0.036	-0.152	0.080
Sex (Male)										-0.011	-0.089	0.068
Ethnicity (Other)										0.148	-0.069	0.364
Random Effects												
Residual Variance	0.421			0.416			0.416			0.417		
Intercept Variance	0.196			0.236			0.226			0.228		
Slope Variance	0.009			0.010			0.009			0.009		
-2 Log Likelihood	-3540.100			-3056.100			-3052.000			-3044.700		
Deviance	7080.100			6112.100			6104.000			6089.500		
AIC	7092.100			6138.100			6144.000			6137.500		
BIC	7128.300			6214.700			6261.700			6278.700		

Note: β coefficients presented on log-scale Income (Ref: Over £71,000); Maternal Age (Ref: 35+); Sex (Ref: Female);
Ethnicity (Ref: White British)

AIC: Akaike information criterion; BIC: Bayesian information criterion

In the fully adjusted model (*model IV*), scores for log-externalising and log-internalising behaviours decreased with age (Externalising βage = -0.176 [95% CI -0.228, -0.124]); Internalising βage = -0.091 [95% CI -0.141, -0.041]). For both log-externalising and log-internalising problems there was a significant time by exposure interaction, whereby, the rate of decline was slower for most disadvantaged children compared to the least disadvantaged children (Externalising βage*income = 0.122 [95% CI0.045, 0.198]; Internalising βage*income = 0.092 [95% CI 0.018, 0.166]).

I found a sex effect only for log-externalising behaviour problems, whereby, boys scored higher (βsex = 0.119 [95% CI 0.031, 0.207]). There was no significant maternal age or ethnicity effect on log-internalising or log-externalising behaviour scores.

A.5.4 Modelling Age x Sex interactions

I formally modelled an age by sex interaction and a three-way interaction between age, sex and income. I compared interaction models to a model which did not include any sex interactions. To formally test whether an interaction model was necessary, I used ANOVAs to compare nested models (table A.5.8). For both internalising and externalising behaviours extending the model to include a sex interaction did not improve the model fit.

Table A.5.8: Analysis of Variance modelling three-way interactions.

	df	**AIC**	**BIC**	**-2 Log-Likelihood**	**Deviance**	**Chi-Square**	**p-value**
Externalising							
Model (no interaction)	12	6433.4	6504	-3204.7	6409.4		
Age x Sex	13	6432.7	6509.2	-3203.4	6406.7	2.66	0.103
Age x Sex x Income	39	6450.5	6680.1	-3186.3	6372.5	36.84	0.098
Internalising							
Model (no interaction)	12	6132.9	6203.5	-2054.4	6108.9		
Age x Sex	13	6134.5	6211.1	-3054.3	6108.5	0.331	0.565
Age x Sex x Income	39	6152.6	6382.1	-3037.3	6074.6	34.323	0.157

Table (A.5.9) reports the beta coefficients from the final fully adjusted models for log-externalising and log-internalising behaviour scores whereby a three-way interaction (age x sex x income) is modelled.

Table A.5.9: Nested models: CBCL behaviour problem scores modelling three-way interactions.

	Externalising			Internalising		
	β	LCI	UCI	β	LCI	UCI
Fixed Effects						
Intercept	2.721			1.972		
Age	-0.228	-0.280	-0.176	-0.082	-0.132	-0.032
Income	-0.050	-0.110	0.010	-0.022	-0.080	0.037
Sex (Male)	-0.201	-0.641	0.238	-0.038	-0.462	0.386
Maternal Age 18-24	0.001	-0.162	0.164	-0.035	-0.180	0.110
Maternal Age 25-34	0.008	-0.123	0.139	-0.0320	-0.149	0.084
Ethnicity (Other)	-0.008	-0.252	0.236	0.138	-0.081	0.356
Interaction						
Age x Income	0.017	0.007	0.027	0.010	0.0001	0.020
Age x Sex	0.069	-0.007	0.1451	0.016	-0.057	0.089
Age x Income x Sex	-0.010	-0.025	0.005	-0.005	-0.020	0.009
Random Effects						
Residual Variance	0.446			0.417		
Intercept Variance	0.244			0.227		
Slope Variance	0.010			0.009		
-2 Log Likelihood	-3202.500			-3053.800		
Deviance	6405.000			6107.600		
AIC	6435.000			6137.600		
BIC	6523.300			6225.900		

Note: β coefficients presented on log-scale. Maternal Age (Ref: 35+); Sex (Ref: Female); Ethnicity (Ref: White British)
AIC: Akaike information criterion; BIC: Bayesian information criterion

A.5.5 Modelling age as linear or quadratic function

I formally modelled age as a quadratic term and used ANOVAs to compare nested models. I compare a model fitting a quadratic term in both fixed and random effects to a baseline model fitting a random intercept and slope. For internalising behaviours extending the model to include a quadratic term did not improve the model fit. There was minimal model improvement observed for externalising models. Therefore, the most parsimonious model treats age as a linear function.

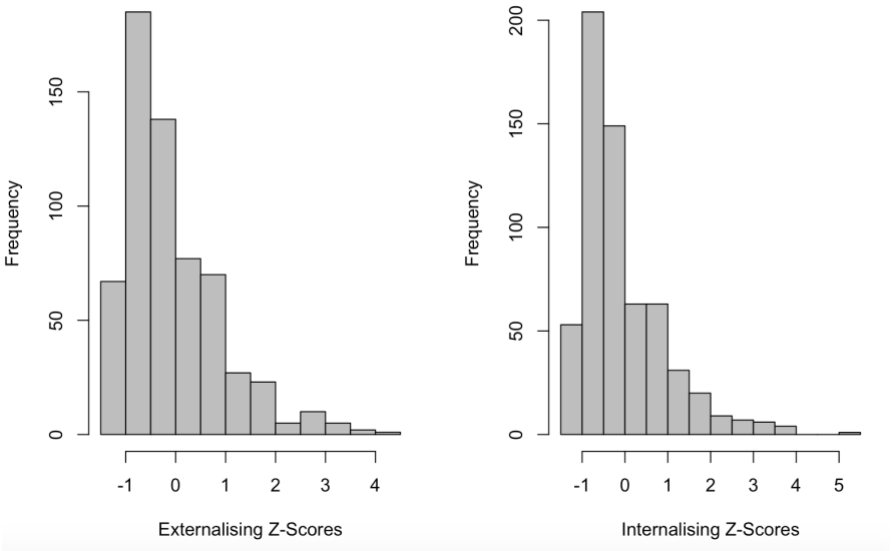
Table A.5.10: Analysis of Variance modelling age as a quadratic function

	df	AIC	BIC	-2 Log Likelihood	Deviance	Chi-Square	Chi Df	P-Value
External								
Age as Linear	6	7463.0	7499.1	-3725.5	7451.0			
Age as Quadratic	10	7458.0	7518.2	-3719.0	7438.0	12.97	4	0.011
Internalising								
Age as Linear	6	7092.1	7128.3	-3540.1	7080.1			
Age as Quadratic	10	7092.6	7152.8	-3536.3	7072.6	7.529	4	0.110

A.5.6 Models testing alternative outcome measures

Z-Scores as an alternative outcome measure

Figure (A.5.4) Distribution of Z-scores for both CBCL internalising and externalising behaviour problems scores at 3.5 years. A logarithmic transformation was applied to the measures with formal modelling undertaken on the log-scale.

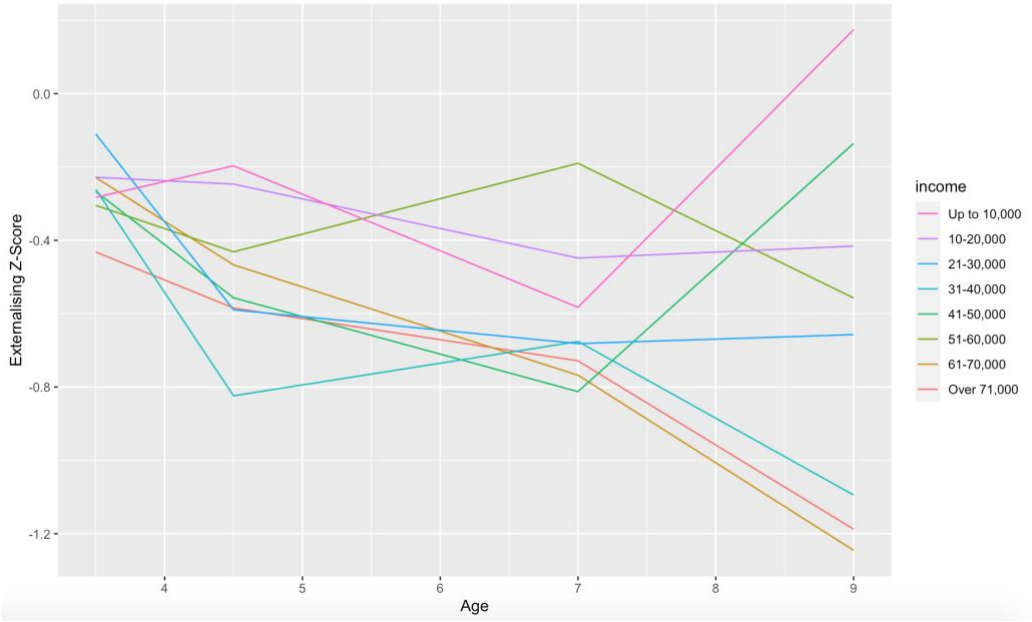


CBCL Z-Scores stratified by household income

I visually explored trends in child mental health outcomes stratified by the exposure measure, household income (figure A.5.5). The plots show the trend in mean CBCL Z-Scores for a child from each level of household income at each time point.

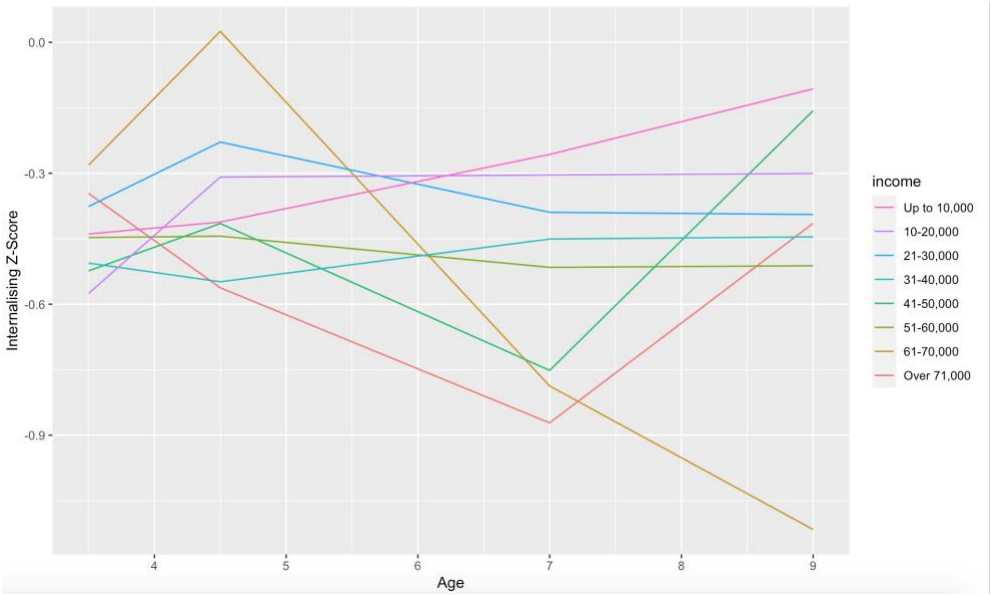
Figure (A.5.5) shows varying profiles for externalising behaviour problems from ages 3.5 to 9 years when stratified by household income. For all income levels except the lowest income group (pink line) there is a decrease in mean z-scores from ages 3.5 to 4.5 years of age. Comparing the least (red line) and most disadvantaged households, there is a decline in scores for both sub-groups between 4.5 and 7 years of age. There are contrasting trajectories from ages 7 to 9 years, whereby, scores for the lowest income group increase and scores for the highest income group decrease. Visually, there is a socioeconomic gap in scores present at 3.5 years which increases by 9 years of age.

Figure (A.5.5) Externalising CBCL Z-scores over time by household income. Each line represents the population average for each level household income.



Exploratory analysis suggests that profiles for internalising behaviour problems z-scores differ by level of household income from ages 3.5 to 9 years (figure A.5.6). Comparing mean scores for children from the lowest (pink) and highest (red) income groups, there are visual differences in trajectories. Mean z-scores for the most disadvantaged children continuously increase from ages 3.5 to 9 years of age. However, mean z-scores for the least disadvantaged children decrease from ages 3.5 to 7 years of age before increasing at 9 years of age. Visually, there is a socioeconomic gap in scores for internalising behaviour problems across childhood.

Figure (A.5.6) Internalising CBCL Z-scores over time by household income. Each line represents the population average for each level household income.

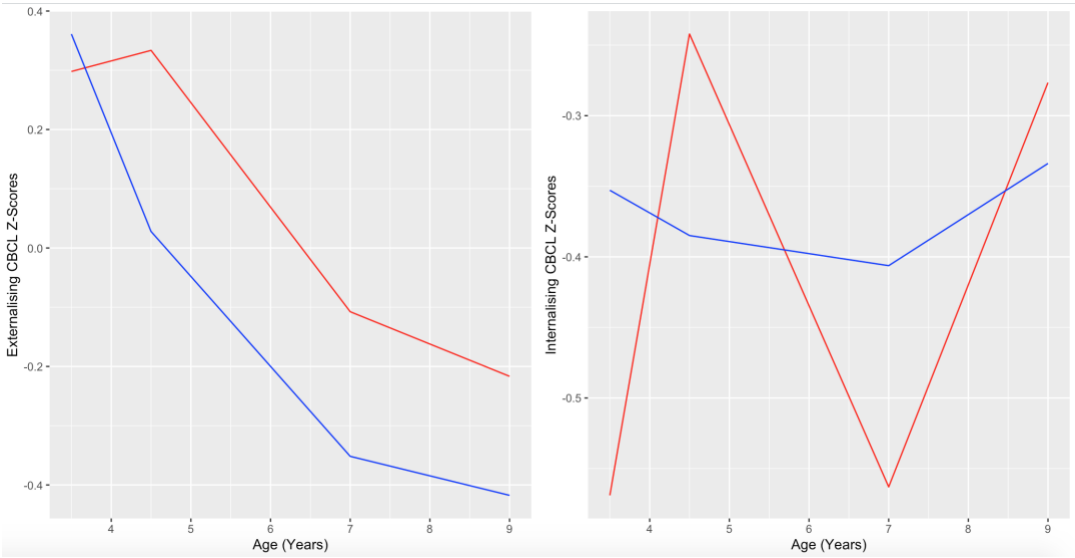


CBCL Z-Scores stratified by sex

I explored trends for child mental health outcomes stratified by the sex. Figure (A.5.7) show the trend in mean scores at each time point. These plots help to visualise any sex differences.

Visually, there are different trajectories for boys and girls for both externalising and internalising behaviour problems. Mean z-scores for boys (red line) increase for externalising behaviour problems before decreasing from ages 4.5 to 9 years. This follows a similar trajectory for girls for the same time period. Visually, scores for girls decline quicker, consequently, boys have higher mean scores from ages 4.5 to 9 years. Notably, there are very different profiles for internalising behaviour problems. Visually, there is a more erratic profile for boys with a sharp increase in scores from ages 3.5 to 4.5 years, followed by a sharp decline at 7 years of age. This is then followed by a sharp increase from ages 7 to 9 years. In contrast, girls scores decrease from ages 3.5 to 7 years of age before increasing at 9 years of age.

Figure (A.5.7) Mean Z-scores for externalising and internalising behaviour problem from ages 3.5 to 9 years by child's sex. Mean scores for male (red line) are contrasted to scores for female (blue line).



CBCL Z-Scores stratified by income and sex

Next, I expanded on the previous plots exploring to stratify by both sex and household income. This approach allows investigation into whether there may be a sex by income interaction. The stratification of the plots below, visualise any potential sex differences by each level of household income.

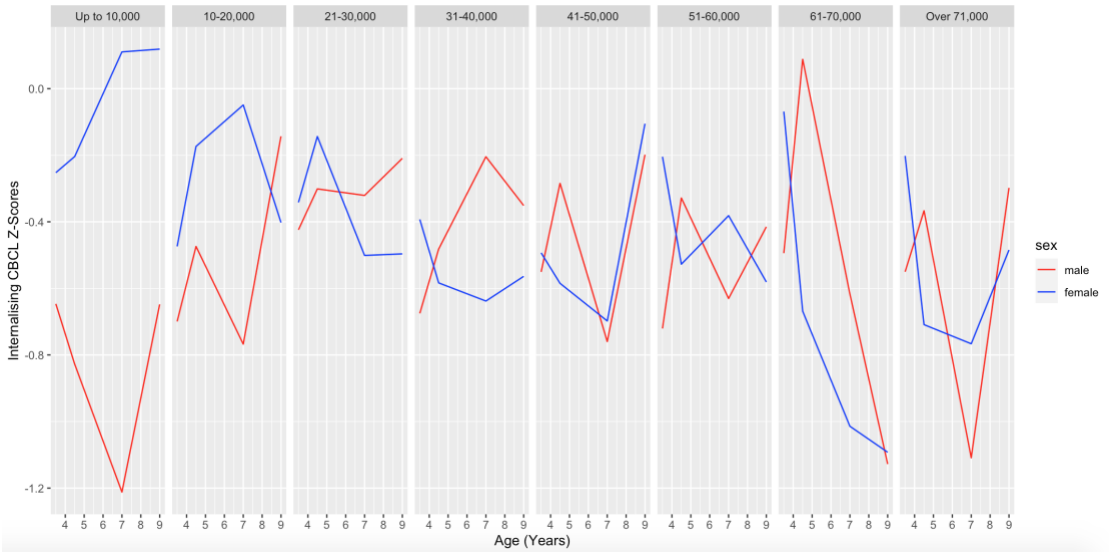
Figures (A.5.8, A.5.9) displays the population average for externalising and internalising behaviour problems by sex and household income. Each panel represents a level in the household income variable. The first panel shows the population mean scores for externalising scores for children in the 'Up to £10,000' income group. The red lines display scores for boys and the blue line scores for girls.

Visually, there are similar trajectories for boys and girls within each household income group for externalising behaviours (A.5.8). For example, in the lowest income group 'Up to £10,000', for both boys and girls, mean z-scores increase from ages 3.5 to 4.5 years. Scores then decrease from 4.5 to 7 years before increasing to 9 years of age.

Figure (A.5.8) Plot of mean externalising behaviour problems versus age by sex and household income.

Visually, the crossing of plot lines shown in figure (A.5.9) suggest that there are no straightforward sex differences for internalising behaviours when stratified by household income. In the lowest income group, 'Up to £10,000', boys have a V-shaped trajectory, with scores decreasing from 3.5 to 7 years before increasing to 9 years of age. In contrast, mean z-scores increase from ages 3.5 to 9 years for girls.

Figure (A.5.9) Plot of mean internalising behaviour problems versus age by sex and household income.



Nested Models

Table (A.5.11) displays the β coefficients for internalising and externalising behaviour problem Z-Scores. Results are shown for the final fully adjusted models (discussed in Chapter 5). Model summary statistics are also provided.

	Externalising (β)	Internalising (β)
Fixed Effects		
Intercept	-0.188	-0.019
Age	0.004	0.001
Income	0.037	0.008
Age x Income	-0.001	0.000
Maternal Age 18-24	-0.003	0.14
Maternal Age 25-34	-0.023	-0.006
Sex (Male)	-0.039	-0.103
Ethnicity (Other)	-0.051	0.05
Random Effects		
Residual Variance	0.69	0.557
Intercept Variance	0.415	1.392
Slope Variance	0	0
-2 Log Likelihood	-1777.1	-1749.5
Deviance	3554.3	3499
AIC	3578.3	3523
BIC	3640.2	3585

Note: Maternal Age (Ref: 35+); Sex (Ref: Female); Ethnicity (Ref: White British)
AIC: Akaike information criterion; BIC: Bayesian information criterion

Appendices to Chapter 6

The appendix for Chapter 6 features exploratory analysis, investigations of model assumptions and sensitivity analyses that were conducted to assess the robustness of the main results from the analysis of WCHADS data presented in Chapter 6.

A.6.1 Mediation analysis using counterfactual framework to assess the proportion of the effect of income on child mental health mediated through maternal mental health

I undertook a formal mediation analysis using the counterfactual framework to assess how much of the effect of SECs (income) on child mental health is mediated via maternal mental health measured at all three time points.

The figure below shows the directed acyclic graph (DAG) for a causal mediation analysis using the counterfactual framework. I estimated the Natural Direct Effect (NDE), Natural Indirect Effect (NIE) and Total Effect (TE) for the the directed acyclic graph (DAG) in figure A.61, adjusting for maternal age at recruitment, ethnicity, child sex and maternal pre- and post-natal mental health, using the *medflex* package in R software. This package offers a flexible set of ready-made functions for fitting natural effect models, which is a novel class of causal models to directly parameterize the path-specific effects of interest, and can accommodate multiple correlated mediators (Steen et al., 2017). We calculated the proportion mediated via maternal mental health applying the formula NIE/(NDE+NIE) (VanderWeele, 2015).

Overall, 37% of the total effect of socioeconomic conditions (low versus high) on child mental health is mediated through maternal mental health (figure A.6.1), with a total effect of 1.055 (95% CI 1.013 to 1.098) and NIE of 1.020 (95%CI 1.009 to 1.031) (table A.6.1).

For the mediation analysis to have a causal interpretation, we assume no exposure/mediator interaction; that adjustment for the four types of confounding has been addressed and that there is no post-treatment confounding. The four types of confounding are: (1) confounding of the exposure-outcome relationship; (2) confounding of the mediator-outcome relationship; (3) confounding of the exposure-mediator association; and (4) mediator-outcome confounders also affected by the exposure. (Vanderweele, 2015).

Figure A.6.1: Causal mediation analysis DAG

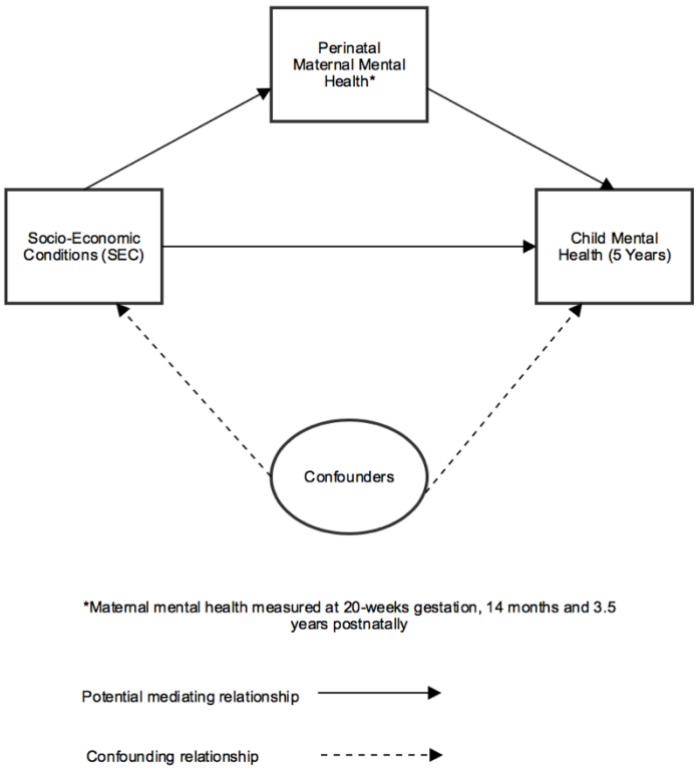


Table A.6.1 Mediation Analysis Results

Mediation Analysis

Effect Breakdown	**(ß)**	**95% LCL**	**95% UCL**	**Exp (ß)**	**95% LCL**	**95% UCL**
Natural Direct Effect	0.033	-0.006	0.073	1.034	0.994	1.076
Natural Indirect Effect	0.020	0.009	0.031	1.020	1.009	1.031
Total Effect	0.053	0.013	0.093	1.055	1.013	1.098

Exposure: household Income. Confounders: maternal age, ethnicity, child sex, maternal mental health (20 weeks gestation, 14 months & 3.5 years postnatal)

1. Vanderweele, T.J. Explanation in Causal Inference: Methods for Mediation and Interaction. Oxford; 2015.
2. Steen J, Loeys T, Moerkerke B, Vansteelandt S. Medflex: an R package for flexible mediation analysis using natural effect models. *Journal of Statistical Software*. 2017;76(11).

A.6.2 Internalising and Externalising Life Course Models Controlling for Rater Bias

I ran lifecourse models controlling for rater-bias at Child Behaviour Checklist (CBCL) measurement at 5 years (tables A.6.2, A.6.3). This was not included in the main analysis due to the change of measurement for maternal mental health. I used the Edinburgh Postnatal Depression Scale (EPDS) as a proxy for maternal mental health in the perinatal period, however, this measure was not available for our analysis sample at age 5 years (Cox et al., 1987). To control for rater bias, I used the Centre for Epidemiological Studies-Depression scale (CES-D), a 20-item measures that captures reporter experience of depression symptoms (Radloff, 1977). For this analysis, I used total score on the CES-D, as a continuous measure. The results are similar to the main analysis, showing that after adjusting for maternal mental health at age 5 years, the association between household income and externalising behaviours becomes non-significant.

[1] Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression: Development of the 10-item Edinburgh Postnatal Depression Scale. *British Journal of Psychiatry* 1987;150:782–6. doi:10.1192/bjp.150.6.782

[2] Radloff, L. S. The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurements* 1977; 1:385-401.

Table A.6.2: Externalising model controlling for rater bias

Child Mental Health Life Course Models (n=663)

	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Externalising Raw Scores						
Household Income	1.026	1.041	1.033	1.037	1.037	1.031
	(0.991, 1.062)	(0.999, 1.084)	(0.991, 1.076)	(0.996, 1.080)	(0.996, 1.080)	(0.990, 1.075)
Child Age		0.975**	0.976*	0.975**	0.975**	0.975**
		(0.957, 0.993)	(0.958, 0.994)	(0.957, 0.993)	(0.957, 0.993)	(0.958, 0.994)
Maternal Age (18-24)		0.959	0.933	0.962	0.950	0.935
		(0.751, 1.225)	(0.730, 1.192)	(0.753, 1.229)	(0.744, 1.213)	(0.731, 1.195)
Maternal Age (25-34)		1.058	1.048	1.062	1.057	1.051
		(0.872, 1.283)	(0.865, 1.271)	(0.875, 1.288)	(0.872, 1.282)	(0.867, 1.275)
Sex (Male)		1.214**	1.210**	1.211**	1.218**	1.213**
		(1.063, 1.387)	(1.060, 1.381)	(1.060, 1.382)	(1.067, 1.390)	(1.063, 1.385)
Ethnicity (Other)		0.838	0.832	0.841	0.857	0.846
		(0.558, 1.258)	(0.555, 1.247)	(0.560, 1.262)	(0.571, 1.286)	(0.564, 1.270)
Maternal Prenatal Depression			1.022*			1.016
			(1.004, 1.040)			(0.996, 1.036)
Maternal Postnatal Depression (14 months)				1.013		1.003
				(0.994, 1.032)		(0.983, 1.023)
Maternal Postnatal Depression (3.5 Years)					1.022*	1.014
					(1.002, 1.042)	(0.993, 1.036)
Maternal Depression (5 Years)	1.024***	1.022***	1.019***	1.019***	1.017**	1.016**
	(1.015, 1.033)	(1.013, 1.031)	(1.009, 1.029)	(1.009, 1.029)	(1.007, 1.027)	(1.005, 1.026)

Note: Exp (ß) interpreted as geometric means. Maternal Age (Reference: 35+); Sex (Reference: female); Ethnicity (Reference: white British) *p<0.05; **p<0.01; ***p<0.001. Maternal Depression 5 Years Measured by CES-D.

Table A.6.3: Internalising model controlling for rater bias

Child Mental Health Life Course Models (n=663)						
	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Internalising Raw Scores						
Household Income	1.013	1.017	1.005	1.011	1.009	1.003
	(0.982, 1.045)	(0.980, 1.055)	(0.968, 1.042)	(0.975, 1.049)	(0.973, 1.046)	(0.967, 1.040)
Child Age		0.975**	0.977**	0.975**	0.975**	0.976**
		(0.959, 0.992)	(0.960, 0.993)	(0.959, 0.992)	(0.959, 0.991)	(0.960, 0.992)
Maternal Age (18-24)		1.024	0.982	1.029	1.005	0.984
		(0.820, 1.277)	(0.788, 1.224)	(0.825, 1.283)	(0.809, 1.250)	(0.791, 1.224)
Maternal Age (25-34)		1.08	1.066	1.086	1.079	1.071
		(0.907, 1.286)	(0.897, 1.267)	(0.913, 1.293)	(0.909, 1.281)	(0.902, 1.271)
Sex (Male)		1.029	1.024	1.024	1.035	1.031
		(0.913, 1.160)	(0.909, 1.153)	(0.909, 1.155)	(0.920, 1.165)	(0.916, 1.160)
Ethnicity (Other)		1.277	1.263	1.283	1.335	1.315
		(0.884, 1.843)	(0.878, 1.816)	(0.890, 1.850)	(0.930, 1.916)	(0.917, 1.887)
Maternal Prenatal Depression			1.032***			1.019*
			(1.016, 1.048)			(1.002, 1.037)
Maternal Postnatal Depression (14 months)				1.020*		1.001
				(1.003, 1.037)		(0.983, 1.019)
Maternal Postnatal Depression (3.5 Years)					1.045***	1.036***
					(1.027, 1.063)	(1.016, 1.056)
Maternal Depression (5 Years)	1.028***	1.027***	1.022***	1.023***	1.017***	1.016**
	(1.019, 1.036)	(1.019, 1.035)	(1.014, 1.031)	(1.013, 1.032)	(1.008, 1.026)	(1.006, 1.025)

Note: Exp (ß) interpreted as geometric means. Maternal Age (Reference: 35+); Sex (Reference: female); Ethnicity (Reference: white British) *p<0.05; **p<0.01; ***p<0.001. Maternal Depression 5 Years Measured by CES-D.

A.6.3. CBCL Internalising Problems Life Course Models

I found no significant association between household income at 20-weeks gestation and internalising problems at age 5 years. In sequential models, maternal mental health entered at any timepoint (prenatal, 14 months and 3.5 years postnatal) was associated with increased internalising scores. A one unit increase in EPDS score increased internalising scores by 4% (95% CI 2-6) in the prenatal period, by 4% (95% CI 2-5) at 14 months postnatal and 6% (95% CI 4-8) at 3.5 years. There was no significant association between child's sex and internalising problem score (table A.6.4).

Table A.6.4: CBCL Internalising Problems Life Course Models

Child Mental Health Life Course Models (n=664)

	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Internalising Raw Scores						
Household Income	1.23	1.26	1.09	1.13	1.10	1.04
	(0.985, 1.535)	(0.968, 1.635)	(0.842, 1.421)	(0.869, 1.468)	(0.855, 1.422)	(0.803, 1.343)
Child Age		0.971***	0.974**	0.972**	0.972***	0.973**
		(0.955, 0.988)	(0.957, 0.990)	(0.956, 0.989)	(0.956, 0.989)	(0.957, 0.990)
Maternal Age (18-24)		1.017	0.963	1.029	0.996	0.978
		(0.810, 1.278)	(0.769, 1.205)	(0.822, 1.288)	(0.800, 1.241)	(0.785, 1.218)
Maternal Age (25-34)		1.068	1.052	1.084	1.074	1.068
		(0.892, 1.279)	(0.882, 1.255)	(0.908, 1.295)	(0.903, 1.277)	(0.899, 1.270)
Sex (Male)		1.058	1.044	1.039	1.05	1.041
		(0.935, 1.196)	(0.925, 1.178)	(0.920, 1.173)	(0.933, 1.182)	(0.925, 1.172)
Ethnicity (Other)		1.211	1.208	1.242	1.32	1.3
		(0.830, 1.768)	(0.834, 1.749)	(0.856, 1.803)	(0.917, 1.901)	(0.904, 1.870)
Maternal Prenatal Depression			1.044***			1.021*
			(1.028, 1.061)			(1.003, 1.039)
Maternal Postnatal Depression (14 months)				1.038***		1.008
				(1.022, 1.054)		(0.991, 1.026)
Maternal Postnatal Depression (3.5 Years)					1.060***	1.046***
					(1.044, 1.076)	(1.027, 1.066)

Note: Exp (ß) interpreted as geometric means. Maternal Age (Reference: 35+); Sex (Ref: female); Ethnicity (Reference: white British) *p<0.05; **p<0.01; ***p<0.001. Household Income represents the socioeconomic (SEC) gap, the difference between the most and least deprived households.

A.6.4. Sensitivity analysis using the English Index of Multiple Deprivation (IMD) as an alternative measure of socioeconomic conditions (SECs).

Tables A.6.5 and A.6.6 presents results from sensitivity analyses assessing model assumptions by modelling IMD as an alternative exposure measure.

Table A.6.5: CBCL Externalising Problems Life Course Models using IMD as an alternative exposure.

Sensitivity: Child Mental Health Life Course Models (n=663)

	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Externalising Raw Scores						
IMD 1	1.394*	1.372*	1.342*	1.323*	1.383*	1.345*
	(1.081, 1.797)	(1.061, 1.775)	(1.040, 1.731)	(1.024, 1.708)	(1.074, 1.781)	(1.044, 1.733)
IMD 2	1.249	1.239	1.228	1.192	1.255	1.226
	(0.949, 1.644)	(0.942, 1.631)	(0.936, 1.610)	(0.907, 1.565)	(0.958, 1.644)	(0.936, 1.607)
IMD 3	1.400*	1.377*	1.362*	1.349*	1.408**	1.379*
	(1.079, 1.815)	(1.060, 1.788)	(1.052, 1.763)	(1.041, 1.748)	(1.089, 1.821)	(1.067, 1.784)
IMD 4	1.432*	1.391*	1.414*	1.374*	1.455*	1.438*
	(1.045, 1.963)	(1.015, 1.907)	(1.036, 1.931)	(1.005, 1.877)	(1.067, 1.985)	(1.055, 1.961)
Maternal Age (18-24)		1.048	0.964	1.027	0.998	0.965
		(0.833, 1.319)	(0.765, 1.214)	(0.818, 1.290)	(0.795, 1.252)	(0.767, 1.213)
Maternal Age (25-34)		1.047	1.03	1.06	1.046	1.042
		(0.858, 1.278)	(0.846, 1.254)	(0.870, 1.291)	(0.860, 1.272)	(0.857, 1.267)
Sex (Male)		1.203**	1.193*	1.187*	1.198**	1.189*
		(1.050, 1.377)	(1.043, 1.363)	(1.038, 1.357)	(1.049, 1.369)	(1.041, 1.358)
Ethnicity (Other)		0.835	0.827	0.849	0.885	0.868
		(0.550, 1.266)	(0.548, 1.248)	(0.562, 1.283)	(0.587, 1.334)	(0.577, 1.307)
Maternal Prenatal Depression			1.037***			1.019
			(1.019, 1.054)			(0.999, 1.039)
Maternal Postnatal Depression (14 months)				1.033***		1.012
				(1.016, 1.051)		(0.992, 1.032)
Maternal Postnatal Depression (3.5 Years)					1.043***	1.028**
					(1.025, 1.062)	(1.007, 1.050)

Note: Exp (ß) interpreted as geometric means. IMD: English Index of Multiple Deprivation (Reference: IMD 5 Least Deprived Quintile); Maternal Age (Reference: 35+); Sex (Ref: female); Ethnicity (Reference: white British) *p<0.05; **p<0.01; ***p<0.001.

Table A.6.6: CBCL Internalising Problems Life Course Models using IMD as an alternative exposure.

Sensitivity: Child Mental Health Life Course Models (n=663)

	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Internalising Raw Scores						
IMD 1	1.227	1.21	1.176	1.156	1.223	1.191
	(0.973, 1.547)	(0.955, 1.532)	(0.934, 1.481)	(0.916, 1.459)	(0.975, 1.534)	(0.950, 1.494)
IMD 2	1.093	1.082	1.07	1.031	1.102	1.079
	(0.851, 1.404)	(0.841, 1.393)	(0.836, 1.368)	(0.805, 1.322)	(0.866, 1.403)	(0.848, 1.374)
IMD 3	1.188	1.176	1.161	1.147	1.215	1.191
	(0.937, 1.506)	(0.925, 1.495)	(0.918, 1.467)	(0.906, 1.452)	(0.965, 1.530)	(0.947, 1.499)
IMD 4	1.174	1.166	1.19	1.147	1.243	1.231
	(0.880, 1.565)	(0.873, 1.557)	(0.897, 1.578)	(0.864, 1.524)	(0.941, 1.640)	(0.933, 1.623)
Maternal Age (18-24)		1.064	0.958	1.039	0.992	0.956
		(0.862, 1.315)	(0.777, 1.181)	(0.844, 1.278)	(0.810, 1.215)	(0.779, 1.172)
Maternal Age (25-34)		1.068	1.046	1.084	1.067	1.061
		(0.890, 1.283)	(0.875, 1.251)	(0.906, 1.297)	(0.895, 1.271)	(0.891, 1.263)
Sex (Male)		1.038	1.027	1.021	1.032	1.024
		(0.916, 1.175)	(0.909, 1.159)	(0.903, 1.153)	(0.916, 1.163)	(0.910, 1.154)
Ethnicity (Other)		1.234	1.22	1.261	1.342	1.315
		(0.842, 1.809)	(0.840, 1.771)	(0.866, 1.835)	(0.930, 1.937)	(0.912, 1.895)
Maternal Prenatal Depression			1.046***			1.021*
			(1.031, 1.063)			(1.003, 1.039)
Maternal Postnatal Depression (14 months)				1.041***		1.01
				(1.025, 1.057)		(0.992, 1.028)
Maternal Postnatal Depression (3.5 Years)					1.063***	1.047***
					(1.046, 1.079)	(1.028, 1.067)

Note: Exp (ß) interpreted as geometric means. IMD: English Index of Multiple Deprivation (Reference: IMD 5 Least Deprived Quintile); Maternal Age (Reference: 35+); Sex (Ref: female); Ethnicity (Reference: white British) *p<0.05; **p<0.01; ***p<0.001.

A.6.5: Sensitivity analysis using clinical cut-offs on the child behaviour checklist (CBCL) as an alternative outcome measure.

I repeated the hierarchical approach to multivariate regression model using clinical cut-offs as an alternative outcome (tables A.6.7, A.6.8). I dichotomised CBCL T-score (age and sex standardised total score) for internalising and externalising problems using established cut-offs. [Reference 0: no clinical-level scores; 1: borderline-clinical scores] (Achenbach, 1991).

[1] Achenbach, T. M. (1991). Manual for the child behavior checklist/4-18 and 1991 profile. Burlington VT.enbach TM. Manual for the child behavior checklist/4-18 and 1991 profile. *Burlingt VT* 1991.

Table A.6.7: CBCL Externalising Problems Life Course Models using clinical cut-offs as an alternative outcome measure.

Sensitivity: Child Mental Health Life Course Models (n=665)

	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Clinical Externalising Scores						
Household Income	1.241*	1.340*	1.279	1.307*	1.26	1.244
	(1.018, 1.529)	(1.056, 1.721)	(1.004, 1.647)	(1.027, 1.683)	(0.990, 1.621)	(0.975, 1.605)
Maternal Age (18-24)		0.563	0.501	0.567	0.472	0.45
		(0.152, 2.386)	(0.134, 2.141)	(0.153, 2.411)	(0.121, 2.056)	(0.115, 1.971)
Maternal Age (25-34)		0.887	0.864	0.902	0.905	0.893
		(0.315, 3.167)	(0.304, 3.101)	(0.319, 3.224)	(0.318, 3.254)	(0.313, 3.217)
Sex (Male)		1.728	1.726	1.681	1.695	1.72
		(0.811, 3.803)	(0.805, 3.820)	(0.784, 3.714)	(0.785, 3.775)	(0.795, 3.842)
Ethnicity (Other)		0	0	0	0	0
Maternal Prenatal Depression			1.091			1.043
			(0.997, 1.189)			(0.940, 1.152)
Maternal Postnatal Depression (14 months)				1.055		0.99
				(0.967, 1.143)		(0.894, 1.086)
Maternal Postnatal Depression (3.5 Years)					1.137**	1.125*
					(1.047, 1.235)	(1.023, 1.235)

Note: Exp (ß) interpreted as geometric means. Maternal Age (Reference: 35+); Sex (Ref: female); Ethnicity (Reference: white British) *p<0.05; **p<0.01; ***p<0.001. Household Income represents the socioeconomic (SEC) gap, the difference between the most and least deprived households

Table A.6.8: CBCL Internalising Problems Life Course Models using clinical cut-offs as an alternative outcome measure.

Sensitivity: Child Mental Health Life Course Models (n=665)						
	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Clinical Internalising Scores						
Household Income	1.156*	1.182	1.095	1.134	1.098	1.062
	(1.004, 1.337)	(0.999, 1.406)	(0.920, 1.308)	(0.955, 1.352)	(0.924, 1.310)	(0.890, 1.272)
Maternal Age (18-24)		1.081	0.876	1.117	0.913	0.808
		(0.390, 3.345)	(0.307, 2.759)	(0.400, 3.475)	(0.315, 2.907)	(0.275, 2.601)
Maternal Age (25-34)		1.39	1.326	1.46	1.48	1.417
		(0.605, 3.773)	(0.567, 3.649)	(0.632, 3.980)	(0.632, 4.079)	(0.601, 3.923)
Sex (Male)		0.976	0.958	0.918	0.923	0.947
		(0.563, 1.683)	(0.546, 1.672)	(0.525, 1.593)	(0.522, 1.624)	(0.533, 1.675)
Ethnicity (Other)		0.567	0.557	0.575	0.778	0.767
		(0.031, 2.879)	(0.030, 2.939)	(0.031, 2.994)	(0.042, 4.093)	(0.041, 4.050)
Maternal Prenatal Depression			1.157***			1.100*
			(1.086, 1.235)			(1.021, 1.183)
Maternal Postnatal Depression (14 months)				1.089**		0.989
				(1.023, 1.158)		(0.916, 1.064)
Maternal Postnatal Depression (3.5 Years)					1.193***	1.159***
					(1.119, 1.274)	(1.077, 1.250)

Note: Exp (ß) interpreted as geometric means. Maternal Age (Reference: 35+); Sex (Ref: female); Ethnicity (Reference: white British) *p<0.05; **p<0.01; ***p<0.001. Household Income represents the socioeconomic (SEC) gap, the difference between the most and least deprived households

A.6.6: Sensitivity analysis using untransformed CBCL scores as an alternative outcome measure.

I repeated the hierarchical approach to multivariate regression model using untransformed CBCL raw scores (table A.6.9). The conclusions are similar to the main analysis. Using the untransformed CBCL scores, the income gap shows a 2.8-point difference between the least and most deprived children in externalising problems in model VI.

Table A.6.9: Untransformed CBCL Externalising Problems Life Course Models

Sensitivity: Untransformed CBCL Scores						
	Model I	Model II	Model III	Model IV	Model V	Model VI
CBCL Externalising Raw Scores						
Household Income	0.428**	0.545***	0.427**	0.471**	0.443**	0.395*
	(0.163, 0.694)	(0.233, 0.856)	(0.113, 0.741)	(0.156, 0.785)	(0.134, 0.753)	(0.081, 0.708)
Child Age		-0.227**	-0.212**	-0.222**	-0.221**	-0.214**
		(-0.370, -0.083)	(-0.354, -0.070)	(-0.365, -0.079)	(-0.362, -0.080)	(-0.355, -0.072)
Maternal Age (18-24)		-0.857	-1.183	-0.803	-0.968	-1.128
		(-2.754, 1.039)	(-3.067, 0.702)	(-2.691, 1.086)	(-2.836, 0.900)	(-3.003, 0.747)
Maternal Age (25-34)		-0.166	-0.257	-0.095	-0.139	-0.194
		(-1.661, 1.329)	(-1.738, 1.223)	(-1.584, 1.393)	(-1.611, 1.333)	(-1.666, 1.278)
Sex (Male)		1.754***	1.675**	1.667**	1.716***	1.676**
		(0.730, 2.777)	(0.661, 2.689)	(0.646, 2.687)	(0.708, 2.724)	(0.667, 2.684)
Ethnicity (Other)		-1.953	-1.972	-1.833	-1.49	-1.598
		(-5.097, 1.191)	(-5.083, 1.140)	(-4.964, 1.298)	(-4.592, 1.611)	(-4.697, 1.500)
Maternal Prenatal Depression			0.256***			0.147
			(0.126, 0.387)			(-0.002, 0.296)
Maternal Postnatal Depression (14 months)				0.179**		0.008
				(0.048, 0.309)		(-0.143, 0.158)
Maternal Postnatal Depression (3.5 Years)					0.313***	0.244**
					(0.182, 0.445)	(0.087, 0.401)

Note: Maternal Age (Reference: 35+); Sex (Ref: female); Ethnicity (Reference: white British) *p<0.05; **p<0.01; ***p<0.001.

A.6.7 Sensitivity analysis using clinical cut-off scores for maternal mental health.

I repeated the main analysis using a validated cut-off for the EPDS measure (table A.6.10)**.** I did not include this in the main analysis due to the small sample size, and because dichotomising the EPDS score means that we lose information by only focusing on the mediating role of the most severe end of the maternal mental health spectrum.

I also undertook a formal mediation analysis using the counterfactual framework to assess how much of the effect of SEC income on child mental health is mediated via maternal mental health (dichotomised as a clinical cut-off) measured at all three time points (table A.6.10). This process is described in A.6.1.

Overall, 8.8 % of the total effect of socioeconomic conditions (low versus high) on child mental health is mediated through maternal mental health with a total effect of 1.05 (95% CI 1.013 to 1.098) and NIE of 1.01 (95%CI 0.998 to 1.012).

Table A.6.10: CBCL Externalising Problems Life Course Models using clinical cut-offs for maternal mental health.

	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Externalising Raw Scores						
Household Income	1.041*	1.055*	1.051*	1.054*	1.053*	1.050*
	(1.005, 1.078)	(1.012, 1.099)	(1.009, 1.095)	(1.011, 1.098)	(1.011, 1.097)	(1.007, 1.094)
Child Age		0.972**	0.973**	0.972**	0.972**	0.973**
		(0.953, 0.990)	(0.954, 0.991)	(0.954, 0.990)	(0.954, 0.990)	(0.955, 0.991)
Maternal Age (18-24)		0.954	0.938	0.954	0.951	0.936
		(0.744, 1.224)	(0.731, 1.203)	(0.743, 1.224)	(0.741, 1.221)	(0.730, 1.202)
Maternal Age (25-34)		1.05	1.046	1.05	1.052	1.047
		(0.863, 1.278)	(0.859, 1.272)	(0.863, 1.278)	(0.864, 1.281)	(0.861, 1.275)
Sex (Male)		1.240**	1.248**	1.238**	1.240**	1.248**
		(1.084, 1.418)	(1.091, 1.428)	(1.082, 1.417)	(1.084, 1.418)	(1.090, 1.428)
Ethnicity (Other)		0.802	0.806	0.802	0.807	0.809
		(0.531, 1.213)	(0.534, 1.217)	(0.531, 1.213)	(0.533, 1.220)	(0.535, 1.222)
Maternal Prenatal Depression			1.285			1.272
			(1.000, 1.651)			(0.986, 1.642)
Maternal Postnatal Depression (14 months)				1.069		1.013
				(0.790, 1.448)		(0.741, 1.383)
Maternal Postnatal Depression (3.5 Years)					1.129	1.076
					(0.818, 1.558)	(0.772, 1.500)

Note: Exp (ß) interpreted as geometric means. Maternal Age (Reference: 35+); Sex (Ref: female); Ethnicity (Reference: white British)
*p<0.05; **p<0.01; ***p<0.001

Table A.6.11 Mediation analysis results using clinical cut-offs for maternal mental health.

Effect Breakdown	**(ß)**	**95% LCL**	**95% UCL**	**Exp (ß)**	**95% LCL**	**95% UCL**
Natural Direct Effect	0.049	0.008	0.089	1.050	1.008	1.093
Natural Indirect Effect	0.005	-0.002	0.012	1.005	0.998	1.012
Total Effect	0.053	0.013	0.093	1.055	1.013	1.098

Note: Exposure: household Income. Confounders: maternal age, ethnicity, child sex, maternal mental health (20 weeks gestation, 14 months & 3.5 years postnatal).

A.6.8 Comparison of baseline and analysis sample demographics

Table A.6.12: Comparison of sample demographics

	Baseline Sample	Analysis Sample
Subjects n	1233	666
Externalising raw score	8.4 (7.7)	7.7 (6.8)
Internalising raw score	6.7 (6.3)	6.2 (5.5)
Log-Externalising raw score	1.9 (0.9)	1.8 (0.9)
Log-Internalising raw score	1.7 (0.8)	1.7 (0.8)
Income Band (%)		
Up to £10,000	104 (10.2)	48 (7.2)
£10-20,000	137 (13.4)	77 (11.6)
£21-30,000	162 (15.9)	97 (14.6)
£31-40,000	195 (19.1)	134 (20.1)
£41-50,000	163 (16.0)	110 (16.5)
£51-60,000	130 (12.7)	101 (15.2)
£61-70,000	61 (6.0)	46 (6.9)
Over £71,000	68 (6.7)	53 (8.0)
Maternal Age (%)		
18-24	489 (39.8)	160 (24.1)
25-34	607 (49.3)	408 (61.4)
35+	134 (10.9)	96 (14.5)
Ethnicity (%)		
Other	45 (3.6)	19 (2.9)
Sex (%)		
Male	599 (48.6)	317 (47.6)
IMD Quintile		
1 (Most Deprived)	514 (41.8)	229 (34.5)
2	225 (18.3)	126 (19.0)
3	294 (23.9)	186 (28.1)
4	105 (8.5)	63 (9.5)
5 (Least Deprived)	92 (7.5)	59 (8.9)
Maternal Mental Health		
Prenatal	6.8 (4.1)	6.4 (4.0)
Postnatal (14 months)	5.2 (3.6)	5.1 (4.0)
Postnatal (3.5 years)	5.3 (3.4)	5.0 (3.9)

Note: Analysis sample: Participants with exposure and outcome data available

Appendix 7: Publications from this thesis

Publications

Rutherford, C. & Taylor-Robinson, D. (2017). *Wide variation in child mental health spend in England*. BMJ (Clinical research ed.), 356, j451. doi:10.1136/bmj.j451

Rutherford, C., Sharp, H., Hill, J., Pickles, A., & Taylor-Robinson, D. (2019). *How does perinatal maternal mental health explain early social inequalities in child behavioural and emotional problems? Findings from the Wirral Child Health and Development Study*. PLOS ONE, 14(5), e0217342. doi:10.1371/journal.pone.0217342

Abstracts

Rutherford C, Hill J, Sharp H, Taylor-Robinson, D (2017)**.** Assessing the impact of childhood socioeconomic conditions on child mental health: findings from the Wirral Child Health and Development Study**.** *Journal of Epidemiology and Community Health*, **71 (**A11-A12.) doi:10.1136/jech-2017-SSMAbstracts.21

Straatmann, V., Campbell, M., **Rutherford, C.,** Wickham, S., & Taylor-Robinson, D. (2017). Understanding social inequalities in child mental health: findings from the UK Millennium Cohort Study. *Journal of epidemiology and community health, 71 (A31).* doi:10.1136/jech-2017-SSMAbstracts.60

thebmj

BMJ 2017;356:j451 doi: 10.1136/bmj.j451 (Published 2017 January 26)

LETTERS

Check for updates

SUSTAINABILITY AND TRANSFORMATION PLANS

Wide variation in child mental health spend in England

Callum A Rutherford *PhD student*[1], David Taylor-Robinson *professor of public health and policy*[2]

[1]Department of Public Health and Policy, Institute of Psychology, Health and Society, The Farr Institute at the Health e-Research Centre, Waterhouse Building (2nd Floor, Block F), University of Liverpool, Liverpool L69 3GL, UK; [2]Department of Public Health and Policy, University of Liverpool, Liverpool L69 3GB, UK

Black and Mays highlight the need for "coherent planning" in the sustainability and transformation plans (STPs) to deliver "place based" health and care services.[1] Reducing inequalities in child mental health is a priority.[2] Despite pledges for increased funding, mental health services are struggling to meet the rising demand in under 18s.[3] Disadvantaged areas are especially affected, as social deprivation is strongly associated with mental health outcomes in children.[4]

The Royal College of Psychiatrists has shown the variation in spending on child and adolescent mental health services.[5] We used publicly accessible data to show the extent of variation in planned spending by clinical commissioning groups (fig 1⇓).[5 6]

Spend per head is only weakly associated with deprivation, and stark unexplained variation in spend remains, raising questions about a potential "postcode lottery." We urgently need to provide effective, readily available mental health services for children and young people. STPs must not increase inequalities in child mental health.

Competing interests: None declared.

1 Black N, Mays N. Sustainability and transformation plans: a troubled start. *BMJ* 2016;356:i6064doi:10.1136/bmj.i6064.
2 Marmot MG, Allen J, Goldblatt P, et al. *Fair society, healthy lives: Strategic review of health inequalities in England post-2010*. The Marmot Review, 2010.
3 Campbell D. Psychiatrists attack 'scandal' of child mental health spending. *Guardian* 2016 November 17. https://www.theguardian.com/society/2016/nov/17/psychiatrists-attack-scandal-of-child-mental-health-spending.
4 Reiss F. Socioeconomic inequalities and mental health problems in children and adolescents: a systematic review. *Soc Sci Med* 2013;356:24-31. doi:10.1016/j.socscimed.2013.04.026 pmid:23746605.
5 Royal College of Psychiatrists. Mental health five year forward view dashboard: analysis from the Royal College of Psychiatrists. November 2016. http://www.rcpsych.ac.uk/pdf/Mental%20Health%20Five%20Year%20Forward%20View%20Dashboard%20-%20analysis%20from%20RCPsych.pdf.
6 Public Health England. National general practice profiles. 2016. https://fingertips.phe.org.uk/profile/general-practice.

c.rutherford@liverpool.ac.uk

Figure

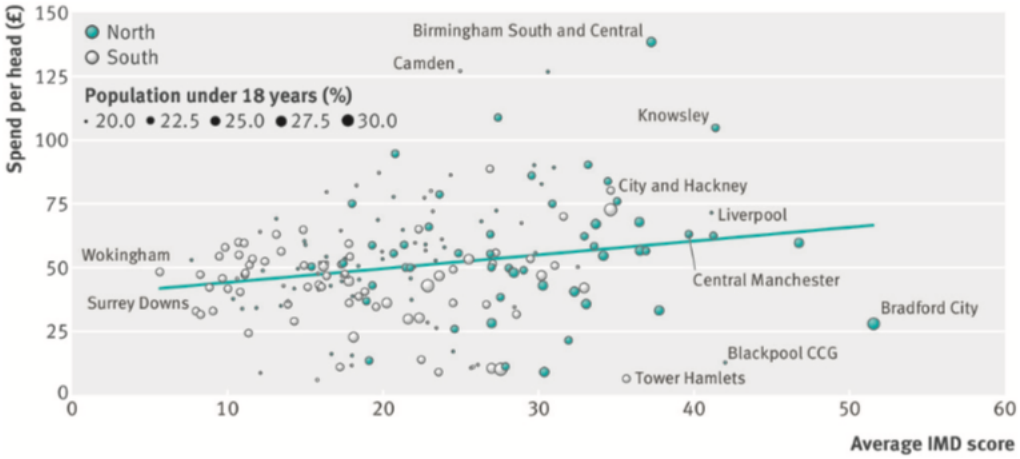


Fig 1 Planned spend by clinical commissioning groups on children and young people's mental health, 2016-17.[56] IMD=index of multiple deprivation

PLOS ONE

RESEARCH ARTICLE

How does perinatal maternal mental health explain early social inequalities in child behavioural and emotional problems? Findings from the Wirral Child Health and Development Study

Callum Rutherford[1]*, **Helen Sharp**[2], **Jonathan Hill**[3], **Andrew Pickles**[4], **David Taylor-Robinson**[1]

1 Department of Public Health and Policy, Farr Institute, University of Liverpool, Liverpool, United Kingdom, **2** Department of Psychological Sciences, University of Liverpool, Liverpool, United Kingdom, **3** School of Psychology & Clinical Language Sciences, University of Reading, Reading, United Kingdom, **4** Biostatistics Department, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, United Kingdom

* C.Rutherford@liverpool.ac.uk

OPEN ACCESS

Citation: Rutherford C, Sharp H, Hill J, Pickles A, Taylor-Robinson D (2019) How does perinatal maternal mental health explain early social inequalities in child behavioural and emotional problems? Findings from the Wirral Child Health and Development Study. PLoS ONE 14(5): e0217342. https://doi.org/10.1371/journal.pone.0217342

Editor: Hudson P. Santos, Jr, University of North Carolina at Chapel Hill, UNITED STATES

Received: October 25, 2018

Accepted: May 10, 2019

Published: May 24, 2019

Data Availability Statement: Data used for this submission will be made available on request to the Executive Committee (first.steps@liverpool.ac.uk). The WCHADS data management plan (available on request) describes in detail the policy regarding data sharing, which is through approved collaborative and protected access facilitated by the WCHADS research team, in line with original ethical permissions. The data underlying the results presented in the study are available from (https://

Abstract

Background

This study aimed to assess how maternal mental health mediates the association between childhood socio-economic conditions at birth and subsequent child behavioural and emotional problem scores.

Methods

Analysis of the Wirral Child Health and Development Study (WCHADS), a prospective epidemiological longitudinal study of the early origins of child mental health (n = 664). Household income at 20-weeks gestation, a measure of socio-economic conditions (SECs) in pregnancy, was the main exposure. The outcome measure was externalising and internalising problems, as measured by the Child Behaviour Checklist at 5 years. We assessed the association of household income with child behavioural outcomes in sequential linear models adjusting for maternal mental health in the pre- and post- natal period.

Results

Children of mothers in more disadvantaged households had higher scores for externalising behaviour with a difference of 3.6 points comparing the most affluent to the most disadvantaged families (the socio-economic (SEC) gap). In our regression model adjusting for baseline confounders, comparing children of mothers in the most disadvantaged households to the least disadvantaged, we found that most disadvantaged children scored 45 percentage points (95% CI 9, 93) higher for externalising problems, and 42% of this difference was explained in the fully adjusted model. Adjusting for prenatal maternal depressive

www.liverpool.ac.uk/psychology-health-and-society/departments/psychological-sciences/research/first-steps/for-researchers/). Proposals to access the dataset should be requested as outlined in the Wirral Child Health and Development Study Data Access Policy document. All proposals are reviewed by the WCHADS Executive Committee.

Funding: CR is funded by The National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care North West Coast (NIHR CLAHRC NWC). WCHADS is funded by grants from the UK Medical Research Council (G0900654; G0400577). DTR is funded by the MRC on a Clinician Scientist Fellowship (MR/P008577/1). The views expressed here are those of the author(s) and not necessarily those of the NHS, the NIHR, or the Department of Health and Social Care. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

symptomology attenuated the SEC gap in externalising problems by about a third, rendering the association non-significant, whilst adjusting for pre- and post-natal maternal mental health attenuated the SEC gap by 42%. There was no significant relationship between household income and internalising problems.

Conclusion

Social disadvantage is associated with higher child externalising behaviour problems score at age 5, and about 40% of this was explained by maternal perinatal mental health. Policies supporting maternal mental health in pregnancy are important to address the early emergence of inequalities in child mental health.

Introduction

Reducing inequalities in mental health outcomes is a public health priority. [1] In the UK, one in ten children and young people (aged 5–16 years) have a clinically diagnosed mental health problem (behavioural 6% and emotional 4%). [2] The prevalence of mental health problems is a growing concern, with 24% of girls and 9% of boys aged 14 years self-reporting high levels of depression in the UK. [3] Poorer socioeconomic conditions (SECs) are associated with worse mental health outcomes. [4] A systematic review of 52 studies from 23 countries found that children and young people from disadvantaged families are two-to-three times more likely to develop mental health problems compared to economically advantaged children. [4] A number of theories describe the pathways through which SECs influence child health, including mental health, with the most commonly cited differentiating between material, psychosocial, behavioural and structural factors. [5] For example, experiences of poverty can have a negative impact on maternal mental health and behaviour, which in turn influences child health. [6]

Inequalities in mental health outcomes are established in the early years of a child's development and these inequalities widen as children start primary education.[7] More support is needed earlier in the lifecourse to narrow inequalities. [7] In order to design and implement effective policies to tackle inequalities, a clearer understanding of the pathways, in the early years, is needed. Furthermore, it is unclear if these putative pathways differ for internalising problems (e.g., depression, anxiety) and externalising behaviour problems (e.g., aggression, attention) in children.

Maternal mental health is a well-established risk factor for child psychopathology and has been identified as a potential mediator of the association between socioeconomic conditions and child mental health outcomes. [8,9] One in five women experience depression in the perinatal period [10], although 60% of women are not detected and clinically diagnosed. [11] A previous episode of perinatal depression is associated with future risk [12], and around 15% of women who experience an episode of depression during pregnancy, experience a new episode within three months postpartum. [11]

Maternal mental health problems have been associated with the level of emotional support a child receives. Furthermore, poor parental mental health can affect children's emotion regulation, development and attachment. [13,14] Few studies have explored the role of maternal mental health in generating social inequalities in child mental health. A greater understanding of the interplay and social patterning of maternal perinatal mental health and their impact on the socioeconomic gap in early child mental health problems is needed in order to design

effective policy interventions to improve child mental health outcomes and reduce inequalities across the lifecourse.[15]

Using a prospective longitudinal study of child mental health trajectories, with frequent early-years measures, the aim of this study was therefore to assess the impact of childhood socio-economic conditions (SECs) on child internalising and externalising behaviours at age 5 years. We further aimed to explore the role of maternal mental health in explaining any social patterning of early child behavioural and emotional problems identified.

Materials and methods

Design, setting and data source

We analysed data from a longitudinal cohort study of children born on the Wirral, in the North West of England. The study recruited 1233 participants consecutively from first-time mothers who booked antenatal care between February 2007 and October 2008 at the Wirral University Teaching Hospital, North West of England. [16] Owing to the socio-demographic composition of the Wirral, 41.7% of the sample were in the most deprived quintile of deprivation at recruitment, using the English Index of Multiple Deprivation (IMD [17]. These indices combine economic, social and housing indicators measures at the census into a composite deprivation score for small areas in England.

WCHADS utilises multiple informant questionnaires alongside novel experimental and observational measures, embedded within a longitudinal design, to measure child social, emotional and behavioural functioning. [16] More information on the sampling design and cohort measures can be found online [https://www.liverpool.ac.uk/psychology-health-and-society/departments/psychological-sciences/research/first-steps/for-researchers/]. This study uses data on 759 children with data available on the CBCL at age 5 years included in the study (62% of the total sample), 664 of these (87.5%) had data on all covariates. A flowchart of the analysis sample is available in the supplementary materials (S1 File). The study was granted ethical approval by the Cheshire North and West Research Ethics Committee [REF: 05/Q1506/107 (June 2006); 10/H1010/4 (June 2010)]. This analysis did not require further ethical approval.

Outcome measures

The main outcome measures were internalising and externalising problem subscale scores on the Child Behaviour Checklist (CBCL) at age five. When the cohort child was aged 4.5–5 years (58.5 months (3.6)) parents completed the preschool version of the Child Behaviour Checklist, a validated instrument, with high rates of validity and reliability across many populations, measuring child emotional and behavioural disorders. [18,19] The measure contains 99 problem items, scored 0 (not true), 1 (somewhat or sometimes true) and 2 (very true or often true). Internalising problems are derived from combining the anxious/depressed, emotionally reactive, withdrawn and somatic complaints scores, and externalising problems by combining aggressive behaviour and attention problem scores. [18] The subsequent main analysis uses raw scores (unadjusted for sex and age) for both internalising and externalising domains, treated as a continuous variable.

Early-life risk factors

The primary exposure measure of childhood socio-economic conditions in pregnancy, our baseline, was household income measured at 20-weeks gestation. Mothers were asked 'What is your approximate annual family income?' with responses collected in £10,000 incremental bands (Range: Up to £10,000 –Over £71,000). Our analysis uses the socioeconomic gap, which is the

difference between the least (Over £71,000, n = 53)) and most deprived (Up to £10,000, n = 48)) households, to explore inequalities in mental health outcomes. In sensitivity analyses, we used IMD quintile score as an alternative exposure of childhood socio-economic conditions.

For maternal mental health, we used total score on the Edinburgh Postnatal Depression Scale (EPDS). The EPDS is a self-reported 10-item measure used as screening tool for depression in the perinatal period. [20] We used the EPDS as a continuous measure, [20] measured at 20-weeks gestation, 14 months postnatal and 3 ½ years as a proxy for maternal mental health. Although primarily used a measure for depressive symptoms, the EPDS has been shown to identify anxiety and has a potential use as a screening tool for other mental disorders. [21]

Demographic characteristics that are potentially associated with child mental health outcomes included as baseline variables in the analysis: maternal age at consent coded as 18–24, 25–34, 35+), child's age, sex and ethnicity. As only 2.9% of the sample identified as other than White-British, we dichotomised ethnicity to be 'White-British' or 'Other'.

Analysis strategy

First, we undertook a univariable analysis estimating association between covariates of interest and total CBCL internalising and externalising problem scores, using linear regression. Due to the outcome data being highly positively skewed, the total scores were log-transformed, with exponentiated beta coefficients interpreted as a geometric means, whereby, a change in the independent variable is represented as a ratio of change in the dependent variable. [22]

A hierarchical approach was used for the multivariate regression modelling. Firstly, we fitted baseline models for each of our two outcomes by family income, treated as a linear function. Secondly, we adjusted for baseline demographic variables: maternal age at recruitment to the study, sex and ethnicity. We then fitted models with measures of maternal depression at our three separate time periods added separately (antenatally; at 14 months; and 3.5 years); and finally, we adjusted for maternal mental health at all three time points.

We took any attenuation in the geometric mean income coefficient on the addition of measures of maternal mental health in a complete case sample to indicate potential mediation of any socio-economic gap in mental health outcomes, [23,24] calculated as 100x(coefficient-adjusted coefficient)/(coefficient -1) to estimate the change in relative gap in behavioural and emotional problems on the basis of family income. [25] (Fig 1).

The socioeconomic gap measures health inequalities between the most and least deprived groups. It is an important tool as often population averages overlook differences in health between groups. This approach has been used in previous studies of health inequalities in social epidemiology. [23,24]

Missing data was handled using listwise deletion. To account for item missingness on the Edinburgh Postnatal Depression scale we used mean substitution. [26] Analyses were conducted using R software (version X).

Robustness test

We undertook a number of sensitivity analyses to test our assumptions. We repeated our analysis using the index of multiple deprivation (IMD) quintile as an alternative measure of socio-economic conditions [27]. We repeated our analysis using clinical cut-offs for internalising and externalising behaviour problems (0 = no clinical level score, 1 = borderline/clinical level score) to assess the association between SEC and clinical levels of child behavioural and emotional problems. Sensitivity analyses were performed using multiple imputation by chained equations to impute missing data values for all of the variables included in the models. We also undertook a formal mediation analysis using the counterfactual framework to assess how

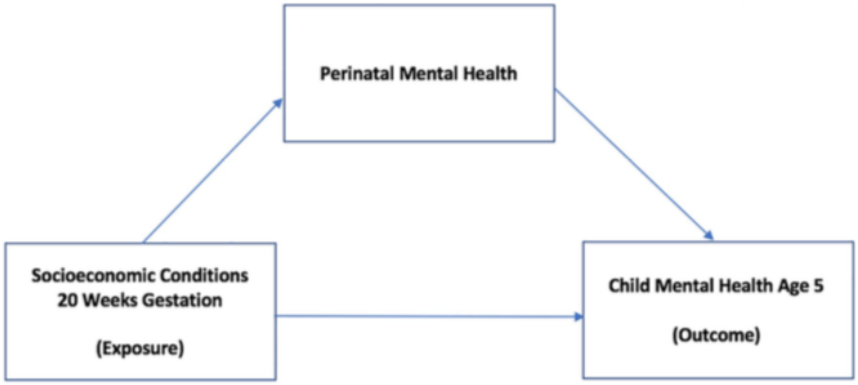


Fig 1. Pathway diagram showing the potential association between socioeconomic conditions (SECs) and child behavioural and emotional problems, with maternal mental health as a potential mediator.

https://doi.org/10.1371/journal.pone.0217342.g001

much of the effect of SEC (household income) on child behavioural problems is mediated via maternal depressive symptomology measured at all three time points. [S1 File]

Results

Table 1 shows sample characteristics stratified by household income. There were differences in mean scores for externalising and internalising behaviour problems by household income. As household income increases, mean scores for internalising and externalising behaviour problems decrease. Scores ranged from 9.9 (8.1 SD) in the lowest income households to 6.3 (6.3 SD) in the highest income households for externalising problems and from 8.1 (5.6 SD) to 5 (4.2 SD) for internalising problems. For all measures of maternal depressive symptoms in the perinatal period, mothers from the lowest income households had higher mean scores. Higher maternal age (> 35 years) was more common in the higher household income groups.

Associations between covariates and child behavioural and emotional problems

Lower household income was associated with higher scores for externalising problems (Table 2) but there was no significant association with internalising problems. Boys had significantly higher scores for externalising problems, whilst there were no significant sex differences for internalising problems. Consequently, the multivariable analysis focuses on externalising problems. In the univariable analysis male sex, child's age and maternal depressive symptoms at 20-weeks gestation, 14 months and 3 ½ years postnatally were associated with increased externalising mental health scores. By contrast there was no association with maternal age and ethnicity. To address the assumptions of mediation, we established that household income was associated with increased scores on the EPDS, using linear regression. (20 weeks (ß 0.58 $p < 0.001$); 14 months (ß 0.40, $p < 0.001$) and at 3.5 years (ß 0.37, $p < 0.001$)).

Association between exposure and outcome, adjusted for other early-life factors

Table 3 shows the results of the multivariable analysis for externalising problems (results for internalising problems are available as supplementary material (S1 File). In the unadjusted

Table 1. Characteristics of the study population by household income.

	Total	Up to £10,000	£10–20,000	£21–30,000	£31–40,000	£41–50,000	£51–60,000	£61–70,000	Over £71,000	p-value#
Subjects n (%)	666 (100)	48 (7.2)	77(11.6)	97(14.6)	134(20.1)	110(16.5)	101(15.2)	46(6.9)	53(8.0)	
Externalising raw score	7.7 (6.8)	9.9 (8.1)	10.9 (8.9)	7 (6.5)	6 (5.4)	7.8 (6.7)	7.5 (6.4)	7.6 (5.3)	6.3 (6.3)	< 0.001
Internalising raw score	6.2 (5.5)	8.1 (5.6)	7.9 (6.7)	5.5 (5.8)	5.1 (4.9)	6.5 (4.9)	6.7 (5.7)	5.6 (5)	5 (4.2)	< 0.001
Log-Externalising raw score	1.8 (0.9)	2.1 (0.9)	2.2 (0.9)	1.7 (0.9)	1.6 (0.9)	1.8 (1)	1.8 (0.9)	2 (0.7)	1.6 (0.9)	< 0.001
Log-Internalising raw score	1.7 (0.8)	2 (0.7)	1.9 (0.8)	1.5 (0.9)	1.5 (0.8)	1.8 (0.8)	1.8 (0.7)	1.6 (0.8)	1.5 (0.8)	< 0.001
Externalising clinical score (%)	29 (4.4)	3 (6.3)	10 (13.0)	3 (3.1)	1 (0.8)	5 (4.5)	5 (5.0)	1 (2.2)	1 (1.9)	< 0.01
Internalising clinical score (%)	58 (8.7)	6 (12.5)	12 (15.6)	7 (7.2)	9 (6.8)	10 (9.1)	9 (8.9)	4 (8.7)	1 (1.9)	0.222
Maternal age years n (%)										
18–24	160 (24.1)	40 (83.3)	44 (57.1)	36 (37.1)	30 (22.6)	6 (5.5)	2 (2.0)	2 (4.3)	0 (0)	< 0.001
25–34	408 (61.4)	5 (10.4)	29 (37.7)	50 (51.5)	83 (62.4)	94 (85.5)	78 (78.0)	33 (71.7)	36 (67.9))	
35+	96 (14.5)	3 (6.3)	4 (5.2)	11 (11.3)	20 (15.0)	10 (9.0)	20 (20.0)	11 (24.0)	17 (32.1)	
Child age (months)	58.5 (3.6)	58.2 (4.5)	58.4 (3.9)	58.4 (3.1)	58.7 (4.2)	58.5 (3.3)	58.8 (3.3)	58.1 (2.6)	58.5 (3.6)	0.965
Child's sex: female (%)	349 (52.4)	28 (58.3)	47 (61.0)	54 (55.7)	66 (49.3)	53 (48.2)	54 (53.5)	15 (32.6)	32 (60.4)	0.064
Child's ethnicity: other (%)	19 (2.9)	1 (2.1)	3 (3.9)	3 (3.1)	4 (3.0)	4 (3.6)	2 (2.0)	1 (2.2)	1 (1.9)	0.996
Maternal depression										
20-weeks gestation	6.4 (4)	9.2 (4.8)	8.1 (4.2)	7.1 (4.4)	5.7 (3.5)	6.2 (3.7)	5.5 (3.8)	4.5 (3.2)	5.2 (3.2)	< 0.001
14 months	5.1 (4)	6.9 (5.1)	6 (4.4)	5.9 (4.5)	4.8 (3.6)	4.7 (3.3)	4.6 (3.8)	4.1 (3.2)	3.9 (3.1)	< 0.001
3.5 years	5 (3.9)	7.5 (6)	5.6 (4.4)	5.6 (3.7)	4.7 (3.7)	4.6 (3.4)	4.4 (3.2)	4.3 (3)	4.4 (3.3)	< 0.001

Data are presented as means (SD), unless otherwise stated. Item missingness: Maternal age 2

F-test: externalising, internalising, maternal depression; Chi-squared: Maternal age, Child's sex; Fisher's Exact: Ethnicity

https://doi.org/10.1371/journal.pone.0217342.t001

Table 2. Univariable associations (n = 666).

		Externalising Raw Scores				Internalising Raw Scores		
Variables (Reference group)	**Exp(ß)**	**95% LCI**	**95% UCI**	**p-value**	**Exp(ß)**	**95% LCI**	**95% UCI**	**p-value**
Primary Exposure								
Household Income	1.04	1.01	1.08	<0.05	1.03	1.00	1.06	0.068
SEC Gap*	1.32	1.04	1.69	<0.05	1.23	0.98	1.53	0.068
Socio-demographic								
Mat Age (ref: 35+)				0.642				0.614
18–24	1.11	0.88	1.39		1.10	0.89	1.35	
25–34	1.09	0.90	1.33		1.09	0.91	1.30	
Child Age (Months)	0.97	0.95	0.99	<0.01	0.97	0.95	0.99	<0.001
Sex (Male)	1.22	1.07	1.40	<0.01	1.05	0.92	1.18	0.473
Ethnicity (Other)	0.79	0.53	1.19	0.265	1.25	0.86	1.81	0.234
Maternal Depression								
20-weeks gestation	1.04	1.07	1.40	<0.001	1.05	1.03	1.06	<0.001
14 months postnatal	1.03	1.02	1.05	<0.001	1.04	1.02	1.06	<0.001
3.5 years postnatal	1.04	1.02	1.06	<0.001	1.06	1.04	1.08	<0.001

Note: Exp (ß) interpreted as geometric means. Maternal Age (Ref: 35+); Sex (Ref: female); Ethnicity (Ref: white British).

*The socioeconomic (SEC) gap, the difference between the most and least deprived households.

https://doi.org/10.1371/journal.pone.0217342.t002

Table 3. Multivariable analysis. Child Mental Health Life Course Models (n = 664).

	Model I	Model II	Model III	Model IV	Model V	Model VI
	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)	Exp (ß)
CBCL Externalising Raw Scores						
Household Income	1.04*	1.06*	1.04	1.04*	1.04*	1.03
	(1.01, 1.08)	(1.01, 1.10)	(0.99, 1.08)	(1.00, 1.09)	(1.00, 1.09)	(0.99, 1.80)
Household Income (SEC Gap)	1.32**	1.45**	1.31	1.34*	1.34*	1.26
	(1.04, 1.69)	(1.09, 1.93)	(0.98, 1.75)	(1.00, 1.79)	(1.00, 1.77)	(0.95, 1.69)
Child Age		0.97**	0.97**	0.97**	0.97**	0.97**
		(0.95, 0.99)	(0.96, 0.99)	(0.95, 0.99)	(0.95, 0.99)	(0.96, 0.99)
Maternal Age (18–24)		0.95	0.92	0.96	0.94	0.93
		(0.74, 1.22)	(0.72, 1.18)	(0.75, 1.23)	(0.74, 1.21)	(0.73, 1.19)
Maternal Age (25–34)		1.05	1.04	1.06	1.05	1.05
		(0.86, 1.28)	(0.85, 1.26)	(0.87, 1.29)	(0.87, 1.28)	(0.87, 1.28)
Sex (Male)		1.24**	1.23***	1.22**	1.24**	1.22**
		(1.08, 1.42)	(1.08, 1.40)	(1.07, 1.40)	(1.08, 1.41)	(1.07, 1.40)
Ethnicity (Other)		0.80	0.80	0.82	0.85	0.84
		(0.53, 1.21)	(0.53, 1.21)	(0.54, 1.23)	(0.56, 1.28)	(0.56, 1.26)
Maternal Prenatal Depression			1.03****			1.02
			(1.01, 1.05)			(0.99, 1.04)
Maternal Postnatal Depression (14 months)				1.03***		1.01
				(1.01, 1.05)		(0.99, 1.03)
Maternal Postnatal Depression (3.5 Years)					1.04***	1.02*
					(1.02, 1.06)	(1.00, 1.05)

Note: Exp (ß) interpreted as geometric means. Maternal Age (Ref: 35+); Sex (Ref: female); Ethnicity (Ref: white British)

*p<0.05;

**p<0.01;

***p<0.001.

The socioeconomic (SEC) gap, the difference between the most and least deprived households.

https://doi.org/10.1371/journal.pone.0217342.t003

model (model 1), children in the most deprived households had scores 32% (95% CI 4, 69) higher for externalising problems, compared to children from the least deprived households. Adjusting for socio-demographic factors slightly increased the household income coefficient such that children in the most disadvantaged households had scores 45% (95% CI 9, 93) higher than those in the least disadvantaged.

Fig 2 shows how independently adjusting for maternal depressive symptoms across the perinatal period attenuates the socioeconomic gap in child externalising behaviour problems. Adjusting for maternal prenatal depressive symptoms antenatally (model 3) the income gap coefficient is attenuated by 31% (Exp(ß) 1.31 [95% CI 0.98, 1.75]), from baseline (model 2), rendering the association with household income non-significant. Adjusting for either maternal depressive symptoms at 14 months or 3 ½ years postnatally (models 4 & 5) attenuated the socioeconomic gap in child externalising problems by 24% (Exp(ß) 1.34 [95% CI 1.00, 1.79]), from baseline, and the association with household income remained significant in both models. Finally, adjusting for maternal depressive symptoms at all three time points (model 6) attenuated the socioeconomic gap to non-significance, attenuating the SEC gap by 42% (Exp (ß) 1.26 [95% CI 0.95, 1.69]) compared to model 2.

In the sequential models maternal depressive symptoms entered at any timepoint (prenatal, 14 months and 3.5 years) was associated with an increased score for externalising problems. A

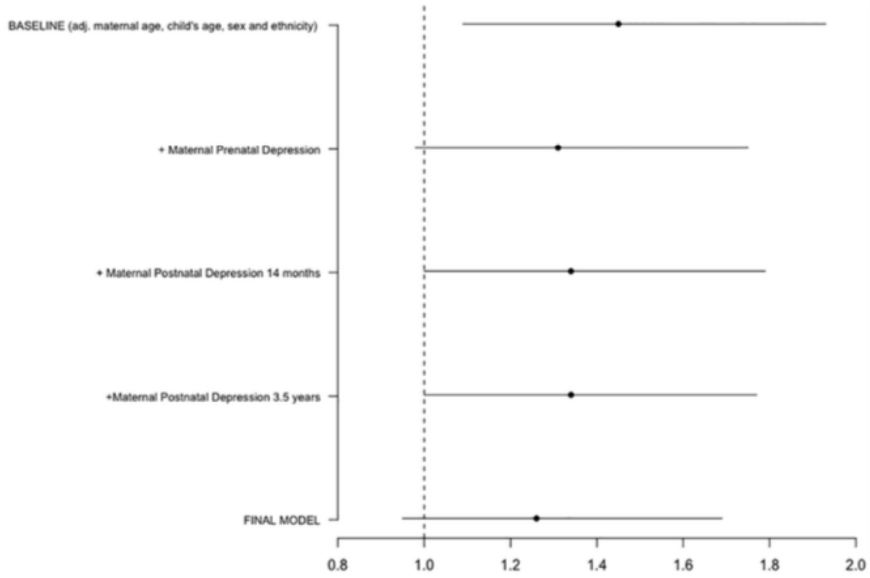


Fig 2. Attenuation of the socioeconomic gap in child externalising behaviour problems independently adjusting for maternal depressive symptoms.

https://doi.org/10.1371/journal.pone.0217342.g002

one unit increase in EPDS score increased externalising scores by 3% (95% CI 1, 5) in the prenatal period and by 4% (95% CI 2, 6) in the postnatal period. Comparing the effect of depressive symptoms between mothers from the most deprived households to the least deprived (calculated as Exp(ß x difference in mean scores)), depressive symptoms in the prenatal period increased externalising scores by 13% (95% CI 6, 22) and by 9% (95% CI 3, 15) and 12% (95% CI 6, 18) for 14 months and 3.5 years postnatally. In our fully adjusted model (model 6), only maternal depressive symptoms at 3 ½ years postnatally, child's age and sex remained significant. Male sex increased scores for externalising problems by 22% (95% CI 7, 40).

Robustness tests

In this study we identified a gap in average CBCL scores across the socioeconomic spectrum of about 3 CBCL points at age 5 years, or one third of a z-score using the untransformed CBCL scores. To contextualise this difference, the effect size for the SEC gap on externalising behaviour problems is similar to the effect size of an evidence-based parenting intervention in a recent meta-analysis and larger than the gender/sex effect in our analysis. [28]

Furthermore, we repeated our analysis using clinical cut-offs for internalising and externalising behaviour problems (0 = no clinical level score, 1 = borderline/clinical level score) to assess the association between SEC and clinical levels of child behavioural and emotional problems. This showed a social gradient in the proportion of children with behaviour problems (Table 1), and our regression modelling using these dichotomised outcomes showed similar results to our main analysis using average values. In the age and sex baseline adjusted model there was an 18% increased risk of behaviour problems across the socio-economic gap. (S1 File).

Using IMD as an alternative measure of SECs, children in the most deprived quintile scored 39% higher (95% CI 8, 80) for externalising problems compared to the least deprived children. Adjusting for maternal depressive symptoms across the perinatal period slightly attenuated the effect to 35% (95% CI 4, 73) in the final model, a reduction of 11%. Male sex and maternal depressive symptoms at all time points significantly increased externalising problem scores (S1 File). We found similar results using a counterfactual framework approach to mediation compared with the approach used in the main analysis (S1 File).

Discussion

Main findings

Using a prospective longitudinal study design with frequent early years measures of child and maternal mental health we show that low SECs in childhood, measured on the basis of household income at 20-weeks gestation, is associated with higher scores for externalising behaviour problems in children by age 5 years, but not for internalising problems. Children growing up in the most disadvantaged circumstances scored about 45% higher for externalising problems compared to children growing up in the least disadvantaged circumstances, with boys scoring significantly higher. About 40% of this association was explained by the increased prevalence of maternal mental health problems, particularly pre-natal mental health, in mothers of children growing up in disadvantaged circumstances. Our analysis suggests that interventions that improve perinatal maternal mental health are likely to reduce social inequalities in child externalising behaviour problems.

Comparison with other findings

Our results corroborate previous studies suggesting that exposure to disadvantaged socioeconomic conditions increases the risk of later child mental health problems. [4,29–32] Socio-economic disadvantage in the early years also has profound effects throughout the lifecourse. Longitudinal studies have shown that the SEC gap in child behavioural and emotional problems can be observed from infancy and that inequalities are maintained or increased throughout early childhood into adolescence. [33,34]

Furthermore our results concur with studies that have shown that the relationship between SECs and behaviour problems is stronger for externalising symptoms. [30,35,36] Whilst our study only found a significant relationship between household income and externalising problems, the relationship with internalising problems did not quite reach significance, and this may be due to our relatively small sample size and sample age. However, this finding should not be overlooked, potential mechanisms of inequalities in internalising problems may differ compared to externalising problems and manifest later in the lifecourse.

The development and prevalence of internalising problems has been associated with increasing age. [37] Although associations between SECs and internalising problems in children have been demonstrated in a number of other larger studies across childhood [29,38,39]. Furthermore, our study found that child's age at time of CBCL assessment significantly decreases externalising problem scores (Exp(ß) 0.97 [95% CI 0.96, 0.99]). Studies have shown that the prevalence of externalising problems decline with age and this occurs across socioeconomic groups. [33,40]

Maternal psychopathology has been identified as risk factor that mediates the association between socioeconomic status and child and adolescent mental health problems at later ages [4,8,41], with effects on child mental health well documented. [9] Kiernan et al [39] found that maternal depression mediated ~30% of the total economic effect on externalising problems, a similar figure to that found when we adjusted for postnatal measures of maternal depression

in our study. Our study extends the evidence base further, by showing how maternal mental health in the perinatal period impacts on the socioeconomic gap in very early measures of child behaviour problems at age 5 years. We show that low income is associated with higher scores of maternal depressive symptoms, and this is in turn related to higher externalising problem scores for children growing up in more disadvantaged SECs. Whilst we found that perinatal mental health is an important mediator of inequalities in child externalising behaviour problems, further studies should explore the mediating role of other perinatal factors such as birthweight and breastfeeding.

Our study demonstrated clear sex differences, with boys at greater risk for externalising problems at age five, after adjustment for a range of covariates in our final model, corroborating previous studies. [8,9,42] There was no association between sex and internalising problems. Research suggests that the pathways and mechanisms for internalising and externalising problems may differ for boys and girls throughout development. Boys may be more susceptible to the impact of adverse environmental stresses, or their behaviour may be met by differing patterns of maternal response. [43]

Policy and practice implications

In the UK, the prevalence of child and adolescent mental health problems is increasing. [3,44] This study has shown that there are very early social inequalities in child behavioural problems. It is essential that policies to address inequalities focus on improving social conditions for all children, whilst also acting on maternal mental health in the perinatal period can potentially reduce the SEC gap in preschool-aged children's externalising behaviour problems.

This study also highlights the importance of maternal mental health in perinatal period for children across the lifecourse. In the UK, maternal mental health problems in the perinatal period have been estimated to cost society £8.1 billion for each one-year cohort of births, with ~ 75% of the cost relating to impacts on the child. [45] Risk starts before birth and estimates suggest that approximately 122,000 babies (under 1) in the UK live with a parent with mental health problems. [1]

Strengths and limitations

This study used data from a prospective longitudinal study with multiple measures of maternal mental health in the perinatal period. WCHADS is a rich dataset, with socio-demographic and environmental risk factors collected during pregnancy and the early-years. A limitation of this study is that our measure of child mental health is based upon maternal report and not a clinical diagnosis. However, we utilised the CBCL 1.5–5, a well-established and validated tool for screening at risk, preschool aged, children that can be used in clinical settings. [46] Our aim was to explore the effects of socio-economic conditions on broad child behavioural and emotional problems and therefore treated CBCL scores as continuous. Although clinical cut offs are available, a dimensional approach better captures the development of behavioural problems, as sub-clinical difficulties are associated with potential clinical disorders over the lifecourse. [47] Furthermore, repeating the analysis using clinical cut-offs led to similar conclusions.

Additionally, maternal mental health at the time of CBCL measurement can influence responses. We have not controlled for rater-bias in the main analysis since at age 5 years, as maternal mental health at age 5 is likely to be on the causal pathway between SECs and child behaviour and emotional problems. Controlling for maternal depressive symptoms at the time of the outcome measure is likely to be an over-adjustment. However, in sensitivity analysis we controlled for maternal depressive symptomology at this timepoint using the Centre for Epidemiological Studies Depression scale (CES-D) and the results are similar (S1 File).

Another limitation of this study is that our measure of maternal mental health relies on a self-report and not a clinical diagnosis. Although, the EPDS is a validated measure of depressive symptomology in the perinatal period its use at 3.5 years postnatal may not fully capture the severity of depressive symptoms later in the lifecourse.

WCHADS retains a large sample size for a developmental study which allows for rich data to be collected on socio-demographic and child behavioural and emotional problems in the perinatal period and offers the potential to investigate causal pathways in the early years. However, as a consequence of cohort attrition our study used data available on 62% of children from the original sample population. Despite this, the socio-demographic composition of WCHADS participants permits analysis exploring the effect of SECs. Although, caution is needed as our measure of SECs relies on self-reported income and does not account for family size or resource allocation. There may not be sufficient statistical power to identify small effect estimates in our study, and effects may not necessarily generalisable to the UK population, though they are likely to be generalisable to similarly disadvantaged areas.

Whilst we have conducted a counterfactual mediation (S1 File) to understand the potential causal pathway using variables that are temporally ordered, further research should explore the complex bi-directional relationship between family SECs and maternal and child behavioural and emotional problems over time. Reassuringly, our sensitivity analysis using different outcome and exposure measures produced similar results and conclusions (S1 File).

Conclusion

More knowledge is needed for the earliest possible identification of children with behavioural and emotional problems. Whilst we have shown that income and deprivation impact maternal mental health and child externalising behaviour problems, there may be threshold effects, and identifying these in future research may usefully inform public health and welfare policy. Further longitudinal investigation, with an early-years focus, is welcomed.

Currently, around 70% of children and adolescents with mental health problems have not had appropriate early intervention. [48] Efforts to reduce inequalities in child behavioural and emotional problems should focus on reducing socioeconomic inequalities, with multi-dimensional strategies and prevention across the lifecourse. Our analysis suggests targeting maternal mental health in the perinatal period is important, but that this alone will not address the increased risk in disadvantaged children.

Supporting information

S1 File. Supplementary materials.
(DOCX)

Acknowledgments

The authors are grateful to all participating families and research staff who contributed to this work. They also thank Wirral University Teaching Hospital NHS Foundation Trust, Wirral Community NHS Foundation Trust, Cheshire and Wirral Partnership NHS Foundation Trust and the National Institute for Health Research (NIHR) Biomedical Research Centre at South London and Maudsley NHS Foundation Trust.

Author Contributions

Conceptualization: Callum Rutherford, Helen Sharp, Jonathan Hill, Andrew Pickles, David Taylor-Robinson.

Data curation: Callum Rutherford, Helen Sharp, David Taylor-Robinson.

Formal analysis: Callum Rutherford, Helen Sharp, David Taylor-Robinson.

Funding acquisition: Helen Sharp, Jonathan Hill, Andrew Pickles, David Taylor-Robinson.

Investigation: Callum Rutherford, Helen Sharp, Jonathan Hill, Andrew Pickles, David Taylor-Robinson.

Methodology: Callum Rutherford, Helen Sharp, Jonathan Hill, Andrew Pickles, David Taylor-Robinson.

Project administration: Callum Rutherford, Helen Sharp, Jonathan Hill, Andrew Pickles, David Taylor-Robinson.

Resources: Callum Rutherford, Helen Sharp, Jonathan Hill, Andrew Pickles, David Taylor-Robinson.

Software: Callum Rutherford, David Taylor-Robinson.

Supervision: Helen Sharp, David Taylor-Robinson.

Validation: Callum Rutherford, Helen Sharp, Jonathan Hill, Andrew Pickles, David Taylor-Robinson.

Visualization: Callum Rutherford.

Writing – original draft: Callum Rutherford.

Writing – review & editing: Helen Sharp, Jonathan Hill, Andrew Pickles, David Taylor-Robinson.

References

1. Marmot M, Allen J, Goldblatt P, Boyce T, McNeish D, Grady M, et al. Fair Society, Healthy Lives. 2010; https://doi.org/10.1016/j.puhe.2012.05.014 PMID: 22784581
2. Green H, McGinnity A, Meltzer H, Ford T, Goodman R. Mental Health of Children and Young People in Great Britain, 2004. Natl Stat. 2005; i-xxviii;1–256.
3. Patalay P, Fitzsimons E. Mental ill-health among children of the new century: trends across childhood with a focus on age 14. Cent Longituidnal Stuides London. 2017;
4. Reiss F. Socioeconomic inequalities and mental health problems in children and adolescents: A systematic review. Soc Sci Med. Elsevier; 2013; 90: 24–31. https://doi.org/10.1016/j.socscimed.2013.04.026 PMID: 23746605
5. Pearce A, Dundas R, Whitehead M, Taylor-Robinson D. Pathways to inequalities in child health. Arch Dis Child. 2019; archdischild-2018-314808. https://doi.org/10.1136/archdischild-2018-314808 PMID: 30798258
6. Wickham S, Whitehead M, Phd T-R, Barr B, Wickham S, Whitehead M, et al. The effect of a transition into poverty on child and maternal mental health: a longitudinal analysis of the UK Millennium Cohort Study. Lancet Public Heal. The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY license; 2017; 2667: 30011–7. https://doi.org/10.1016/S2468-2667(17)30011-7
7. Marryat L, Thompson L, Minnis H, Wilson P. Primary schools and the amplification of social differences in child mental health : a population-based cohort study. J Epidemiol Community Heal. 2017; 0: 1–7. https://doi.org/10.1136/jech-2017-208995 PMID: 29056594
8. Carneiro A, Dias P, Soares I. Risk Factors for Internalizing and Externalizing Problems in the Preschool Years: Systematic Literature Review Based on the Child Behavior Checklist 1½–5. J Child Fam Stud. Springer US; 2016; https://doi.org/10.1007/s10826-016-0456-z
9. Goodman SH, Rouse MH, Connell AM, Broth MR, Hall CM, Heyward D. Maternal Depression and Child Psychopathology: A Meta-Analytic Review. Clin Child Fam Psychol Rev. 2011; 14: 1–27. https://doi.org/10.1007/s10567-010-0080-1 PMID: 21052833

10. Schmied V, Johnson M, Naidoo N, Austin M-P, Matthey S, Kemp L, et al. Maternal mental health in Australia and New Zealand: A review of longitudinal studies. Women and Birth. Australian College of Midwives; 2013; 26: 167–178. https://doi.org/10.1016/j.wombi.2013.02.006 PMID: 23583667
11. Gavin NI, Meltzer-Brody S, Glover V, Gaynes BN. Is Population-Based Identification of Perinatal Depression and Anxiety Desirable? [Internet]. Identifying Perinatal Depression and Anxiety. 2015.
12. Lancaster CA, Gold KJ, Flynn HA, Yoo H, Marcus SM, Davis MM. Risk factors for depressive symptoms during pregnancy: a systematic review. Am J Obstet Gynecol. Elsevier Inc.; 2010; 202: 5–14. https://doi.org/10.1016/j.ajog.2009.09.007 PMID: 20096252
13. Murray L, Arteche A, Fearon P, Halligan S, Goodyer I, Cooper P. Maternal postnatal depression and the development of depression in offspring Up to 16 years of age. J Am Acad Child Adolesc Psychiatry. Elsevier Inc.; 2011; 50: 460–470. https://doi.org/10.1016/j.jaac.2011.02.001 PMID: 21515195
14. Murray L, Cooper PJ. Editorial: Postpartum depression and child development. Psychol Med. 2002; 27: 253–260. https://doi.org/10.1017/s0033291796004564
15. Diderichsen F, Hallqvist J, Whitehead M. Differential vulnerability and susceptibility: how to make use of recent development in our understanding of mediation and interaction to tackle health inequalities. Int J Epidemiol. 2018; 268–274. https://doi.org/10.1093/ije/dyy167 PMID: 30085114
16. Sharp H, Pickles A, Meaney M, Marshall K, Tibu F, Hill J. Frequency of Infant Stroking Reported by Mothers Moderates the Effect of Prenatal Depression on Infant Behavioural and Physiological Outcomes. PLoS One. 2012; 7. https://doi.org/10.1371/journal.pone.0045446 PMID: 23091594
17. Noble M, Wright G, Dibben C, Smith G, McLennan D, Anttila C, et al. The English Indices of Deprivation 2004 (revised) Report to the Office of the Deputy Priminister. London: Neighbourhood Revewal Unit [Internet]. 2004. http://webarchive.nationalarchives.gov.uk/20100410180038/http://www.communities.gov.uk/archived/publications/communities/indicesdeprivation
18. AchAchenbach, T. M. (1991). Manual for the child behavior checklist/4-18 and 1991 profile. Burlington VT. enbach TM. Manual for the child behavior checklist/4-18 and 1991 profile. Burlingt VT. 1991;
19. Ivanova MY, Achenbach TM, Rescorla LA, Harder VS, Ang RP, Bilenberg N, et al. Preschool psychopathology reported by parents in 23 societies: Testing the seven-syndrome model of the child behavior checklist for ages 1.55. J Am Acad Child Adolesc Psychiatry. Elsevier Inc.; 2010; 49: 1215–1224. https://doi.org/10.1016/j.jaac.2010.08.019 PMID: 21093771
20. Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression: Development of the 10-item Edinburgh Postnatal Depression Scale. Br J Psychiatry. 1987; 150: 782–786. https://doi.org/10.1192/bjp.150.6.782 PMID: 3651732
21. Alvarado-Esquivel C, Sifuentes-Alvarez A, Salas-Martinez C. Detection of mental disorders other than depression with the Edinburgh Postnatal Depression Scale in a sample of pregnant women in northern Mexico. Ment Illn. 2016; 8. https://doi.org/10.4081/mi.2016.6021 PMID: 27403273
22. Batty GD, Der G, Macintyre S, Deary IJ. Does IQ explain socioeconomic inequalities in health? Evidence from a population based cohort study in the west of Scotland. Br Med J. 2006; 332: 580–584. https://doi.org/10.1136/bmj.38723.660637.AE PMID: 16452104
23. Graham H. Tackling Inequalities in Health in England: Remedying Health Disadvantages, Narrowing Health Gaps or Reducing Health Gradients? J Soc Policy. 2004; 33: 115–131. https://doi.org/10.1017/S0047279403007220
24. Taylor-Robinson DC, Pearce A, Whitehead M, Smyth R, Law C. Social inequalities in wheezing in children: Findings from the UK Millennium Cohort Study. Eur Respir J. 2016; 47: 818–828. https://doi.org/10.1183/13993003.01117-2015 PMID: 26677938
25. Richiardi L, Bellocco R, Zugna D. Mediation analysis in epidemiology: Methods, interpretation and bias. Int J Epidemiol. 2013; 42: 1511–1519. https://doi.org/10.1093/ije/dyt127 PMID: 24019424
26. Horowitz J, Murphy C, Gregory K, Wojcik J, Pulcini J, Solon L. Nurse home visits improve maternal-infant interaction and decrease severity of postpartum depression. J Obs Gynecol Neonatal Nurs. 2013; 42: 287–300.
27. Galobardes B, Lynch J, Smith GD. Measuring socioeconomic position in health research. Br Med Bull. 2007; 81–82: 21–37. https://doi.org/10.1093/bmb/ldm001 PMID: 17284541
28. Menting ATA, Orobio de Castro B, Matthys W. Effectiveness of the Incredible Years parent training to modify disruptive and prosocial child behavior: A meta-analytic review. Clin Psychol Rev. Elsevier Ltd; 2013; 33: 901–913. https://doi.org/10.1016/j.cpr.2013.07.006 PMID: 23994367
29. Robinson M, Oddy WH, Li J, Kendall GE, De Klerk NH, Silburn SR, et al. Pre- and postnatal influences on preschool mental health: A large-scale cohort study. J Child Psychol Psychiatry Allied Discip. 2008; 49: 1118–1128. https://doi.org/10.1111/j.1469-7610.2008.01955.x PMID: 19017026

30. Bøe T, Øverland S, Lundervold AJ, Hysing M. Socioeconomic status and children's mental health: Results: from the Bergen Child Study. Soc Psychiatry Psychiatr Epidemiol. 2012; 47: 1557–1566. https://doi.org/10.1007/s00127-011-0462-9 PMID: 22183690

31. Essex MJ, Kraemer HC, Armstrong JM, Boyce WT, Goldsmith HH, Klein MH, et al. Exploring risk factors for the emergence of children's mental health problems. Arch Gen Psychiatry. 2006; 63: 1246–1256. 63/11/1246 https://doi.org/10.1001/archpsyc.63.11.1246 PMID: 17088505

32. Holmes J, Kiernan K. Persistent poverty and children's development in the early years of childhood. Policy Polit. 2013; 41: 19–42. https://doi.org/10.1332/030557312X645810

33. Mazza JRSE, Boivin M, Tremblay RE, Michel G, Salla J, Lambert J, et al. Poverty and behavior problems trajectories from 1.5 to 8??years of age: Is the gap widening between poor and non-poor children? Soc Psychiatry Psychiatr Epidemiol. 2016; 51: 1083–1092. https://doi.org/10.1007/s00127-016-1252-1 PMID: 27324139

34. Mcleod JD, Shanahan MJ. Trajectories of Poverty and Children's Mental Health. 1996; 37: 207–220.

35. Amone-P'Olak K, Burger H, Ormel J, Huisman M, Verhulst FC, Oldehinkel AJ. Socioeconomic position and mental health problems in pre- and early-adolescents: The trails study. Soc Psychiatry Psychiatr Epidemiol. 2009; 44: 231–238. https://doi.org/10.1007/s00127-008-0424-z PMID: 18714424

36. Velez CN, Johnson J, Cohen P. Longitudinal Analysis of Selected Risk Factors for Child Psychopathology. J AM Acad Child Adolesc Psychiatry. 1989; 861–864. https://doi.org/10.1097/00004583-198911000-00009 PMID: 2808256

37. Allin S, Stabile M. Socioeconomic status and child health: what is the role of health care, health conditions, injuries and maternal health? Heal Econ Policy Law. 2012; 7: 227–242. https://doi.org/10.1017/S174413311100034X PMID: 22277158

38. Fanti K a Henrich CC. Trajectories of pure and co-occurring internalizing and externalizing problems from age 2 to age 12: findings from the National Institute of Child Health and Human Development Study of Early Child Care. Dev Psychol. 2010; 46: 1159–1175. https://doi.org/10.1037/a0020659 PMID: 20822230

39. Kiernan KE, Huerta MC. Economic deprivation, maternal depression, parenting and children's cognitive and emotional development in early childhood. Br J Sociol. 2008; 59: 783–806. https://doi.org/10.1111/j.1468-4446.2008.00219.x PMID: 19035922

40. Strohschein L. Household Income Histories and Child Mental Health Trajectories*. J Health Soc Behav. 2005; 46: 359–375. https://doi.org/10.1177/002214650504600404 PMID: 16433281

41. Fisher SD, Brock RL, O'Hara MW, Kopelman R, Stuart S. Longitudinal contribution of maternal and paternal depression to toddler behaviors: Interparental conflict and later depression as mediators. Couple Fam Psychol Res Pract. 2013; 4: 61–73. https://doi.org/10.1037/cfp0000037

42. Mäntymaa M, Puura K, Luoma I, Latva R, Salmelin RK, Tamminen T. Predicting internalizing and externalizing problems at five years by child and parental factors in infancy and toddlerhood. Child Psychiatry Hum Dev. 2012; 43: 153–170. https://doi.org/10.1007/s10578-011-0255-0 PMID: 21956275

43. Murray L. The impact of postnatal depression on infant development. J child Psychol psychiatry. 1992; 33: 543–61. https://doi.org/10.1111/j.1469-7610.1992.tb00890.x PMID: 1577898

44. Gunnell D, Kidger J, Elvidge H. Adolescent mental health in crisis. Bmj. 2018; 2608: k2608. https://doi.org/10.1136/bmj.k2608 PMID: 29921659

45. Bauer A, Parsonage M, Knapp M, Iemmi V, Adelaja B, Hogg S. The costs of perinatal mental health problems. Cent Ment Heal. 2014;

46. Warnick EM, Bracken MB, Kasl S. Screening Efficiency of the Child Behavior Checklist and Strengths and Difficulties Questionnaire: A Systematic Review. 2008; 13: 140–147. https://doi.org/10.1111/j.1475-3588.2007.00461.x

47. Pike A, Iervolino AC, Eley TC, Price TS, Plomin R. Environmental risk and young children's cognitive and behavioral development. Int J Behav Dev. 2006; 30: 55–66. https://doi.org/10.1177/0165025406062124

48. Society TC. The Good Childhood Report. 2015; http://www.childrenssociety.org.uk/sites/default/files/tcs/good_childhood_report_2012_final_0.pdf