UNIVERSITY OF LIVERPOOL

Psychological and Behavioural Mechanisms Contributing to Post-Bariatric Surgery Alcohol Misuse

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By

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Author's Declaration

This thesis is the result of my own work; I designed this research in conjunction with my supervisors and was responsible for data collection, analysis and write-up. The material contained in this thesis has not been presented, nor is currently being presented, either in part or wholly for any other degree qualification.

Acknowledgements

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Abstract

Introduction: Bariatric (i.e. 'weight loss') surgery is an effective obesity treatment; however, an unanticipated outcome includes increased risk for alcohol misuse. While some risk factors have been identified (e.g., gender, age), these and other theorised contributors do not sufficiently address psychological mechanisms implicated in alcohol misuse (e.g., coping). Therefore, the first aim of this thesis was to develop a model of alcohol misuse and over-eating, mediated by coping. A second aim was to gather empirical support for the role of negative affect and coping in post-bariatric surgery alcohol misuse. **Methods:** A mixed methodological approach was used; Chapter 2 addressed the first aim qualitatively through utilising semi-structured interviews with post-bariatric surgery participants. From the identified themes, Chapter 3 empirically tested a negative reinforcement motivational model for drinking and over-eating using online survey responses from non-bariatric participants. To address the second aim, Chapter 4 was a secondary analysis of pre and post-surgery clinical questionnaire data, while Chapter 5 analysed similar constructs in a service evaluation of qualitative hospital data. Supported by this evidence, Chapter 6 tested Chapter 3's model using online survey responses from bariatric participants. **Key Findings**: Greater pre-surgery drinking increased the risk for later alcohol misuse, but there was also evidence for new-onset cases (Chapters 2, 4 and 5). Pre-surgery mental health status did not, with the exception of history of suicide idealisation or attempt (Chapters 4 and 5). Post-surgery mental health contributors included anxiety (Chapter 4), depression and increased life stress (Chapter 5). Further, alcohol misuse represented an affect regulation strategy for individuals higher in negative affect-related traits (Chapters 2, 3 and 6). Alcohol misuse was a distinct coping strategy, as those who reported eating as their coping mechanism (or post-surgery grazing) were *less* likely to over-consume alcohol (Chapters 3, 5 and 6). Bariatric participants identified '*I drank because I couldn't eat"* as a sub-theme in Chapter 2, and Chapter 5 provided partial support for a model of post-surgery drinking as behavioural substitution (or 'transfer' in coping mechanisms) from pre-surgery eating. **Implications:** Specific pre and post-surgery negative affect-related factors raise the likelihood for post-surgery alcohol misuse, particularly if eating is an unavailable coping mechanism. Theoretically, post-surgery alcohol misuse could function as a substitute coping mechanism from emotional eating for some individuals, while for others it appears a continuation of pre-surgery

drinking behaviours. Practical applications could assess coping behaviours prior to surgery and offer support throughout the bariatric pathway. Future research could explore interventions to reduce post-surgery alcohol misuse guided by these findings.

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List of Abbreviations

ADHD – Attention deficit hyperactivity disorder

AEBS - Addiction-Like Eating Behaviour Scale

AGB – Laparoscopic adjustable gastric band

AUD – Alcohol use disorder

AUDIT – Alcohol Use Disorder Identification Test

AUDIT-C – Alcohol Use Disorder Identification Test (Consumption)

BAC – Blood alcohol concentration

BED – Binge Eating Disorder

BES – Binge Eating Scale

BMI – Body mass index

BrAC – Breath alcohol concentration

CNS – Clinical nurse specialist

DA – Dopamine

D2 – Dopamine receptor

DEBQ – Dutch Eating Behaviour Questionnaire

DSM – Diagnostic and Statistical Manual of Mental Disorders

EES – Emotional Eating Scale

GAD-7 – Generalised Anxiety Disorder Assessment

GI – Gastrointestinal

GLP-1 – Glucagon-like peptide

GP – General practitioner

HPA – Hypothalamic-pituitary-adrenal

IRAS – Integrated Research Application System

JRO – Joint Research Office

Kcals - Kilocalories

LABS-2 – Longitudinal Assessment Bariatric Surgery

MCS – Mental component summary

MDMQ-R SF – Modified Drinking Motives Questionnaire Short Form

MDT – Multidisciplinary team

NAcc – Nucleus accumbens

NICE – National Institute for Health and Care Excellence

NPAU – Non-problematic alcohol use

PAU – Problematic alcohol use

PCS – Physical component summary

PHQ – 9 – Patient Health Questionnaire for Depression

PEMS – Palatable Eating Motives Scale

PFC – Prefrontal cortex

REC – Research Ethics Committee

RECORD – Reporting of studies Conducted using Observational Routinely-collected health Data

Rep(eat)-Q – Repetitive Eating Questionnaire

RMSEA – Root mean square error of approximation

RYGB – Roux-en-Y gastric bypass

SCID – Structured Clinical Interview for DSM-IV Axis I

SCOTS – SurgiCal Obesity Treatment Study

SF – Social functioning role limitations due to emotional problems

SF-36 – Short Form Health Survey

SG – Sleeve Gastrectomy

SOS – Swedish Obese Subjects

SUD – Substance use disorder

SRMR – Standardized Root Mean Square Residual

SURPS – Substance Use Risk Profile Scale

TFEQ – Three-Factor Eating Questionnaire

UoL – University of Liverpool

WHO – World Health Organization

YFAS – Yale Food Addiction Scale

Chapter 1: Introduction

From the late 1990s, research and public health policy organisations have termed the escalating rate of excess body fat amongst adults and children an 'obesity epidemic' (Fletcher, 2014). Body mass index (BMI; a measurement produced from weight in kilograms divided by height squared) functions to measure and define categories of body weight, where a person with a BMI of 25kg/m² to 29.9 kg/m² has *overweight*, and a person with 30kg/m² or higher has *obesity* (WHO, 2006). Nearly 30% of the world's population is overweight or obese, which is predicted to rise to 50% by 2030 (Dobbs et al., 2014). The prevalence of obesity in the United Kingdom (UK) is currently reported at 26% (Statistics Team, NHS Digital, 2017), which poses an associated £2.47 billion financial burden to the UK government (Tovey, 2017). Globally increasing rates of adiposity pose multiple health risks on an individual and population level; including an increased risk for type 2 diabetes, certain cancers, cardiovascular disease, but also encompassing negative psychological outcomes, including reduced health-related quality of life, and depression (Kopelman, 2007; Must et al., 1999; Onyike, Crum, Lee, Lyketsos, & Eaton, 2003; Sarwer & Steffen, 2015). Therefore, efforts to attenuate weight gain have moved to the forefront of medical and public policy objectives. To this end, obesity experts have identified bariatric, or 'weight loss' surgery as an effective treatment for its substantial effects on weight loss (Mechanick et al., 2013).

Section 1.1 of this chapter will briefly overview the complex aetiology of obesity and the weight management services designed to address it in the UK. This review focuses specifically on the Tier 4 bariatric surgery service, its efficacy and health outcomes, one of which being an unexpected risk for post-surgical alcohol misuse. Section 1.2 presents what is known about the increased risk for post-surgery alcohol

misuse, including factors significantly associated with alcohol misuse outcomes in the bariatric literature, and highlights where the evidence remains mixed. Further explored are theoretical contributors offered by clinicians, researchers and members of the public health community seeking to understand the increased prevalence of alcohol misuse after bariatric surgery, including where the explanatory value of each theory falls short. Section 1.3 reviews the quantitative and qualitative evidence supporting psychological contributors to post-surgical alcohol misuse and connects this to the extant literature for both obesity and alcohol misuse in bariatric and other populations. Specifically, coping is identified as a critical motivation implicated in both obesity and alcohol use, and it is proposed that post-surgery alcohol misuse represents a substitute coping strategy from food due to surgical restriction imposed on some individuals.

1.1. Bariatric surgery: A physiological solution to a multi-faceted problem

1.1.1 The complex aetiology of obesity

One characterisation of obesity is that it results from a mismatch between evolutionary internal programming and present societal conditions. Indeed, the evolutionary selection of over 110 human obesity genes and 127 obesity gene risk variants contributes to humankind's digestive efficiency and optimisation of energy metabolism (Alves, Chaleil, & Sternberg, 2002; Caetano-Anollés et al., 2009; Castillo, Hazlett, Orlando, & Garver, 2017). However, food shortages and occasional famines are no longer the reality confronted by most individuals in developed societies. Instead, these previously advantageous obesity genes now pose disadvantages in the 'obesogenic environment,' characterised by an over-abundance of accessible, high-calorie and low-cost foods paired with a sedentary lifestyle (Chakravarthy, 2003). Nevertheless, the aetiology of obesity is only partially

explained by this interaction, as not every individual within it becomes obese. Rather than being a linear biological process, obesity arises from within a complex inter-relationship between homeostatic processes, reward pathways, cognitive and psychological processes.

1.1.1.1 Mechanisms driving eating behaviour

Elucidating the mechanisms driving eating behaviour and appetite control is essential to understanding the development of overweight and obesity. Traditional concepts propose that two major processes motivate eating: 1) the homeostatic pathway, which regulates energy balance through increasing motivation to eat using hormonal communication to the brain following a depletion of energy stores, and 2) the hedonic (i.e. 'reward') pathway, which influences the consumption of high fat, calorically dense foods and supersedes the homeostatic pathway when energy is not depleted to increase the desire to eat (Hommel et al., 2006; Lutter & Nestler, 2009; Morton, Cummings, Baskin, Barsh, & Schwartz, 2006). However, the role of cognition (attention, memory and learning) in eating behaviour is becoming increasingly studied. Therefore, Higgs et al (2017) proposed a new framework which emphasises inter-relationships between neurochemical substrates of homeostatic and reward systems and incorporates the role of higher-level cognitive systems in promoting or inhibiting eating behaviour. See Figure 1.1 for a diagram of this model of appetite control.

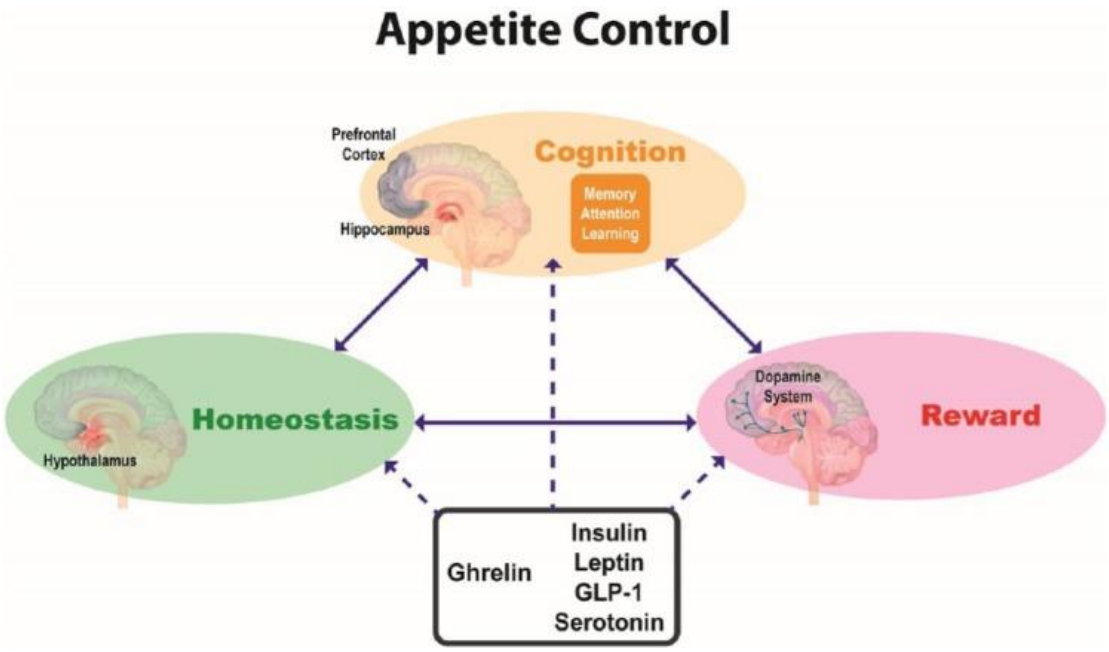

Figure 1.1. A schematic diagram adapted from Higgs et al. (2017) outlining a model of appetite control involving interactions between homeostatic, reward and cognitive processes (*indicated by solid arrows*) and the modulation of these processes by metabolic signals including insulin, leptin, glucagon-like peptide 1 (GLP-1), serotonin and ghrelin (*indicated by dashed arrows*). © SAGE Publishing (http://creativecommons.org/licenses/by/4.0/).

According to this model of appetite control, homeostatic networks comprised of metabolic signals interact with reward-related neural circuitry, which modulates how attractive food is to an individual based on how deprived or sated they feel, or by direct action of metabolic signals on the dopamine system. Cognitive processes before, within and between meals further modulate reward-related neural processes through inhibiting or promoting eating behaviour. The connections between metabolic signals, cognition and eating behaviour are emergent; the literature suggests that changes in metabolic processes can impact cognitive function, produce

changes in eating and food-related responding, and promote enhancement of meal or food memories. The supporting literature for each individual pathway is comprehensively reviewed by Higgs et al. (2017). Altogether, metabolic signalling impacts upon reward processes either directly or indirectly through homeostatic feedback mechanisms alongside alterations in cognition, which plays a critical role in reward valuing and subsequent eating behaviour. Dysregulation in one or multiple relationships within this appetite control model can result in overeating behaviour - one of the key contributors to overweight and obesity.

1.1.1.2 Dysregulated eating behaviour as a pathway to obesity

Both genetic and un-related contributors to overweight and obesity share a behavioural component – dysregulated eating behaviour (i.e. chronic overeating) (Barsh, Farooqi, & O'Rahilly, 2000; Webber, 2003). Overeating, or 'hedonic eating,' occurs irrespectively of metabolic needs in the context of highly palatable, rewarding and energy dense foods with high fat, sugar or salt content (Lowe & Butryn, 2007). While environmental factors (i.e., obesogenic environment, reduced physical activity, increased stress) contribute to obesity's development (Badland & Schofield, 2006; Berthoud, 2012; Morris, Beilharz, Maniam, Reichelt, & Westbrook, 2015), these do not fully explain individual differences in eating behaviour and body weight. As previously detailed, individual homeostatic, reward and cognitive processes form an explanatory model of appetite control (Higgs et al., 2017). Moreover, Blundell and colleagues (2005) posit that related characteristics of appetite control and food motivation form a *behavioural* phenotype for obesity; these include homeostatic (weak satiety response, post-ingestive satiety), reward (strong hedonic attraction to and/or preference for high fat foods), cognitive (inhibitory control), and psychological processes (negative mood and eating style).

Understanding how each of these systems drive eating behaviour and contribute to overweight or obesity is critical to designing strategies to reduce this phenomenon at an individual and population level.

1.1.1.2.1 Homeostatic processes

One theory of appetite control by Blundell, Finlayson, Gibbons, Caudwell and Hopkins (2015) describes eating patterns as consequential of interactions between tonic (i.e. long term) and episodic (i.e. short term) physiological signals. Specifically, body composition (i.e. fat free mass, resting metabolic rate) informs energy demands, from which the tonic signal for appetitive drive arises. This is inhibited by leptin (decreases appetite), which reflects the body's stored energy reserves. Episodic signals also interrupt and suppress the drive to eat through peptides released by the gastrointestinal (GI) tract following food ingestion. These include; ghrelin (appetite-stimulating), cholecystokinin (CKK), peptide YY (PYY), and glucagon-like peptide-1 (GLP-1) (appetite-inhibiting). Predisposition towards weight gain is associated with several metabolic factors (e.g., high insulin sensitivity, low plasma leptin), many of which are reversed upon a consistent state of obesity (Blundell & Finlayson, 2004). Persons with obesity tend towards higher leptin levels, the inability of which to control body weight points to a leptin resistance process, which could promote further obesity through impacting brain signalling involved in energy intake and expenditure (Sáinz, Barrenetxe, Moreno-Aliaga, & Martínez, 2015). Another metabolic adaptation includes circulating ghrelin, which is reduced in persons with obesity (Tschöp et al., 2001). However, fasting plasma ghrelin levels rise proportionately with weight loss or food restriction (Hansen et al., 2002; Tschop, Smiley, & Heiman, 2000). This results in feeling hungrier, potentially negating weight loss efforts through promoting eating behaviour to reach satiety. Altogether,

metabolic factors and physiological changes arising from obesity can promote dysregulated eating patterns and create a propensity towards weight gain.

Further, behavioural risk factors for energy intake and expenditure form a biological disposition for weight gain through acts or physiological processes which promote or allow changes in behaviour. These include eating behaviour, hedonic events influencing behaviour, preferences for and choices of specific foods, or the strength of hunger and satiety sensations (Blundell & Finlayson, 2004). The 'Satiety Cascade' is a conceptual framework wherein satiation and satiety are depicted as both conceptually separate and inter-related (Blundell, Rogers & Hill, 1987; Blundell et al., 2010). 'Satiation' refers to the process that ends eating, encompassing within-meal events (e.g., nutrient composition, palatability) in the transition to the second state, satiety. Satiety refers to the inhibition of eating, alongside hunger suppression (and increasing fullness) once eating has ended (López-Nicolás et al., 2016). Critically, behavioural phenomena associated with weight gain include weaknesses in within-meal satiation and post-meal satiety, along with external factors such as difficulties resisting food cues (Halford, Boyland, Blundell, Kirkham, & Harrold, 2010; Halford & Harrold, 2012). Indeed, low satiety responsiveness is a critical mechanism through which genetic risk for obesity is associated with weight gain in an obesogenic environment (Llewellyn, Trzaskowski, Van Jaarsveld, Plomin, & Wardle, 2014). Therefore, weight gain can be promoted by physiological processes which contribute to dysregulated eating behaviour directly, or through interactions with external factors.

While homeostatic and metabolic signals are modulated by genetics, body composition and eating behaviour, non-homeostatic contributors can similarly promote dysregulated eating behaviour. Homeostatic signal strength can be over-

ridden by signals from the brain's reward system, thereby promoting food consumption beyond homeostatic needs (Alonso-Alonso et al., 2015), further detailed in section 1.1.1.2.2. Metabolic signalling similarly interacts with cognition and impacts upon eating behaviours, although more research is needed (Higgs et al., 2017). For example, ghrelin administration in humans appears to activate the hippocampus and enhance food memory (Goldstone et al., 2014; Saima Malik, McGlone, Bedrossian, & Dagher, 2008), indicating an increased hedonic valuation of food. Taken together, this evidence articulates the role of homeostatic processes in promoting dysregulated eating behaviour and weight gain, and invites further examination of co-occurring reward, cognitive and psychological processes.

1.1.1.2.2 Reward processes

The reward system is part of an integrated model of eating behaviour (section 1.1.1). In contrast to the homeostatic system, brain reward circuitry functions with a bias towards positive energy balance. Reward signals respond to the hedonic qualities of food, can override homeostatic signals and promote eating behaviour beyond maintaining energy balance (Kenny, 2011). Broadly, desirable foods are higher in calories, sugar, fat or salt, and the caloric surplus arising from overeating leads to weight gain. These foods are desirable in that they are both 'liked' (relating to the pleasure of consuming) and 'wanted' (related to motivation to consume, or '*incentive salience'*) (Berridge & Robinson, 2016). Although representing distinct processes, the experience of both 'wanting' and 'liking' these foods influences reward appraisal. Critically, brain circuitry mediating the psychological process of 'wanting,' is separable from 'liking' (Berridge & Robinson, 2016). 'Wanting' a reward is mediated by a large brain system including dopamine projections to forebrain targets (e.g., nucleus accumbens (NAcc) and other parts of the striatum),

whereas ‘liking’ is mediated by a neural system of tiny hedonic hotspots in the brain comprised of the NAcc, prefrontal cortex and ventral pallidum (Berridge & Kringelbach, 2015). The separate nature of these reward processes is pertinent to the development of obesity, as although increased motivation to eat (‘wanting’) has been associated with obesity, it is not necessarily associated with more pleasure experienced from eating (‘liking’) (Mela, 2006). Altogether, activation within the reward system and its impact upon behaviour is critical to dysregulated eating behaviour.

The dynamic-vulnerability model of obesity expands upon this by using instances of both hypo and hyper-reward circuitry in persons with obesity to explain individual differences in reward responsivity’s contribution to dysregulated eating behaviour (Burger & Stice, 2011). Eating rewarding food releases dopamine (DA) into the brain area responsible for reward pursuit (i.e. the dorsal striatum) and the more pleasant the food is, the greater the magnitude of DA released (Small, Jones-Gotman, & Dagher, 2003). Cross-sectional studies evidence that persons with obesity have lower DA receptor availability than lean individuals, possibly contributing to a reduced (hypo) reward response to eating palatable food (Wang et al., 2001). This relationship could be reciprocal, as longitudinal evidence suggests that reduced response to food may be caused by overeating or weight gain (Stice, Figlewicz, Gosnell, Levine, & Pratt, 2013). In this way, overeating could produce down-regulated DA-based reward regions, creating a dampened response in the striatum to food, thereby promoting overeating to achieve the same initial reward (Davis, Strachan, & Berkson, 2004).

Hyper-responsivity to reward is also implicated in the development of obesity; it is theorised that those who experience greater reward from eating, or more

anticipation for food rewards, have an increased risk for overeating (Davis et al., 2004; Dawe & Loxton, 2004; Stice, Spoor, Bohon, Veldhuizen, & Small, 2008). Initially offered as an explanation for substance dependence, the incentive sensitization theory proposes that compulsive consummatory behaviours are motivated by neuroadaptations increasing sensitivity to reward, caused by repeated exposure to and consumption of a substance (Robinson & Berridge, 1993, 2000). Theoretically, rewards from anticipating and receiving food appear to operate alongside the development of foods' reinforcing value. However, while the repeated presentation of a substance may increase its anticipatory reward (wanting), the hedonic value of a substance (liking) is thought to decrease (Berridge & Robinson, 2016). Overeating could therefore result in greater responsivity within regions involved in the incentive salience of food-related cues and further dysregulate eating behaviour through heightening vulnerability to these cues in the obesogenic food environment, which invites the need for cognitive control over eating behaviour.

1.1.1.2.3 Cognitive processes

Cognitive processes, specifically high-level 'executive' functions, moderate the behavioural drive for palatable food. As cited in section 1.1.1, cognitive processes act before, within and between meals and promote or inhibit eating behaviour through their inter-relationship with both homeostatic and reward processes. Cognition enables self-regulation over eating behaviour, and associated networks include the brain's lateral and dorsomedial regions (Alonso-Alonso et al., 2015). Dual process models argue that overeating and weight gain occur as a result of increased food reward and reduced inhibitory control (Appelhans, 2009). 'Inhibitory control' is a component of executive function over eating behaviour and impulsivity, defined as the ability to stop, change or delay a behavioural response

(Bickel, Jarmolowicz, Mueller, Gatchalian, & McClure, 2012; Logan, Cowan, & Davis, 1984; Miyake et al., 2000). Likewise, 'impulsivity' is defined as a reactionary pre-disposition to (internal or external) stimuli without regard for the negative consequences (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001), which could represent a tendency to have rapid, unplanned reactions to food, leading to overeating (Bénard et al., 2017). Although food reward valuation motivates eating behaviour, cognitive control can be exerted to suppress the rewarding aspects of food in favour of other goals (e.g., long term benefits of not eating palatable food in that moment) (Yokum & Stice, 2013). Nevertheless, the relationship between cognitive control and reward-driven eating remains antagonistic, with individual differences in both sensitisation to food-related reward and inhibitory control abilities potentially contributing to the development of dysregulated eating behaviour and obesity (Appelhans et al., 2011).

Based on the incentive sensitization theory by Robinson and Berridge (1993) differences in food-related cue sensitivity may manifest as an 'attentional bias,' although evidence supporting its association with obesity is equivocal (Doolan, Breslin, Hanna, & Gallagher, 2015). Individuals with a heightened sensitivity to food cues report more frequent thoughts, feelings and urges about food despite not being calorically deprived (Van Dillen, Papies, & Hofmann, 2013). This is especially evident when coupled with a lower capacity to exert inhibitory control over eating (Appelhans et al., 2011; Rollins, Dearing, & Epstein, 2010). Therefore, rather than functioning as an index of reward craving, attentional bias may be more indicative of a *susceptibility* towards craving, as food cues lose their command over attention, cravings and consumption when an individual simultaneously exerts mental effort within the working memory (Van Dillen et al., 2013). The capacity to exert

inhibitory control overeating is another executive function controlled by the prefrontal cortex (PFC), and stronger neural activation within the PFC is associated with decreased food craving and successful weight loss outcomes (DelParigi et al., 2007; Small, 2001). Therefore, cognitive processes interact with reward sensitivity on an individual level to either facilitate or attenuate dysregulated eating and subsequent obesity.

1.1.1.2.3.1 The brain disease model of obesity and food addiction

Neural changes in reward circuitry and the ability to exert cognitive behavioural control are critical components the conceptualisation of obesity as a 'brain disease,' due to shared features with the brain disease model of drug addiction. Key assertions of the brain disease model of obesity state that eating rewarding food produces powerful momentary increases in DA activity in the reward system, which overrides homeostatic control mechanisms over food intake and thereby produces a series of long-term functional changes in brain structures governing reward sensitivity, incentive motivation and self-control, reducing inhibitory control over food intake (Volkow, Wang, Tomasi, & Baler, 2013; Volkow, Wang, Fowler, & Telang, 2008). Additionally, highly palatable foods (e.g., chocolate, crisps) are posited to share similar addictive characteristics to substances of abuse, given the high doses of fat and/or sugar and rapid rates of absorption into the system, or 'glycaemic load' (Schulte, Avena, & Gearhardt, 2015). Given these connections, overeating has been increasingly conceptualised in the scientific literature as an addictive disorder (Devlin, 2007; Gearhardt, Grilo, DiLeone, Brownell, & Potenza, 2011; Ifland et al., 2009; Volkow & O'Brien, 2007).

Regarding conceptual validity, there are notable difficulties inherent to applying drug addiction models to studying food addiction (Fletcher & Kenny,

2018). While there are behavioural patterns and experiential resemblances to substance use disorder (SUD) in food consumption, the applicability of symptoms named in the Diagnostic Statistical Manual (DSM) IV and V (e.g., cessation of important social, occupational or recreational activities) is questionable (Ziauddeen, Farooqi, & Fletcher, 2012). Nevertheless, the direct mapping of substance dependence criteria constitutes the Yale Food Addiction Scale (YFAS; Gearhardt, Corbin, & Brownell, 2009; Schulte & Gearhardt, 2017). Food addiction's role in obesity is supported by instances of positive associations between YFAS score and BMI (Pedram et al., 2013; Schulte & Gearhardt, 2017). However, the relationship between food addiction and weight is not consistently observed; persons with obesity do not always meet the YFAS criteria for food addiction, and YFAS-diagnosed food addicts do not unilaterally have obesity (Davis et al., 2011). Taken together, while some researchers, clinicians and the public alike conceptualise dysregulated eating as evidence supporting 'food addiction' (and, by extension, the brain disease model of obesity), applying these models to eating behaviour has limitations, which merit alternative frameworks (Ruddock, Christiansen, Halford, & Hardman, 2017; Ziauddeen & Fletcher, 2013) and additional study (Fletcher & Kenny, 2018).

Another key point to consider before translational applications to obesity is that the brain disease model of addiction itself is contested. Both food and drug addiction models are characterised by structural and functional brain changes from chronic exposure to rewarding stimuli, increases in consummatory motivation and reductions in the ability to inhibit behaviour (Volkow et al., 2013). Critical to the disease model's explanatory power is the specificity of addictive drugs and rewarding foods in creating these changes. However, Lewis (2017) proposes that - rather than indicating disease - structural reorganisation and changes in neural

functions occur when repetitive, highly motivated goal seeking creates habitual behaviour, which occurs for a wide range of normative compulsive behaviours (i.e. shopping). In Lewis' developmental-learning model of addiction (2017), these changes result from recurrent desire for a single goal. Given the considerable debate about the initial validity of the brain disease model of addiction, and specific critiques to its applicability towards explaining the onset of obesity, focusing instead on the behavioural patterns that characterise addictive-like eating could yield informative results about the construct's contribution to obesity (Ruddock et al., 2017). To this end, the developmental-learning model of addition identifies several points of entry, including environmental, cognitive and emotional causes.

To overcome the limitations inherent to applying substance-dependence criteria to understanding addictive-like eating behaviour, Ruddock et al (2017) developed a measure of Addiction-like Eating Behaviour (AEBS), the structure of which supports a dual-process theory of motivation. Theoretically, heightened reward-related cue responsivity (i.e. appetitive drive) pairs with a reduced ability to exert inhibitory control (i.e. dietary control) and suggests a behavioural, rather than substance-based, understanding of addictive-like eating (Wiers et al., 2007). Critically, the AEBS accounted for a greater amount of variance in BMI than both the Binge Eating Scale (BES), and the YFAS (Ruddock et al., 2017). Given that some individuals classified as 'food addicts' using the YFAS are not obese (Davis et al., 2011), re-thinking addictive-like eating as reflective of a behavioural tendency, rather than creating a similar impairment as substance dependence, appears to offer more explanatory power for weight. Interestingly, the AEBS was positively correlated with the Emotional Eating Scale (EES), highlighting the potential for additional factors underpinning motivated food seeking and reduced inhibitory

control. Indeed, individuals may overeat highly palatable foods to dampen activity in the chronic stress-response neural circuitry (Dallman et al., 2003; Pecoraro, Reyes, Gomez, Bhargava, & Dallman, 2004). Similarly, overeating may appear as bouts of addictive-like eating behaviour (Parylak, Koob, & Zorrilla, 2011). Therefore, a pathway to developing addictive-like dysregulated eating behaviour and subsequent obesity could arise from a stress response, with compulsive overeating functioning as a coping mechanism for negative affect (Leigh & Morris, 2018).

1.1.1.2.4 Psychological processes

'Negative affect' is a subordinate term referring to psychological states encompassing stress responses to situations, emotions (e.g., anger) and moods (e.g., depression) (Gross, 2014). Clarifying the distinction between emotions and moods is important in understanding negative affective states (e.g., emotions) and traits (e.g., moods). Emotions are defined as responses to specific 'objects' or circumstances (i.e. fear or sadness), while moods are typically longer in duration (Parkinson, Totterdell, Briner & Reynolds, 1996). Degrees of emotional reactivity individually differ, and 'neuroticism' (i.e. the tendency towards negative emotional states) contributes to the onset of mood disorders, especially anxiety and depression (Tellegen, 1985; Widiger, 2009; Zinbarg et al., 2016). Trait proneness towards negative emotions also uniquely contributes to overeating, and individuals with greater stress reactivity tend to consume more calories, especially from highly palatable food (Epel, Lapidus, McEwen, & Brownell, 2001; Oliver, Wardle, & Gibson, 2000). Trait proneness includes anxiety sensitivity (i.e. distress resulting from the awareness of anxiety symptoms) and hopelessness (i.e. expectation of negative events, pervasive feelings of despondency), both of which are implicated in overeating and obesity (Davis et al., 2008; Gerlach, Herpertz, & Loeber, 2015). An association similarly exists

between a lifetime diagnosis of mood disorders and obesity or overweight, especially for women (Anderson, Cohen, Naumova, & Must, 2006; Gariepy, Nitka, & Schmitz, 2010). This relationship could be reciprocal; depression is predictive of developing obesity, but obesity also increases the risk of depression (for a systematic review and meta-analysis, see Luppino et al., 2010). Therefore, certain personality traits and mood disorders represent risk factors for overeating and obesity, although a simple direct association is unlikely.

Personality traits, mood disorders and obesity could be linked though specific underlying eating behaviours. Distinct psychological eating styles (i.e. emotional, restrained and external eating) have been identified using the Dutch Eating Behaviour Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986). Using the DEBQ, researchers found that emotional and restrained eating were higher in persons with overweight, while external eating (i.e. in response to food-related cues) did not differ between persons with overweight and average weight (van Strien, Herman, & Verheijden, 2009). The Restraint Theory of Overeating posits that negative affect triggers disinhibited eating behaviour specifically in restrained individuals, while food intake for non-restrained eaters remains unchanged, or decreases (Heatherton, Herman, & Polivy, 1991; Polivy, Herman, & McFarlane, 1994). While 'restraint' has been assessed using the Restraint Scale (Herman & et al, 1978), DEBQ (van Strien et al., 1986) and Three-Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985), the link between dietary restraint and overeating is not uniformly observed (Chua, Touyz, & Hill, 2004; van Strien & Ouwens, 2003). Rather, this relationship becomes significant in the context of emotional eating. From this evidence, Williams and colleagues (2002) proposed that dietary restraint increases vulnerability to overeating if restrained eaters react emotionally to violating

their restraint objectives, and engage with emotional disturbances by eating, thereby maintaining that overeating is not driven by restraint alone. Therefore, although restrained eating behaviour can create conditions that promote overeating, this specifically arises in the context of eating to cope. This becomes especially relevant for those who have a predisposition towards negative affect, or more specific personality traits and mood disorders.

1.1.1.2.4.1 Eating to cope

Emotion is a key determinant of overeating behaviours, whereby eating functions as a coping strategy for some individuals. Of particular note is the distinction between 'emotional eating' and eating in response to negative emotions. Indeed, current assessments of 'emotional eating' reflect general eating concerns, lack of control, a tendency to *attribute* overeating to negative affect or being a cue reactive person (Bongers & Jansen, 2016). Importantly, eating in response to a negative affective state alters the emotion trajectory through producing changes in latency, rise time, magnitude and duration of the negative emotion (Gross, 1998). These changes partially occur due to highly palatable food's fat, sugar or carbohydrate constituents stimulating endogenous opioid release, which protects an individual from the deleterious effects of stress and attenuates the stress response through decreasing the activity of the hypothalamic-pituitary-adrenal (HPA) axis (Adam & Epel, 2007). Consequently, overeating behaviour is reinforced through foods' ability to relieve negative affect.

According to motivational principles, individuals engage in self-regulation towards desirable states and away from undesirable states (Köpetz, Lejuez, Wiers, & Kruglanski, 2013). Drawing upon the motivational models of alcohol use literature, Burgess and colleagues (2014) proposed that individuals eat for positive (e.g., to

celebrate an event) or negative reasons (e.g., to cope with negative affect). These motivational pathways can be sub-divided, where positive motives include both social (e.g., to enjoy social gatherings) and enhancement motives (e.g., because one enjoys the feeling). Counterpart negative motives also include conformity (e.g., to not feel left out), and coping (e.g., to forget about negative emotions) (Burgess et al., 2014). If repeated use of food to cope is learned, however, it may lead to neurobiological adaptations and an increasingly compulsive dysregulated eating behaviour (Volkow & Wise, 2005), which in turn heightens the risk for developing overweight or obesity.

Eating to cope, (i.e. to feel better when experiencing negative circumstances or moods) shares a relationship with several critical psychological experiences and traits. In a study by Boggiano and colleagues (2017), eating to cope was associated with being triggered to eat by emotions related to anger, frustration, anxiety and depression, being more concerned about eating and having a higher BMI (particularly in females). Although there was an association between eating concerns and coping motivations in males, females reported greater perceived reactivity to social conflict and personal failure, more concerns about shape and weight, and greater binge eating severity alongside coping. Conversely, eating for enhancement (i.e. to experience pleasure) was not associated with any of the stress or symptoms of eating pathology for males or females. Although there was an association between anxiety and depression, this was only cited in females. Given that these psychological tendencies are associated with both eating to cope and obesity, personal effort and weight management interventions neglecting to address the underlying motivational components of overeating behaviour could presumably increase the incidence of failure, noncompliance or further weight gain. Additionally,

emotions such as anger, frustration, anxiety or depression could follow an unsuccessful weight loss attempt, as could feelings of personal failure and concerns about weight and eating, which together risk promoting the cycle of eating to cope.

1.1.2 Personal effort and structured weight loss programmes

With the aforementioned processes contributing to dysregulated eating behaviour, it is reasonable that weight loss efforts primarily driven by personal effort would have varying degrees of success. The current provision in the UK for obesity is a tiered weight management structure, with Tier 1 being universal prevention services, Tier 2 being lifestyle weight management interventions provided by public, private or volunteer organisations, Tier 3 being specialist multidisciplinary weight management services, and Tier 4 being bariatric surgery (NICE, 2014). See Figure 1.2 for a depiction of the obesity care pathway in the UK.

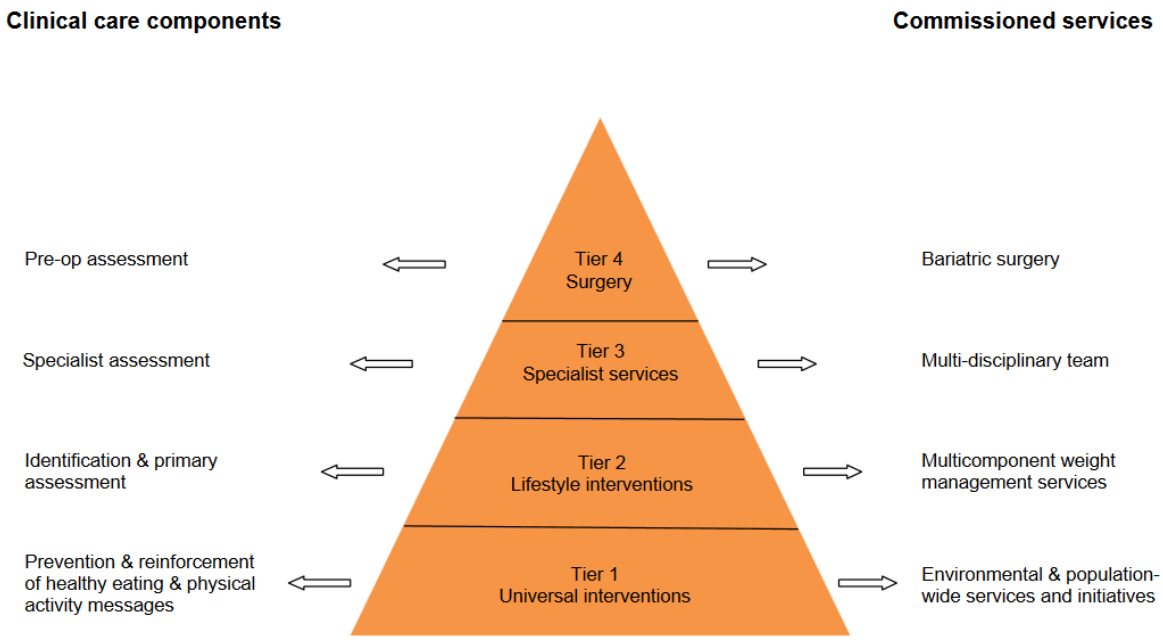

Figure 1.2. The UK Obesity Care Pathway (Department of Health, 2013). © Crown copyright 2011.

For individuals on a Tier 2 pathway, maintaining weight loss achieved through lifestyle and behavioural changes remains difficult, with nearly a third of weight regain occurring the year following an intervention (Simpson, Shaw, & McNamara, 2011). However, there is evidence that medications intended for weight loss can also help sustain weight maintenance (Franz et al., 2007; Wadden, Sternberg, Letizia, Stunkard, & Foster, 1989). For adults with a BMI of $\geq$ 30 who have been unsuccessful on a Tier 2 service, referral to a Tier 3 service is optional (NICE, 2016). These are comprised of a clinician-led specialist team and tend to have clinically significant weight reduction outcomes, although dropout rates are high (43-62%) and little evidence exists for their impact on quality of life or long-term behaviour change (Brown et al., 2017). Tier 4 bariatric surgery provision, on the other hand, has become increasingly popular in the last decade as evidence for its safety and efficacy is increasingly available (Welbourn et al., 2014).

1.1.3 Bariatric surgery

As previously discussed, the route to developing obesity is multi-layered and complex; with inter-relationships between biological, cognitive, psychological and environmental processes. Compared to non-surgical weight loss interventions (e.g., Tier 2 or 3 pathway services), bariatric surgery is highly effective both clinically and in terms of obesity-related healthcare costs (Picot et al., 2009). 'Bariatric surgery' is an umbrella term applied to several surgical procedures intended to produce weight loss through either restricting the amount of food that can be eaten, mal-absorptive mechanisms or both. The most recent figures for the most commonly performed surgeries in the UK include gastric banding (20%), sleeve gastrectomy (25%) and Roux-en-Y gastric bypass (55%) (Booth et al., 2016) which entail the following (Harvey, Arroyo, Korner, & Inabnet, 2010; Tsai & Osborne, 2017);

- Gastric banding (i.e. laparoscopic adjustable gastric band, AGB) is an exclusively restrictive procedure where a band placed at the top of the stomach is connected to a subcutaneous injection port. This transports fluid used to inflate the band, creating a restrictive pouch and induces satiety by limiting the amount of food that can be held in the stomach.
- Sleeve gastrectomy (SG) is a restrictive procedure where more than half of the greater stomach curvature is re-sectioned. The remaining portion connected to the fundus and proximal to the pylorus (opening from the stomach to the small intestine) is stapled closed, leaving a thin vertical tube. This also leads to hormonal changes (reduced ghrelin) and an increase in satiety hormones (PYY and GLP-1)
- Roux-en-Y gastric bypass (RYGB) is a procedure with a combination of restrictive and mal-absorptive mechanisms. A gastric pouch of $\leq$ 6cm is separated from the fundus (portion of the stomach above the horizontal line that passes through the cardia), and the gastrointestinal tract is reconfigured with the jejunum divided and re-arranged in a Y-shape. This creates a limited stomach capacity, which combines with similar gastrointestinal hormone alterations as SG and reduces appetite and food intake.

For a graphical depiction of these procedures, please see Figure 1.3.

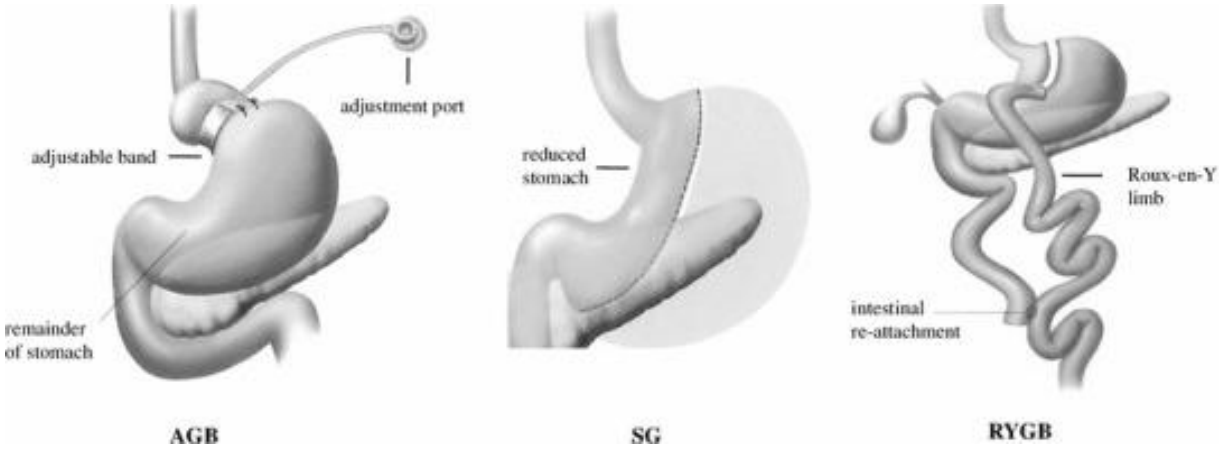

Figure 1.3. Types of bariatric surgery; adjustable gastric banding (AGB), sleeve gastrectomy (SG), and Roux-en-Y gastric bypass (RYGB). Sasaki, Wakabayashi & Yonei, (2014). © Springer Japan (http://creativecommons.org/licenses/by/4.0/).

While bariatric surgery has been heralded as the most durable solution for obesity by some researchers and clinicians (Mechanick et al., 2013), others have framed it as a 'last resort,' (Castle, 2015). Nonetheless, the National Institute for Health and Care Excellence (NICE) guidelines recognises bariatric surgery as a treatment option for adult patients who fulfil all items of their criteria (See Table 1.1 below).

Table 1.1. The NICE guidelines (Clinical guideline 189) for assessing adults for surgical interventions for obesity. © National Institute for Health and Care Excellence 2014.

1	The patient's BMI is 40 kg/m² or more, or between 35 - 40 kg/m² with a co-morbid disease where weight loss would facilitate improvement
2	Previous failure to achieve or maintain clinically beneficial weight loss after attempting non-surgical measures for minimum six months
3	The patient has been or will be managed within a Tier 3 service
4	The patient is physically fit enough for anaesthesia and surgery
5	The patient commits to long-term follow up after surgery
6	For adults with a BMI of more than 50 kg/m² where other interventions have not been effective
7	Patients with a BMI of 30 - 34.9 kg/m² and recent onset type 2 diabetes as long as they are also receiving or will receive assessment in a tier 3 service (or equivalent)
8	Patients of Asian family origin with a BMI of lower than 30 kg/m² and recent onset type 2 diabetes as long as they are also receiving or will receive assessment in a tier 3 service (or equivalent)

Correspondingly, the surgical procedure is selected following a comprehensive evaluation of the patient's medical, psychological and social history (Kubik, Gill, Laffin, & Karmali, 2013). In effect, bariatric surgery is an intervention offered to individuals meeting specific guidelines, and clinicians recognise that applying a biopsychosocial understanding of the patient is an essential part of the surgery's efficacy. Importantly, not all bariatric surgery techniques produce

equivalent weight-related outcomes (detailed below in section 1.1.4) and benefits and associated risks should be considered by clinical teams and the patient.

Critically, bariatric surgery represents a physiological approach to solving a problem of multifactorial origin. As addressed in section 1.1.1, the aetiology of obesity is complex; involving homeostatic, reward, cognitive and psychological processes, including motivational differences driving overeating (e.g., eating to cope). Therefore, the development of obesity should be framed contextually, and the relevant literature should be used to tailor interventions to maximise treatment outcomes by addressing obesity's root causes. Interestingly, not every individual who would qualify to receive bariatric surgery seeks the procedure. Rather, evidence suggests that those electing to have bariatric surgery possess a unique psychological profile. Compared to persons with average weight or other patients with obesity not seeking surgery, those seeking surgery have a higher prevalence of co-morbidities including; mood, personality and eating disorders, psychological distress, lower self-esteem and quality of life (Abilés et al., 2010; Greenberg, Sogg, & Perna, 2009; Kalarchian et al., 2007; Kubik et al., 2013; Pull, 2010). Psychological screening is routinely performed to identify possible contraindications for surgery and optimise weight loss outcomes through identifying candidates' educational or psychological needs (Block & Sarwer, 2013). However, psychological monitoring following surgery remains under-prioritised and research into persisting psychological problems is sparse (Jumbe, Hamlet, & Meyrick, 2017). Therefore, psychologically diverse outcomes following surgery could be proportional to pre-surgical co-morbidities, amount of support and education provision, alongside variance in degree of excess weight loss.

1.1.4 Mechanisms of action, health outcomes and the increased prevalence of alcohol misuse

Bariatric surgery is endorsed as the ideal option for individuals meeting NICE criteria, and a well-established evidence base demonstrates its variable efficacy for weight loss and improved metabolic outcomes. This efficacy is due in part to the role of gut hormones in reducing appetite and food reward valuation. As discussed in section 1.1.1.2.1, peptides from the GI tract regulate appetite and eating behaviour. Whereas persons with obesity have lower satiety responsiveness, satiety gut hormones are significantly higher after receiving RYGB surgery (relative to AGB) (Bose et al., 2010; Le Roux et al., 2006; Scholtz et al., 2014). As this was not observed post-AGB, these hormonal changes are separable from weight loss in general. Rather, le Roux and colleagues (2006) found that altered postprandial PYY and GLP-1 could combine post-RYGB surgery to enhance satiety and reduce calorie intake, and increased GLP-1 and insulin could improve glycaemic control. Further, these enhanced gut hormonal responses may be a mechanism by which RYGB surgery-produced gut alterations attenuate brain and behavioural reward responses to food (Goldstone et al., 2016). Although the literature largely focuses on RYGB and AGB surgery types in human and non-human rat models, similar findings are observed after SG surgery (Mans, Serra-Prat, Palomera, Suñol, & Clavé, 2015; Wilson-Pérez et al., 2013). In this way, bariatric surgery functions to correct biological deficits associated with obesity, making it easier to manage weight on a meal-by-meal basis through reaching and sustaining satiety, and exert more cognitive control over eating with reduced reward system activation.

Regarding bariatric surgery's efficacy on excess weight loss (EWL), a systematic review and network meta-analysis of randomized controlled trials by

Kang and Le (2017) reveals key differences between the three most commonly performed surgeries (ABG, SG and RYGB). Results indicated that while all surgery types produced significant EWL compared to patients' pre-surgical weight, more EWL was achieved at 1 year using RYGB technique (mean % EWL = 67.3) than AGB (40.6%). Moreover, there was no significant difference in weight loss outcomes between RYGB and SG (71.2%), and both surgical techniques yielded superior results to AGB. However, surgery does not represent a magic bullet; weight loss tends to plateau 2 years post-surgery, and weight-regain is also observed (Sarwer, Dilks, & Ritter, 2012). Importantly, the drastic weight loss characterising first years after surgery becomes variable in the long term. Although there is a paucity of research on long term outcomes, the Swedish Obese Subjects (SOS) cohort results reveal that patients only lost an average of 16% of their pre-surgical body weight 10 years after surgery (Sjöström et al., 2004). Alongside weight loss, remission of type 2 diabetes is possible, as well as improvements in metabolic syndrome irrespectively of surgery type (Picot et al., 2009). Other benefits extend to reductions in cardiometabolic risk factors, preventing some forms of cancer and improvements in quality of life (Mechanick et al., 2013; Schauer et al., 2014; Sjöström et al., 2004). For these reasons, bariatric surgery remains effective for some degree of weight loss in both the short and long term, as well as producing improvements in other health domains.

Alongside the well-evidenced benefits, there is also the risk for bariatric surgery-related side effects and further complications. 'Dumping syndrome' is one associated complication, which refers to the symptoms produced by food reaching the small bowel too quickly (e.g., abdominal pain, diarrhoea, bloating, nausea or palpitations; Tack, Arts, Caenepeel, De Wulf, & Bisschops, 2009). Other common

side effects include increased risk for nutritional deficiencies, gastrointestinal complications, mechanistic failures, changes in psychosocial status or increased physical and mental stress (Kalarchian, Marcus, Courcoulas, Cheng, & Levine, 2014; Marihart, Brunt, & Geraci, 2014; Shankar, Boylan, & Sriram, 2010).

Another significant but under-communicated side effect is the increased risk of developing alcohol misuse, especially after the 2 year 'honeymoon period' of rapid weight loss post-surgery (King et al., 2012; Parikh, Johnson, & Ballem, 2016; Svensson et al., 2013). Prevalence rates of post-surgical alcohol misuse vary throughout the literature, ranging from 2.3% to 13% (Parikh et al., 2016), with specifically new-onset cases reaching as high as 20% (King et al., 2017). Although substance misuse outcomes are usually concurrently examined, post-surgery substance misuse tends to be specifically alcohol-related (Conason et al., 2013). Alcohol misuse can have deleterious effects on the brain, heart, liver, pancreas, immune system and increase the risk for certain cancers (National Institute on Alcohol Abuse and Alcoholism, n.d.). Therefore, it is noteworthy that post-bariatric surgery patients are potentially exchanging one negative health outcome (i.e., excess weight) for another. Given this evidence, understanding the causes and contributors to post-surgical alcohol misuse and the most likely impacted patients is of critical importance to researchers, clinicians and patients themselves.

Meriting distinction in the event of post-surgical alcohol misuse is whether these symptoms represent un-resolved pre-surgery alcohol misuse patterns or new-onset patterns post-surgery. Pre-surgical screening for SUD (which includes alcohol use disorder, AUD) is routinely employed by bariatric services, as alcohol consumption can increase the risk for post-surgical complications and impede upon weight loss (Mechanick et al., 2013). The prevalence of patients meeting the

diagnostic criteria for SUD at their first pre-surgical evaluation is quite low (1.7%; Kalarchian et al., 2007), and having an AUD pre-surgery does not necessarily preclude an individual from receiving surgery. Interestingly, estimates indicate that upwards of 80% of patients at risk for problematic drinking proceed with bariatric surgery (Kudsi et al., 2013). Assessing the presence of AUD both pre and post-surgery typically utilises either the DSM-V definition, or the Alcohol Use Disorder Identification Test (AUDIT) (American Psychiatric Association, 2013; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The DSM-V characterises AUD if at least 2 of the symptoms described below in Table 1.2 are present. Classifications range between mild (the presence of 2 to 3 symptoms), moderate (4 -5), and severe (6 or more).

Table 1.2. Descriptions of the symptoms in the *Diagnostic and Statistical Manual of Mental Disorders-V* for AUD (APA, 2013). Adapted from the National Institute on Alcohol Abuse and Alcoholism. Alcohol Use Disorder: A Comparison Between DSM–IV and DSM–5. NIH Publication 13-7999 (NIAA, 2016).

In the past year, have you:	
1	Had times when you ended up drinking more, or longer, than you intended?
2	More than once wanted to cut down or stop drinking, or tried to, but couldn't?
3	Spent a lot of time drinking? Or being sick or getting over other aftereffects?
4	Wanted a drink so badly you couldn't think of anything else?
5	Found that drinking – or being sick from drinking – often interfered with taking care of your home or family? Or caused job troubles? Or school problems?
6	Continued to drink even though it was causing trouble with your family or friends?
7	Given up or cut back on activities that were important or interesting to you, or gave you pleasure, in order to drink?
8	More than once gotten into situations while or after drinking that increased your chances of getting hurt (such as driving, swimming, using machinery, walking in a dangerous area, or having unsafe sex)?
9	Continued to drink even though it was making you feel depressed or anxious or adding to another health problem? Or after having had a memory blackout?
10	Had to drink much more than you once did to get the effect you want? Or found that your usual number of drinks had much less effect than before?
11	Found that, when the effects of alcohol were wearing off, you had withdrawal symptoms, such as trouble sleeping, shakiness, restlessness, nausea, sweating, a racing heart or a seizure? Or sensed things that were not there?

Measuring alcohol misuse in a bariatric population draws upon several screening and diagnostic tools, accompanied by some limitations. Currently AUD is clinically defined using responses to 11 criterion items within the DSM-V. Bariatric surgery studies also utilised the previous diagnostic manual (DSM-IV) definition before the current revision was published. Differences between the two versions include the DSM-V integrating the previously distinct disorders (alcohol abuse and alcohol dependence) into a single disorder (AUD) with sub-classifications, changes in diagnostic thresholds, removal of legal problems as a previous criterion, and language updates (NIAA, 2013). Another assessment tool is the AUDIT; a 10-item screening questionnaire with possible scores ranging from 0-40, where a score of ≥ 8 indicates hazardous or harmful alcohol use (Saunders et al., 1993). Critiques for using the AUDIT for bariatric patients are that it could lead to over-diagnosis due to primarily being a screening tool, and because other diagnostic tools (i.e. Structured Clinical Interview for DSM-IV Axis I; SCID) found a comparatively lower prevalence of new-onset post-surgical AUD in the same study (Mitchell et al., 2015). Overall, Parikh and colleagues (2016) argue that the extant literature does not paint a clear picture of lifetime or current AUD prevalence in bariatric surgery candidates. Difficulties in ascertaining true prevalence arise due to reliance on retrospective studies with often small sample sizes, few control groups included, low patient response rates and variance due to diagnostic and screening tools. To summarise, pre-surgical assessment of AUD is routinely employed using several measures across bariatric services, although true prevalence remains difficult to ascertain.

Difficulties in understanding the onset and prevalence of alcohol misuse similarly persist following bariatric surgery. Primarily, the definition of post-surgical alcohol misuse varies across bariatric studies, with some cases identified as “high-

risk," while others as "misuse" or "abuse/dependence," making precise comparison after surgery difficult (Parikh et al., 2016). For the purpose of this thesis, terms relating to alcohol use post-surgery will be determined according to the way they were measured in each of the experimental chapters. These categories are described below in Table 1.3.

Table 1.3. Terms referring to alcohol use post-surgery, their rationale and associated measures

Alcohol Use Classification	Measurement Used
Non-problematic alcohol use	Sub-clinical or non-concerning levels of drinking as determined by clinical screening and measurement tools assessing alcohol use, or qualitative data
Problematic alcohol use or *alcohol problems*	This term refers to problematic alcohol use determined using qualitative data in the absence of a measurement tool such as the AUDIT, AUDIT-C or structured clinical interview
Hazardous drinking	Classified using a score of 8+ on the AUDIT (Saunders et al., 1993), or a score of 4+ (men) or 3+ (women) on the 3-item subscale AUDIT-C (Bush et al., 1998)
Alcohol use disorder (AUD)	Referring to diagnoses made elsewhere in the literature using specific measurement such as the AUDIT, Structured Clinical Interview for DSM-IV Axis I (SCID), Substance Use Disorder Identification Test (Alcohol Inclusive), or other clinical screening and measurement tools.
Alcohol misuse	A term referring to drinking excessively (NHS, 2015), which for the purpose of this thesis will encompass alcohol problems, hazardous drinking and AUD as determined by measurement tools including the AUDIT, except where these terms are specifically identified in the literature.

The time course to developing alcohol misuse after surgery is also significant. Two of the largest longitudinal surgery outcomes studies reveal that post-surgical AUD prevalence rates do not deviate from pre-surgery until the second year (King et al., 2012; Svensson et al., 2013). Among these, the Longitudinal Assessment Bariatric Surgery (LABS-2) study compared AUDIT scores and found that pre-surgery AUD rates remained similar 1-year post-surgery (7.6% to 7.3%, respectively), however this significantly increased at year 2 (9.6%) (King et al., 2012). Further, the cumulative incidence of new onset AUD symptoms post-surgery was 20.8% (King et al., 2017). Similarly, the Swedish Obese Subjects (SOS) study had an extended follow-up time (8-22 years), where researchers found that not only does AUD risk increase after 2 years, it also persists beyond this time point (Svensson et al., 2013). SOS study results should be interpreted bearing in mind that AUD was determined using responses to a validated SOS dietary questionnaire (rather than DSM-IV, V or AUDIT classifications). Nonetheless, the significant increase in alcohol misuse at 2 years post-surgery is also evidenced in prospective studies with composite scores of substance and alcohol use (Conason et al., 2013). Methodology notwithstanding, there is significant evidence to suggest that alcohol use and misuse increases for some individuals beginning at 2 years post-surgery, with potential to endure afterwards.

1.2. Identified contributors to alcohol use disorder in patients following bariatric surgery and other potential causes

1.2.1 What is already known about post-surgical causality

As clinicians, researchers and the wider medical community become more aware of the increased incidence of alcohol misuse post-bariatric surgery, research

has been conducted to identify risk factors contributing to this phenomenon. The extant evidence base comprises studies using regularly collected medical record data from the surgical pathway, cross-sectional analysis, prospective observational cohort studies and longitudinal assessments. The outcomes reviewed below form the outline for which later theoretically driven research can be conducted to better understand the cause of post-bariatric surgery alcohol misuse.

1.2.1.1 Demographic risk factors

Bariatric surgery presupposes a medical setting, with demographic information accessible from medical records and research-related questionnaires. Interestingly, these yield conflicting results in identifying contributors to post-surgical alcohol misuse. Table 1.4 presents a review of the evidence for demographic predictors of post-bariatric surgery alcohol use, misuse and dependence in studies that assessed alcohol or substance misuse as an outcome variable. Male gender and younger age appear to increase the risk for post-surgery AUD in some cases. Likewise, there is mixed evidence that habitual predictors (i.e. smoking or history of substance use) increase the likelihood of alcohol misuse. Moreover, much of the extant literature indicates receiving RYGB surgery type as increasing the likelihood of post-surgical AUD, relative to AGB. However, another study indicates that SG carries a similar risk (Ibrahim et al., 2018). Section 1.2.2.1 later explores possible mechanisms underlying surgery-specific associations with alcohol misuse. Interestingly, although some evidence supports that AUD/SUD history can improve weight loss outcomes (Heinberg & Ashton, 2010), concerns over alcohol, drug use or post-surgery AUD are also cited as significant predictors of weight re-gain (Odom et al., 2010; Yanos, Saules, Schuh, & Sogg, 2015). This non-linear relationship between AUD/SUD history and weight outcomes is possibly due to measurement

differences. Overall, demographic factors have significant (albeit conflicting) associations with an increased risk for post-surgical alcohol misuse, and conclusions cannot be definitively drawn, which invites inquiry into other possible contributors.

Table 1.4. A review of the evidence for demographic predictors of post-surgical alcohol use, misuse or dependence.

As per	Subjects	Measured	Pre-surgical predictors of post-surgical increased alcohol use or AUD						
			Gender	**Age**	**Household income**	**Education level**	**Lifestyle and substance use**	**Pre-surgical weight/BMI**	**Surgery type**
Black, Goldstein & Mason (2003)	*N* = 44 VBG patients, N = *10* male	Alcohol abuse/dependence diagnosis	N/A	N/A	N/A	N/A	N/A	Post-surg weight loss (non-sig)	N/A
Conason et al. (2013)	*N* = 155 patients, *N* = 23 male	Substance use (alcohol incl.)	N/A	N/A	N/A	N/A	N/A	N/A	RYGB
Ibrahim et al. (2018)	MBSC registry, *N* = 5794, *N* = 1235 male	Post-surgical AUD	Non-sig	Non-sig	Higher (+) RYGB only	Lower (+) RYGB only	Alcohol consumption (+)	Non-sig	RYGB SG
Ivezaj, Saules & Schuh (2014)	RYGB patients *N* = 143, *N* = 23 male	Post-surgical SUD (AUD incl.)	Non-sig	N/A	N/A	N/A	Personal SUD history (non-sig) Family SUD history (+)	Non-sig	N/A
Kanerva, Larsson, Peltonen, Lindroos & Carlsson (2017)	Swedish Obese Subjects; *N* = 1695 patients, male *N* = 512)	Increased alcohol intake	Male (+)	Younger (+)	N/A	Non-sig	Smoking – non-sig Sedentary lifestyle (+)	N/A	RYGB
King et al. (2012)	LABS-2 study, *N* = 1945 patients, male *N* = 413	Post-surgery AUD	Male (+)	Younger (+)	Non-sig	Non-sig	Smoking (+) Rec. drug use (+) Regular alcohol consumption (+)	Non-sig	RYGB
King et al. (2017)	LABS-2 study, *N* = 2003, male *N* =	Post-surgery AUD	Male (+)	Younger (+)	Non-sig	Non-sig	Smoking (+) Illicit drug use (non-sig) Starting regular alcohol consumption (+)	Non-sig	RYGB

Table 1.4. A review of the evidence for demographic predictors of post-surgical alcohol use, misuse or dependence

Lent et al. (2013)	*N* = 155 RYGB patients responding to alcohol use question, 80.6% female	Increased alcohol consumption	Non-sig	Older age (-)	N/A	N/A	Alcohol consumption (+)	Higher pre-surgical BMI (+) Post-surg weight loss (non-sig)	N/A
Ostlund et al. (2013)	*N* = 11,115, *N* = 2,567 male	Diagnosis of alcohol abuse	Non-sig	N/A	N/A	N/A	N/A	N/A	RYGB
Saules et al. (2010)	*N* = 54 bariatric patients (*N* = 16 male), *N = 54* matched controls	Admission to substance abuse treatment facility (62.3% alcohol related)	Female (+)	N/A	N/A	N/A	Non-smoking status (+) Alcohol consumption (+)	N/A	N/A
Suzuki, Haimovici & Chang (2012)	*N* = 51 patients, N = *7* male	Post-surgery AUD	N/A	N/A	N/A	N/A	Lifetime history of AUD (+)	Post-surg weight loss (non-sig)	RYGB
Svensson et al. (2013)	Swedish Obese Subjects; *N* = 2,010 surgery; *N* = 2,037 control	Increased alcohol consumption, alcohol problems, alcohol abuse diagnoses	Male (+)	Non-sig	N/A	N/A	Smoking (+) Alcohol consumption (+)	Non-sig	RYGB and VBG
Tedesco, Hua, Lohnberg, Bellatorre & Eisenberg (2013)	*N* = 205 US veteran bariatric patients	DSM-IV diagnosis of substance abuse or screening-positive history (alcohol incl.)	N/A	N/A	N/A	N/A	More patients with current substance abuse had a history of alcohol or drug abuse, but non-sig	N/A	N/A

* NA = either not applied in an analysis, or not available information, SG = sleeve gastrectomy, RYGB = Roux-en-Y gastric bypass, VBG = vertical banded gastroplasty

Importantly, demographic characteristics of patients reporting post-surgical alcohol misuse often stand in contrast to extant data on AUD prevalence in non-bariatric populations. Generally, persons with obesity tend to report lower rates of SUDs (Pickering et al., 2011; Scott, McGee, Wells, & Oakley Browne, 2008; Simon et al., 2006). Although data stratifying the incidence of SUD by age, gender and BMI is not available in non-bariatric populations, approximately half of AUDs appear in individuals' early 20s, and nearly all occur before 41 years (Grucza et al., 2010; Kessler et al., 2005). While younger age has been cited as a risk factor for post-bariatric surgery AUD, this has been assessed in populations with average age ranges between 47 - 50.1 (King et al., 2017; Lent et al., 2013). Although some gender-related findings of increased male prevalence are parsimonious in both bariatric and non-bariatric populations, contrasting evidence of increased risk for female bariatric surgery patients exists, even in middle age (Kessler et al., 2005; Saules et al., 2010). Spadola et al (2015) similarly noted that the typical post-surgical patient included in studies examining alcohol misuse is female and older than 45, presenting a risk for alcohol misuse during an otherwise low-risk period in their lifespan. These comparisons highlight that specific demographic differences within this patient group deviate from population norms, which could indicate inherent vulnerabilities or the combined impact of their surgical procedures as potentially contributing to alcohol misuse outcomes.

1.2.1.2 Pre-surgical drinking habits

While the pathway to developing alcohol misuse is complex, one possible contributor identified in non-bariatric populations is the maintenance of alcohol's stimulatory and rewarding effects in those with heavy drinking patterns (King, Hasin, O'Connor, McNamara, & Cao, 2016). This is supported by evidence where bariatric

surgery patients with a lifetime history of AUD were subsequently more likely to report having an AUD after surgery, relative to those without (Suzuki, Haimovici, & Chang, 2012). These findings are expanded upon in the LABS-2 study, where not only did reporting an AUD before surgery increase the odds of reporting an AUD after surgery, but so did regularly drinking alcohol below hazardous levels (King et al., 2012, 2017)**.** Indeed, another study found that as pre-surgical alcohol consumption quantity rose, the odds of consuming any alcohol post-surgery increased six-fold (Lent et al., 2013). The positive association between baseline alcohol consumption and post-surgical AUD is further supported in both RYGB and SG (Ibrahim et al., 2018). Therefore, the amount of alcohol an individual drinks before surgery bears an impact upon post-surgical alcohol-related outcomes. On the other hand, evidence also offers that not all cases of post-surgical alcohol misuse reflect continuations of alcohol misuse or intensifications of regular drinking patterns from pre-surgery.

There is evidence for new-onset alcohol misuse following bariatric surgery, which comprises a modest amount of the total recorded alcohol misuse cases. The LABS-2 cohort is considered the gold standard in research assessing AUD post-surgery, with up to 7 years of longitudinal data (Sogg, 2017). Herein, 20.8% of RYGB patients reported post-surgery onset AUD by the fifth post-surgical year, compared to 11.3% of AGB patients (King et al., 2017). Although lifetime history of AUD was not assessed (therefore true representation of new-onset AUD cannot be deduced) outcome data were compared to baseline measures of AUD. Key findings from this study are that individuals with RYGB have a greater risk for post-surgical AUD, and the percentage of new onset cases after surgery was substantial. Spadola et al (2017) also found that 20% of post-bariatric surgery AUD cases were newly onset,

while Steffen et al (2015) found that 40.6% of post-surgical AUD were new-onset cases. Conversely, other studies recorded instances of new-onset AUD as low as 7% (Ibrahim et al., 2018; Wee et al., 2014). Other evidence from a study of bariatric surgery patients and matched non-surgery controls in a substance abuse treatment facility indicated that 43.4% of individuals initiated heavy substance use de novo after surgery (Saules et al., 2010). There remains a dearth in the literature regarding prevalence of alcohol misuse after SG, however recent evidence indicates 8.5% new onset cases of AUD from the first to second year post-surgery (Ibrahim et al., 2018). Taken together, a history of alcohol misuse does not represent the only risk factor for post-surgery alcohol misuse, as a significant percentage of patients develop new-onset alcohol misuse after surgery. This illustrates that additional research is needed regarding the motivations and events leading to the new uptake of alcohol post-surgery and invites inquiry into whether problems with alcohol ameliorate after surgery.

Indeed, a reverse phenomenon exists where some individuals with 'high risk' drinking before surgery discontinue following surgery. One study by Woodard and colleagues (2011) reported short-term declines in alcohol consumption as soon as 6 months post-surgery, including number of drinking events, (1.9 days per week to 0.9), average number of drinks (2.4 to 1.5) and total drinks per week (4.4. to 1.8). Other research indicates that alcohol use can decrease significantly after surgery, where up to 71% of individuals with pre-surgical high-risk drinking discontinue their drinking patterns following surgery (Lent et al., 2013; Wee et al., 2014). This observation is also validated when AUD is included in a composite measure of pre-surgical SUD (Ivezaj et al., 2014). In summary, pre-surgical drinking levels do affect post-surgical alcohol misuse outcomes, but do not explain all the drinking behaviour

variability following surgery; including new-onset alcohol misuse, and discontinuation of pre-surgical drinking patterns.

1.2.1.3 Other identified risk factors

Variable conclusions can be drawn from evidence derived from demographic risk factors, including pre-surgical drinking habits. Therefore, expanded approaches using a biopsychosocial perspective offer further evidence into factors increasing the risk for alcohol misuse post-surgery. Importantly, social support is critically linked with alcohol use, and those with supportive friends and family members are often more successful in their efforts to reduce alcohol use (Beattie & Longabaugh, 1999; Gordon & Zrull, 1991; Tucker, Vuchinich, & Pukish, 1995). This is similarly identified in the bariatric literature, where lower social support and sense of belonging is significantly associated with post-surgical AUD, as well as becoming single (versus remaining married) (King et al., 2012, 2017). As social support is critical to mental health, it follows that less improvement in or worsening mental health is also associated with higher risk for post-surgery AUD (King et al., 2017). Additional contributors to mental health include poor coping skills and potential life stressors, which have significant associations with new-onset SUD (AUD inclusive) after bariatric surgery (Ivezaj et al., 2014). This is consistent with results from non-bariatric populations in treatment for AUD, where patients reported more difficulties identifying and describing emotional states, alongside lower emotion regulation skills relative to non-addicted healthy individuals (Kopera et al., 2018). Given the evidence above, it is possible that alcohol misuse represents a post-surgical coping strategy for individuals with lower support, mental health, and fewer alternative coping skills. As described in section 1.1.1.2.4.1, eating also functions as a coping strategy, and it is possible that physical restrictions imposed by bariatric surgery

could lead individuals to replace this strategy with alcohol use where food is no longer accessible.

Other psychological difficulties implicated in post-bariatric surgery increased alcohol consumption are symptoms of attention deficit hyperactivity disorder (ADHD; Alfonsson, Sundbom, & Ghaderi, 2014). While cited for bariatric patients in this instance, a meta-analysis on ADHD and prevalence of AUD in non-bariatric populations suggests a significant association, which does not extend to general alcohol use (Charach, Yeung, Climans, & Lillie, 2011; Lee, Humphreys, Flory, Liu, & Glass, 2011). However, Lee and colleagues (2011) caution that other, less examined co-morbid disorders (e.g., disruptive behaviour disorder) could complicate these inferences. Moreover, while pre-surgical depression has been associated with a lower risk for post-surgical AUD in SG patients, this could also indicate contact with a mental health service, which could form a protective factor against AUD development (Ibrahim et al., 2018). Although demographic predictors are regularly examined in bariatric surgery patients, the few studies that extend beyond demographic qualities into psychosocial factors are largely consistent with the wider AUD literature in connecting AUD with social support, mental health and coping. In conjunction, additional contributors to post-surgical alcohol misuse are identified using theoretically based research approaches, which yield meaningful (though complex) data for clinicians seeking to understand susceptibility to post-surgical alcohol misuse.

1.2.2 Theoretically relevant contributors to post-surgical alcohol misuse

Prospective cohort, cross-sectional and longitudinal studies form an evidence base of possible contributors to alcohol misuse following bariatric surgery, although

parsing out specific risk factors is difficult against instances where the evidence is mixed. Compelling evidence from a non-human animal study indicates that food deprivation (a key mechanism to bariatric surgery's success) causes increased alcohol use, findings which have also been preliminarily linked to humans (Cummings & Tomiyama, 2018). Nevertheless, authors caution that the effects of restricted eating on increased alcohol use may be subject to different moderators (e.g., food types, restriction patterns), mediators (e.g., altered metabolism, emotion regulation), and outcome measures (e.g., sub-clinical drinking, AUD) and more research is needed to identify causality. Similarly, there remains a dearth in the literature explaining specific mechanisms of why bariatric surgery is associated with the increased risk for alcohol misuse, particularly for RYGB patients. Importantly, the prevalence of increased alcohol misuse post-surgery only occurs within a small, albeit significant, percentage of individuals. Therefore, clinicians, researchers and psychologists alike have proposed several relevant theories to address this explanatory gap, which are evaluated further below.

1.2.2.1 Pharmacokinetic changes in alcohol metabolism

As described in section 1.2.1.1, receiving RYGB carries an increased risk for alcohol misuse after surgery. This could be related to changes in alcohol metabolism following this surgery type (Hagedorn, Encarnacion, Brat, & Morton, 2007; Klockhoff, Näslund, & Jones, 2002; Maluenda et al., 2010; Steffen, Engel, Pollert, Li, & Mitchell, 2013; Woodard et al., 2011). Indeed, a review on the pharmacokinetics of alcohol after bariatric surgery by Steffen et al (2015) offers that, despite variability from obtaining alcohol measurement via blood (BAC) or breath (BrAC) assessments, RYGB patients quickly achieve significantly higher BAC and BrAC concentrations than pre-surgical or matched non-surgical comparison groups.

Further, more time is needed to eliminate alcohol after RYGB surgery (Hagedorn et al., 2007; Pepino et al., 2015; Woodard et al., 2011). Changes in subjective experiences of alcohol metabolism are also cited, where up to 84% of post-RYGB patients report feeling more sensitive to the effects of alcohol (Buffington, 2007; Ertelt et al., 2008). Anatomical changes in RYGB surgery contributing to changes in alcohol metabolism include; decreases in stomach surface area, which contains gastric alcohol dehydrogenase and is involved in first-pass alcohol metabolism (Meier & Seitz, 2008), a faster emptying of liquids into the small bowel (Dirksen et al., 2013; Melissas et al., 2013) and post-surgical excess weight loss, potentially impacting upon metabolic processes (Ivezaj, Stoeckel, et al., 2017). However, it is expected that alcohol metabolism changes are experienced by all RYGB patients. Therefore, pharmacokinetic changes produced by RYGB do not fully explain why a modest percentage of patients have post-surgical alcohol misuse, while the majority do not.

Furthermore, evidence exploring the changes in alcohol metabolism produced by other restrictive-type procedures (i.e. AGB and SG) remains mixed. One study using BrAC found that AGB and SG do not share the same altered alcohol metabolism as RYGB (Changchien, Woodard, Hernandez-Boussard, & Morton, 2012), while another found that SG produces changes similar to RYGB (i.e. faster and higher peak BAC post-surgery relative to a pre-surgery group; Acevedo et al., 2018). Critiques to RYGB studies similarly apply, with the possible reason underpinning this discrepancy being that breathalyser measurements (BrAC) are not valid for this population. Indeed, a comparison of both techniques by Acevedo and colleagues (2018) revealed that BrAC under-estimated BAC by 27%. While the mechanisms producing faster and higher peak BAC after drinking alcohol in SG or

RYGB patients are not fully understood, these could also be related to similarly increased gastric emptying between both procedures, which potentially reduces first-pass metabolism (via the gut and liver) before circulating throughout the system (Dirksen et al., 2013; Levitt, 2002; Sista et al., 2017). While the prevalence of using SG as a surgical technique is increasing, only one recent study has found that SG carries a similar risk as RYGB (Ibrahim et al., 2018). Given that SG has a similarly high BAC post-surgically as RYGB, this presents an additional research opportunity. Altogether, there is mixed evidence for whether surgeries other than RYGB produce changes in alcohol metabolism.

1.2.2.2 Shared neural systems driving overeating and addictive behaviours

Although bariatric surgery produces anatomical and physiological GI system changes and thereby possible alterations in alcohol metabolism, post-surgical alcohol misuse nevertheless occurs within a subset of patients. This invites exploration into other possible risk factors. As reviewed in section 1.1.1, the interplay between neural reward circuitry and cognitive control mechanisms are integral to the development of overeating and obesity. Importantly, neural systems driving the rewarding effects of eating have been similarly cited for addictive drugs and alcohol (Volkow et al., 2013). Therefore, how these shared systems are implicated in the increased incidence of alcohol misuse post-surgery merits consideration. One critical motivator of both palatable food and alcohol intake is DA release in the striatum (Grace, 2000; Wise, 2006). This neurotransmitter modulates reward primarily through its projections from the ventral tegmental area into the NAcc, where more DA release is considered associated with increased 'wanting' of the reward, without necessarily impacting upon 'liking' (Berridge & Kringelbach, 2015). Correspondingly, it has been theorised that lower D2 receptor availability creates a vulnerability to addiction, as

alcoholics have lower D2 receptor availability relative to non-alcoholics (Volkow et al., 1996, 2002). Similarly, an inverse relationship is observed between DA receptor availability and BMI, possibly promoting obesity through compensating for decreased reward circuit activation by overeating (Wang et al., 2001). Given these shared reward mechanisms in both obesity and addiction, Steffen and colleagues (2015) theorised that bariatric surgery's imposed restrictions on palatable food intake could produce changes in the ability to stimulate the neurotransmitter system using food. Therefore, alcohol may be substituted due to its similar mesolimbic reward system activation and DA release when overeating is inaccessible due to surgical restriction or malabsorption.

Indeed, paralleling instances of decreased dopamine receptor (D2) availability are cited in both obesity and addiction, which ostensibly could indicate a shared 'addictive' neural pathway. However, this inference pre-supposes a causal pathway between decreased reward system activation and later obesity, and contrary findings exist where decreased DA does not increase motivation for food or liking (Hardman, Herbert, Brunstrom, Munafò, & Rogers, 2012). Importantly, evidence from bariatric patients indicates that while overeating results in a downregulation of D2 receptors, weight loss after surgery reverses this, indicating that decreased D2 receptor availability represents an outcome of obesity rather than its cause (Steele et al., 2010). Blackburn and colleagues (2016) further posit that RYGB and its associated weight loss may reverse the dysregulation of DA reward processing and thereby improve reward sensitivity. This follows from preclinical evidence where diet-induced obese rats initially favour food over alcohol, and researchers suggest that RYGB can reverse this preference through two pathways; increased reward sensitivity and learned food aversion due to malabsorption and gastrointestinal

discomfort from eating high fat or sugar foods. Moreover, Blackburn et al (2016) propose that this increased reward sensitivity extends to alcohol, as alcohol is not controlled by anorexigenic homeostasis as it is with food intake. Therefore, because post-surgery weight loss could upregulate D2 receptor availability and thereby improve reward sensitivity to alcohol, the nature of these neural changes and their role in post-surgical alcohol intake merits further research. Indeed, neural changes are cited in the literature as possible enabling factors for post-surgical alcohol misuse. However, the instrumental constraints of the present thesis did not allow for neural imaging studies in human or non-human participants, therefore this was not examined.

1.2.2.3 Ghrelin and increased reward value of alcohol post-surgery

Alongside shared neural systems, another factor increasing the risk for post-surgical alcohol misuse could be surgically-produced alterations in the alcohol's rewarding effects and its individual valuation. Indeed, animal models evidence that alcohol's reward value increases similarly to alcohol consumption in obese rats following a RYGB procedure (Hajnal et al., 2012; Thanos et al., 2012). As previously described, valuation changes are possibly attributable to improvements in DA reward processing after weight loss. As incentive motivation is believed to be mediated through DA reward system and modulated by gut-brain hormones (Abizaid, 2009; Abizaid et al., 2006; Dunn et al., 2012), post-surgery changes in gut hormones are another possibility, specifically ghrelin. While central ghrelin signalling increases alcohol intake through stimulating the reward system (Jerlhag et al., 2009), less is known about peripheral impacts. This is important because ghrelin is mainly produced peripherally in the stomach, and post-surgical changes in ghrelin appear specific to surgery type (Cummings, 2004; Korner et al., 2009). Generally,

ghrelin increases after AGB, and reduces after RYGB and SG surgery (Bužga et al., 2014; Korner et al., 2009; Morínigo et al., 2004). Although this varies, as ghrelin increased in one-fourth of RYGB patients independent of weight loss in a study by Korner and colleagues (2009). Changes in ghrelin system responsiveness and increased ethanol-seeking behaviours were observed in diet-induced obese rats given RYGB surgery which Hajnal et al. (2012) ascribe to DA system sensitivity improvement. Obesity and bariatric surgery create the context for connections between DA, ghrelin and alcohol reward, as research using non-obese, non-surgically altered mice found that peripherally circulating ghrelin does not mediate alcohol reward or intake (Jerlhag, Ivanoff, Vater, & Engel, 2014). Therefore, changes in DA receptor sensitivity and ghrelin after some bariatric surgery types could motivate increased drinking and greater alcohol intake through changing individual sensitivity to alcohol's reward value.

Importantly, section 1.2.1.2 provides a framework to examine whether post-surgical alcohol misuse represents a continuation or increase in drinking patterns. Particularly, patients with a history of AUD or heavy drinking are more likely to have post-surgical AUD (King et al., 2017; Lent et al., 2013; Suzuki et al., 2012). Conversely, animal models reveal that post-surgical increases in alcohol intake appear specific to obese rats *without* pre-surgical alcohol preferences. Indeed, research with ethanol-preferring rats given an RYGB procedure found subsequent *decreases* in ethanol intake and reward value (Davis et al., 2012). Moreover, Davis et al (2013) later found that while RYGB surgery increased ethanol consumption in non-preferring rats, this effect was not explained by pre-surgical weight, dietary composition, post-surgical weight loss, altered alcohol metabolism or post-surgical changes in ghrelin release. Rather, researchers discovered alterations in gene

expression patterns within regions of the rat brain that mediate appetitive and consummatory behaviour (i.e. lateral hypothalamus, NAcc) after RYGB surgery, potentially increasing alcohol seeking and reward. These studies highlight that neurobiological changes may be critical to understanding increased alcohol misuse above surgically-produced changes in alcohol metabolism or its impact upon appetite hormones. This is supported by Polston et al (2013) where researchers bypassed the stomach by using intravenously-administered alcohol and observed an increase in the rewarding effects of alcohol and consumption patterns for obese RYGB-treated rats. Altogether, bariatric surgery changes alcohol's reward value for obese, non-alcohol preferring rats, however its generalisability to humans bears consideration. Further, post-surgical changes in alcohol's reward value are not fully attributed to alterations in GI-related alcohol metabolism, but rather involve neurobiological changes in reward circuits implicated in both obesity and alcohol intake.

In summary; bariatric surgery produces neurochemical and genetic expression changes in shared neural reward systems driving both eating and alcohol incentive motivation, alongside changes in gut hormones, which potentially modulate this process. However, the explanatory value of resultant increased reward sensitivity contributing to post-surgical alcohol misuse remains incomplete. Reward is one of several pathways to obesity, alongside cognition, psychology and emotion regulation (section 1.1.1). Likewise, addictive behaviours may arise from neurobiological adaptations modulated by DA, which are influenced by other factors such as genetic heritability, substance availability (e.g., alcohol or highly palatable foods), stress, and excessive intake (Volkow & Wise, 2005). The developmental learning model of addiction also supports that there are several points of entry to alcohol misuse, including environmental, cognitive and emotional causes (Lewis, 2017). Therefore,

shared neural mechanisms and changes in reward sensitivity post-surgery are unlikely to be the primary driving forces, as underlying causal factors (e.g., stress) are not sufficiently incorporated theoretically. Moreover, reward sensitivity and processing changes have also been implicated in mood disorders (Alloy, Olino, Freed, & Nusslock, 2016). As addictive-like dysregulated eating behaviour has been conceptualised as a coping mechanism for negative affect (Leigh & Morris, 2018), it is possible that increased alcohol use could represent a substitute for previously food-centred addictive behaviours when food becomes inaccessible after surgery, conceptualised as 'addiction transference.'

1.2.2.4 'Food addiction' transference: Applying addictions models toward understanding the problem

In popular media and research, there has been increased attention given to the development of 'addictive' behaviours, particularly alcohol misuse, in post-bariatric surgery patients. As previously mentioned, the 'addiction transference' model hypothesises that post-bariatric surgery patients will adopt other inappropriate coping strategies (e.g. alcohol use) to attenuate negative emotions when it becomes difficult to engage in previous coping strategies centred on food (Hardman & Christiansen, 2018; Spencer, 2006; Steffen et al., 2015). The implicit assumption in this hypothesis, however, is that individuals who present with alcohol misuse post-surgery were 'addicted to food' beforehand. While some significant associations have been observed between post-surgical alcohol misuse, demographic traits, pre-surgical habits, and select psychosocial variables (section 1.2), the evidence remains inconclusive in determining causal pathways to post-surgical alcohol misuse. Therefore, the relationship between food addiction, alcohol misuse and the 'addiction transfer' hypothesis merits exploration.

The evidence depicting the relationship between food addiction and alcohol misuse is detailed in a systematic review of food addiction and bariatric surgery by Ivezaj and colleagues (2017). Researchers found the relationship between food addiction and substance use (including alcohol misuse) is non-significant before surgery (Koball et al., 2016; Meule, Heckel, Jurowich, Vögele, & Kübler, 2014). Further, findings were mixed for the relationship between pre-surgical food addiction and post-surgical SUD/AUD (which would theoretically indicate 'addiction transference'). Studies using a retrospective assessment of food addiction found evidence supporting both positive (Reslan, Saules, Greenwald, & Schuh, 2014) and non-significant (Clark & Saules, 2013) associations between pre-surgery food addiction and post-surgery SUD (AUD inclusive). Even in longitudinal studies, the evidence remains inconclusive, as one study found support for possible 'addiction transfer' where bariatric surgery patients who reported problems with high sugar/low fat and high GI foods before receiving surgery were at greater risk for developing new-onset SUD post-surgery (Fowler, Ivezaj, & Saules, 2014). Conversely, a non-significant association between pre-surgical food addiction and post-surgical SUD (AUD inclusive) was found by Koball et al (2016), although outcomes were assessed at 12 months following surgery, while AUD prevalence rates tend to significantly increase at 24 months (King et al., 2012, 2017). Therefore, although pre-surgical food addiction is offered as a theoretical pathway to post-surgical alcohol misuse (along with SUD), the evidence supporting this hypothesis is still inconclusive, partly due to methodological constraints.

Other findings contradict the food addiction hypothesis. Notably, findings from the LABS-2 cohort evidenced that neither binge eating nor loss of control eating before surgery were associated with SUD-related outcomes (King et al., 2017). As

described in section 1.1.1.2.3.1, the claim that highly-palatable food is 'addictive' is heavily debated, and challenges to the 'brain disease' model of obesity point out that brain responses when anticipating/consuming food and differences in neural functioning between persons with and without obesity are not consistently observed in the literature (Ziauddeen et al., 2012). Overall, critiques cite that the addiction transfer model functions tautologically, and does not yield useful information without support from empirical data (Sogg, 2017). Rather, the addiction transfer model appears related to the 'symptom substitution' theory proposed by Kazdin (1982); where the ending of one behaviour, without treating its underlying cause, may lead to substitute behaviour. Accounts from popular media echo this theory, evidenced by 'coping' being critical to the addiction transfer hypothesis (Hardman & Christiansen, 2018; Steffen et al., 2015). Rather than applying the addiction transfer model, which pre-supposes the addictive quality of food and assumes a positive, linear relationship between food addiction and obesity - the increase in post-surgical alcohol misuse could represent seeking substitute behaviours to cope with an underlying vulnerability, which is addressed in below in section 1.3.

1.3 Drinking to cope with negative affect as the pathway to post-surgical alcohol misuse

1.3.1 Underlying vulnerabilities: A theoretical model of negative reinforcement mechanisms associated with alcohol misuse in non-bariatric populations

Though the underlying processes driving alcohol use are complex, the extant literature highlights the role of psychological states and motivational drive in the pathway to alcohol misuse. 'Negative affect' refers to psychological states encompassing stress responses, emotions and moods (Gross, 2014). Like obesity, it is

argued that negative affect is central to the development and maintenance of alcohol misuse or AUD (Baker, Piper, McCarthy, Majeskie, & Fiore, 2004; Pandina, Johnson, & Labouvie, 1992; Stasiewicz & Maisto, 1993). Indeed, personality and affect-related mood disorders (e.g., depression and anxiety) are associated with increased AUD risk and co-occur with higher rates of post-AUD treatment relapse in non-bariatric populations (Bradizza, Stasiewicz, & Paas, 2006; Hasin, Stinson, Ogburn, & Grant, 2007). This is relevant to bariatric populations, as section 1.1.1.2.4 illustrates that negative affect-related personality traits (e.g., depression, anxiety) and mood disorders have been similarly implicated in overeating and obesity (Anderson et al., 2006; Davis et al., 2008; Gariepy et al., 2010; Gerlach et al., 2015). Although this frames the above as risk factors it is unlikely they have a simple direct association, as negative affect (e.g., loneliness, or anxiety) is also predictive of desire to drink and alcohol consumption (Carney, Armeli, Tennen, Affleck, & O'Neil, 2000; Swendsen et al., 2000). Rather, the relationship between negative affect and alcohol use could be mediated by inadequate self-regulatory processes, such as affect regulation (Carpenter & Hasin, 1999; Castellanos-Ryan & Conrod, 2012; Cooper, Frone, Russell, & Mudar, 1995), where individuals emotionally regulate through employing cognitive and behavioural strategies to maintain emotions within a tolerable range (Gross, 1998). Altogether, negative affect-related personality traits and mood disorders associated with obesity could similarly form a pathway to the development of post-bariatric surgery alcohol misuse through drinking alcohol as a behavioural strategy to regulate negative affect.

Alongside the contributions of negative affect, motivational processes are also critical to understanding alcohol misuse in bariatric and non-bariatric populations. Significantly, the categorical model of motivation described in section

1.1.1.2.4.1 was originally developed for alcohol use, where positive reinforcement (e.g., *a substance's inherent positive, hedonic qualities*), and negative reinforcement (e.g., *the ability of some substances to relieve negative affect*) maintain the overconsumption of alcohol (Cooper, 1994; Miles Cox & Klinger, 1990; Cox & Klinger, 1988). Likewise, motivations to drink alcohol are categorised into positive motives; social (e.g., drinking alcohol to enjoy social gatherings) and enhancement (e.g., because one enjoys the feeling), and negative motives; conformity (e.g., to not feel left out), and coping (e.g., to forget about negative emotions) (Cooper, 1994; Stewart & Devine, 2000). However, not all motivations bear equal influence upon hazardous drinking outcomes, and these may be subject to individual differences.

Evidence for the role of individual differences draws upon studies where individuals with specific personality traits, including higher anxiety sensitivity and hopelessness (i.e. depression), had a greater susceptibility towards hazardous drinking through using alcohol to cope (Baines, Jones, & Christiansen, 2016; Castellanos-Ryan & Conrod, 2012; Stewart, Zvolensky, & Eifert, 2001). Support for the role of motivation in predicting post-surgical alcohol misuse is also gathered from evidence supporting greater drinking to cope in individuals with a DSM-IV diagnosis of alcohol dependence compared to those without, even while controlling for depressive (i.e. negative) affect (Carpenter & Hasin, 1999). Overall, coping is one of the strongest predictors of hazardous drinking (Holahan, Moos, Holahan, Cronkite, & Randall, 2003; Kassel, Jackson, & Unrod, 2000; Kuntsche & Kuntsche, 2009), especially when an individual possesses fewer adaptive coping strategies (Merrill & Thomas, 2013). Nevertheless, while coping is a key motivator for both overeating (section 1.1.1.2.4.1) and alcohol use, there remains a paucity in the literature examining whether individual differences in personality factors (e.g.,

anxiety or depression) predispose individuals to common eating and drinking motives, and whether these pathways are used inter-changeably or exclusively (e.g., drinking to cope, but not eating to cope).

1.3.2. Applications of the theoretical negative reinforcement model of alcohol misuse within bariatric populations

1.3.2.1 Pre-surgery: Prevalence of affective disorders, distal risk factors and their impact on post-surgical alcohol misuse

With the alcohol literature highlighting the influence of negative affect on alcohol-related outcomes, applications of the negative reinforcement model of alcohol misuse to bariatric populations merits exploration. However, determining the prevalence of affective disorders in bariatric surgery candidates has inherent difficulties. Psychological evaluation is typically incorporated into the bariatric surgery approval process (Santry, Chin, Cagney, Alverdy, & Lauderdale, 2006), and upwards of 53% of bariatric surgery programs recognise the presence of current depressive symptoms as contraindicative (Bauchowitz et al., 2005). Of critical note is whether the psychological evaluation is independent of the approval process, and what patients understand about the impact their responses have upon their candidacy. Given the rigors of the approval process, Fabricatore et al (2007) proposed that bariatric surgery candidates may respond by engaging in 'impression management.' This involves exaggerating or suppressing psychological distress if they believe it will improve their chances of receiving the mental health professionals' approval for surgery. Indeed, a review by Malik et al (2014) attests that studies using an independent evaluation process reveal a higher prevalence of psychiatric disorders (Kalarchian et al., 2007; Mitchell et al., 2012; Mühlhans, Horbach, & de Zwaan,

2009), compared to when assessments are part of the pre-surgical evaluation process (Mauri et al., 2008; Rosenberger, Henderson, & Grilo, 2006), although differences in the disorders included in the assessment could explain this variation. Therefore, candidates engaging in impression management could downplay pre-existing psychological vulnerabilities if they view it as a barrier. This becomes particularly concerning if they previously ate to cope, as using alcohol could become an alternative coping strategy due to its post-surgical increased bioavailability, tolerability, and stimulatory effects on the reward system.

Motivational differences in pre-surgical disclosure notwithstanding, negative affect-related disorders appear uniquely prevalent in bariatric surgery candidates compared to other persons with obesity. A systematic review by Malik et al (2014) found that current and lifetime rates of psychiatric disorders are higher in bariatric surgery candidates relative to both non-treatment seeking persons with obesity and the general population, although true comparison remains difficult due to methodological differences, (e.g., psychopathology assessment instruments). Possible contributors could be weight-related, as obesity is positively associated with increased rates of depression (Onyike et al., 2003). Given that the weight criteria for bariatric surgery typically requires a BMI of 40 kg/m^2 or more, it follows that those seeking surgical treatment would be more likely to have higher degrees of psychopathology than those not meeting the criterion threshold. The foremost identified affective disorders in bariatric candidates include depression and anxiety (19% and 12%, respectively), as well as binge eating disorder (17%) (Dawes et al., 2016). As previously stated, whether the evaluation was independent of or integrated with the approval process for bariatric surgery could also impact upon results. Taken together, evidence supports that bariatric surgery candidates present a unique

psychological profile apart from other persons with obesity and the general population, which could represent a contributor to a negative reinforcement model of post-surgical alcohol misuse.

Applications of the proposed negative reinforcement model of alcohol misuse in bariatric patients could further incorporate related mental health considerations. Health-related quality of life is one example, as evidence drawn from the Short-Form Health Survey (SF-36; Ware et al., 1996) indicates that bariatric candidates typically have lower scores on most (or all) of the eight physical and mental sub-scales (*physical functioning, role functioning, bodily pain, general health, vitality, social functioning, role-emotional functioning and mental health*) (Schok et al., 2000). Therefore, seeking quality of life improvement could motivate electing for bariatric surgery. Evidence from a national survey of US adults also found that a significant decline in mental health was associated with the transition to alcohol dependence (Dawson, Li, Chou, & Grant, 2008), which bears implications for bariatric surgery patients with affective disorders or sub-clinical mental health problems. Indeed, the LABS-2 study found that less improvement in or worsening mental health was associated with higher risk for post-surgery AUD (King et al., 2017). More severe forms of psychopathology could also impact upon the risk for post-surgical alcohol misuse. One study found that nearly 10% of bariatric surgery candidates reported a lifetime history of a suicide attempt (Sansone, Wiederman, Schumacher, & Routsong-Weichers, 2008), which is greater than prevalence rates for UK adults (6.7%) (Mcmanus et al., 2016). This is relevant to post-surgical alcohol misuse, as although the connection between severe psychopathology (e.g., suicide idealisation or attempt) and alcohol outcomes in bariatric populations is under-explored, other (non-bariatric) literature reveals that nearly 40% of those seeking treatment for AUD

have at least one reported lifetime suicide attempt (Roy, 2003). In summary, related mental health considerations are implicated in the development of alcohol misuse in non-bariatric populations. These risk factors appear uniquely prevalent in bariatric patients, therefore meriting incorporation into applications of the theoretical negative reinforcement model of post-surgical alcohol misuse.

Though prevalence rates of pre-surgical affective disorders have been widely reported in bariatric surgery candidates, much less is known about their impact upon post-surgical alcohol misuse. As described, bariatric surgery candidates possess a particular psychological profile, with evidence supporting higher rates of affective disorders and some related mental health considerations relative to other persons with obesity or population norms. Drawing upon evidence from non-bariatric populations in section 1.3.1, the presence of an affective disorder (e.g., depression or anxiety) could be a factor increasing the risk for post-surgical alcohol misuse if it is not addressed. It is noteworthy that there is a dearth of studies examining the impact of pre-bariatric surgery affective disorders or distal psychological risk factors on post-surgical alcohol misuse or related SUD outcomes. Indeed, evidence from section 1.2.1.3 describes cohort studies finding that lower social support, and poorer coping skills are each associated with increased likelihood of reporting post-surgical alcohol misuse, AUD or SUD, although some of this evidence is retrospective (Ivezaj et al., 2014). Although one study identified that SG patients with a pre-surgical diagnosis of depression had a lowered risk for post-surgical AUD, authors note that patients possibly had more regular contact with mental health providers (Ibrahim et al., 2018). Therefore, research into the presence of negative affect and related psychological risk factors pre-surgery is a priority, as these have been positively associated with the development of alcohol misuse in non-bariatric studies.

1.3.2.2. Post-surgery: Changes in affective disorders and evidence for a 'transfer' in coping strategies from food to alcohol

In exploring the applications of a negative reinforcement model of post-surgical alcohol misuse in bariatric patients, related psychological risk factors from both pre and post-surgery should be considered. As well as necessitating physical changes, bariatric surgery impacts upon psychological aspects of patient's lives, and carries potential for changes in social, sexual, physical and food-related relationships (Coulman, MacKichan, Blazeby, & Owen-Smith, 2017). Generally, receiving bariatric surgery is associated with lower rates of depression, improvements in depression symptoms, and decreased use of antidepressants at 3 years post-surgery (Dawes et al., 2016). However, Burgmer and colleagues (2014) noted that a small subset of patients (18.5%) with less than 25% weight loss developed new depression symptoms. Similarly, while short-term reductions in anxiety symptoms were recorded within the SOS cohort 1 year after surgery, anxiety symptoms rebounded in the years following, and overall symptom improvement settled at 23% after 10 years (Karlsson, Taft, Rydén, Sjöström, & Sullivan, 2007). Altogether, bariatric surgery is associated with modest improvements in pre-surgical affective disorder symptoms, particularly depression and anxiety. Nevertheless, there are subsets of patients whose symptoms do not ameliorate or for whom new symptoms appear, which could lead to the increased use of alcohol as a coping mechanism to regulate negative affect.

Given that improvements in affective disorders and sub-clinical mental health problems are not uniformly observed, or worsen for some, this possibly constitutes a negative reinforcement model of post-surgical alcohol misuse. This follows from the evidence detailed in section 1.2.1.3, where less improvement or worsening mental health, poorer coping skills, and increased life stressors after surgery have been

independently positively associated with post-surgical alcohol misuse or AUD (Ivezaj et al., 2014; King et al., 2017). Possible contributors to worsening mental health or increased stress could be sub-optimal weight loss outcomes and reduced quality of life. While evidence is lacking to support an association between pre-surgical mental health and post-surgical weight loss, post-surgical weight loss has been associated with a reduction in prevalence, frequency and severity of depressive symptoms (Dawes et al., 2016). Although the authors note that causal relationships cannot be inferred, and other pathways may be implicated. Further, pre-surgical depression has been linked to having a poorer physical and mental quality of life, all of which improve with post-surgical weight loss (Dixon, Dixon, & O'Brien, 2003). Importantly, weight loss could improve self-image and interpersonal relationships, which could reduce the risk of alcohol misuse post-surgery through increasing quality of life. Overall, more research is needed on the inter-relationships between mental health (i.e. depression, anxiety), quality of life and post-surgical alcohol misuse. A reduced quality of life that does not improve with weight loss post-surgery could represent an additional contributor to affective disorders or could independently represent a stressor for which food is no longer available as a coping mechanism.

From the evidence detailed in section 1.2.1.2, pre-surgical alcohol use (i.e. heavy use or AUD) has been associated with an increased likelihood of reporting post-surgical alcohol misuse or AUD. However, this is coupled with evidence of new-onset alcohol misuse, which could represent an alternative behavioural strategy to regulate negative affect. Prior behaviours could include eating to cope through binge eating, as persons with obesity and binge eating disorder (BED) report greater psychopathology (e.g. affect-related disorders and substance use) than those without

BED (Specker, de Zwaan, Raymond, & Mitchell, 1994; Yanovski, Nelson, Dubbert, & Spitzer, 1993). While this is not unilaterally observed in bariatric candidates (de Zwaan et al., 2003; Hsu et al., 2002), a study by Jones-Corneille et al (2012) found that BED was associated with in increased prevalence of depression, anxiety and lower self-esteem beyond the elevated rate already associated with severe obesity. As outlined in section 1.3.1, negative affective traits and disorders impact upon motivation to drink alcohol and negative alcohol-related outcomes. Therefore, examining whether alcohol misuse and overeating related pathology co-occur could yield further insight about whether a 'switch' in coping mechanisms occurs for patients with new onset post-surgical alcohol misuse.

If appropriate coping strategies are not learned or employed following bariatric surgery, it follows that emotional eating would persist for those who previously ate to cope if surgical restriction permits. As described in section 1.2.1.1, it is well evidenced that RYGB is associated with an increased risk for post-surgical alcohol misuse. Hence, the ability to perpetuate either binge or emotional eating could be impacted by the type of surgery a patient receives, as RYGB creates both restriction and mal-absorption, while AGB and SG rely more upon restriction. This bears importance because a small percentage of individuals (24%) with AGB report being able to continue pre-surgical binge eating patterns or disinhibited eating (Lang, Hauser, Buddeberg, & Klaghofer, 2002; Wilkinson, Rowe, Sheldon, Johnson, & Brunstrom, 2017), in addition to more feelings of hunger and poorer excess weight loss (Himpens, Dapri, & Cadière, 2006). This evidence suggests that the ability to maintain problematic or overeating behaviours could be more accessible for AGB patients compared to RYGB, potentially negating the need to seek alternative coping strategies for negative affect, such as drinking alcohol. Also, these pre-surgical

behaviours could manifest differently with a new surgical restriction to overcome. It has been noted that patients who report pre-surgical binge eating could be similarly inclined towards post-surgical 'grazing' patterns considering restriction (Colles, Dixon, & O'Brien, 2008a; Conceição, Mitchell, Pinto-Bastos, et al., 2017). In effect, patients who can cope with negative affect through continuing or adapting their eating behaviour may be less likely to develop post-surgical alcohol misuse, although evidence supporting this connection is lacking.

One such adapted eating behaviour that could represent a post-surgical coping mechanism is grazing; an eating pattern characterised by repetitively eating small amounts of food outside of hunger or satiety signals, linked with reduced weight loss in obese patients (Conceição et al., 2013, 2014). Conceição and colleagues (2014; 2015) offered that there are two behavioural subtypes; 1) compulsive grazing, where an individual reports not being able to resist eating, and 2) non-compulsive grazing in a distracted or mindless manner. Evidence indicates that grazing symptoms may be present together with binge eating (Busetto et al., 2005; Colles et al., 2008; Goodpaster et al., 2016) and are associated with negative affect, depression and lower mental health (Colles et al., 2008; Poole et al., 2005). Likewise, patients who engaged in pre and post-surgical grazing reported eating in response to emotional distress from negative moods (Colles et al., 2008). Therefore, both the presence of negative affect and the motivation to use food as a coping strategy are implicated in the development of post-surgical grazing behaviour. It has been theoretically proposed that when eating to cope (or grazing) is not viable due to surgery-induced limitations on eating behaviours, post-surgical alcohol misuse could subsequently develop as an alternative coping strategy to regulate negative emotions (Hardman & Christiansen, 2018; Steffen et al., 2015; Yoder, MacNeela, Conway, & Heary, 2018).

One limitation is that the surgical mechanisms preventing engaging in grazing and, by association, eating as a coping mechanism have not been fully elucidated. However, some instances where post-surgical grazing may not be available could be attributed to 'dumping syndrome.'

As described in section 1.1.4, 'dumping syndrome' is triggered post-surgery by eating, especially high fat or high-sugar foods (Tack et al., 2009). Dumping syndrome is predominantly reported in RYGB patients, and it is estimated that more than 40% have symptoms (Banerjee, Ding, Mikami, & Needleman, 2013). At the surface level, this appears related to the connection between RYGB and the increased risk for post-surgical alcohol misuse. A similar prevalence (up to 40%) has also been observed for SG (Papamargaritis et al., 2012), which is also preliminarily linked to a similar risk for post-surgical AUD (Ibrahim et al., 2018). Although the impact of dumping syndrome on grazing behaviour remains under-examined, it has been suggested that the food aversion produced by dumping syndrome promotes weight loss. Notably, a prospective study by Banerjee et al (2013) found no relationship between post-RYGB weight loss and dumping syndrome. Further, no differences were observed in emotional eating scores between patients with dumping syndrome, and those without, and no relationship was found between emotional eating and weight loss. One limitation in translating these results to alcohol use is that the final assessment was given at 2 years post-surgery, where problems with alcohol typically appear (King et al 2012; 2017). This speaks to the need for more research on the role of psychological vulnerabilities and their impact on post-surgical emotional eating patterns, such as grazing (Conason, 2014). The present thesis seeks to contribute by examining the role of psychological vulnerabilities on both post-surgical eating to

cope and drinking to cope motivations, in addition to their behavioural correlates of grazing and alcohol consumption.

1.3.3 Qualitative evidence points to the role of negative reinforcement in post-surgical alcohol misuse

Although prospective cohort studies comprise much of the evidence base examining increases in alcohol misuse and AUD following bariatric surgery, qualitative evidence lends unique insight into the role of negative reinforcement. One study by Ivezaj and colleagues (2012) interviewed 24 post-bariatric surgery patients in an inpatient treatment program for SUD (AUD inclusive) and four themes emerged regarding the aetiology of post-surgical substance misuse; 1) 'unresolved psychological problems,' 2) 'addiction transfer/ substitution,' 3) faster onset or stronger effects from substances and 4) increased availability of pain medications. Pertaining to alcohol use, section 1.2.2.1 addresses the faster onset and heightened effects of alcohol, while pointing out that this does not fully account for the increase in post-surgical alcohol misuse as pharmacokinetic changes occur in varying degrees for most (if not all) bariatric surgery patients. Additionally, given the recent popularisation of 'food addiction' (Lee et al., 2013), it follows that this phrase may function as an availability heuristic for persons with obesity. Section 1.2.2.4 comprehensively reviews the evidence surrounding 'addiction transference' and proposes that the increase in post-surgical alcohol misuse is more indicative of a substitute coping behaviour. Indeed, the theme 'unresolved psychological problems' maps onto the theoretical model described in section 1.3.1, where negative reinforcement mechanisms (e.g., affect and motivation) are implicated in alcohol misuse in non-bariatric populations.

Similarly, ‘unresolved psychological problems’ arose in another qualitative study by Yoder and colleagues (2018) with eight patients who received surgery between 3-12 years prior, and subsequently experienced AUD. Using a constructivist grounded theory, researchers proposed an explanatory model of ‘filling the void’ for the development of AUD after surgery. Similar to findings from Ivezaj et al (2012), a key feature of their model includes accounts of ‘unresolved psychological issues,’ wherein participants disclosed adverse events that led to difficulties in emotion regulation and eating as a coping strategy before surgery. Although a ‘honeymoon period’ marked by rapid weight loss, elevated mood and other positive outcomes was experienced for nearly 2 years following surgery, the need for an external coping mechanism eventually re-emerged. Alcohol represented a substitute coping strategy when eating to cope was no longer accessible due to physical restrictions brought on by surgery. ‘Filling the void’ describes how participants contend with symptoms of unresolved psychological issues, where drinking alcohol functions as substitute behaviour for eating. Importantly, the participants were exclusively those who had problems with alcohol. A comparison group of patients who have not experienced similar problematic alcohol use following surgery is therefore lacking, which could reveal additional insight regarding what differentiates those that misuse alcohol after surgery from those that do not.

1.4 The present thesis

Obesity has complex biopsychosocial aetiology, for which bariatric surgery is a recommended physiological treatment option. However, this carries an increased risk of alcohol misuse for a subset of patients. While some demographic and theoretically relevant contributors have been identified, there is a lack of research into psychological motivators, which represent risk factors in other populations. Although

psychosocial contributors are identified in the qualitative bariatric literature, findings do not meaningfully compare patients with post-surgical alcohol misuse to other patients. Psychological motivators for alcohol misuse post-surgery similarly remain under-examined in quantitative bariatric studies; particularly affective disorders (i.e. anxiety and depression), but also quality of life or more severe psychopathology. Correspondingly, there is a dearth of research into the relationship between pre-surgical emotional eating, grazing and alcohol misuse. This is critical to elucidate given the substantial evidence suggesting a negative reinforcement model of alcohol misuse, wherein common personality traits and affective disorders that pre-dispose some individuals to developing obesity could also predict the development of alcohol misuse through their relationship to coping. However, the separate nature of these motivations and behaviours is not fully understood in community samples, nor have these been examined in a post-bariatric surgery population. This is merited, as whether these pathways are used inter-changeably or exclusively (e.g., drinking to cope, but not also eating to cope) has implications for patients that can maintain negative affect-related coping strategies by grazing, as they may be less likely to 'switch' to alcohol as a method of affect regulation (Hardman & Christiansen, 2018). Therefore, the above points name clear priorities for research, and the current thesis is designed to address these gaps in the literature using a mixed-methods approach.

Aim 1: To develop a model of problematic alcohol use and eating, mediated by coping (Chapters 2-3)

Chapter 2

The first aim of the thesis was addressed in Chapter 2, where a qualitative study was conducted to explore motivators of problematic alcohol use after bariatric

surgery and thereby inform a model of post-surgery problematic alcohol use. To achieve this, participants were interviewed about their experiences before and after surgery, which were analysed thematically by examining their alcohol use. Thus, Chapter 2 describes core themes between both participants with and without problematic alcohol use, including which factors may contribute or be protective. Further, Chapter 2 highlights drinking to cope as a critical motivation behind problematic alcohol use post-surgery and offers that this strategy could occur as substitute behaviour from eating.

Chapter 3

Findings from Chapter 2 were used to inform a model of distinct negative reinforcement mechanisms associated with alcohol misuse and unhealthy snacking in a group of undergraduates, online weight-related research volunteers and community members. Critically, this included drinking to cope as a mediator between hopelessness (i.e. hopelessness), anxiety sensitivity and drinking. It was predicted that the relationship between anxiety sensitivity, hopelessness and hazardous drinking would be mediated by a 'drinking to cope' motivation, not 'enhancement'. Further, it was predicted that the relationship between anxiety sensitivity, hopelessness and unhealthy snacking would be motivated by eating to cope, not enhancement. Further, the model evidences whether eating and drinking to cope represent separate coping strategies.

Aim 2: To gather empirical support for the model in a bariatric population and assess its application to post-surgical alcohol misuse (Chapters 4-6).

Building upon the evidence for drinking to cope with negative affect as the pathway to post-surgical alcohol misuse (section 1.3), a second aim of the thesis was

to gather empirical support for a negative reinforcement model of post-surgical alcohol misuse. This was theoretically supported by evidence from Chapters 4 and 5 and applied in Chapter 6.

Chapter 4

Chapter 4 was a secondary data analysis that constructed two models to explore the role of demographic, psychological and behavioural predictors of hazardous drinking 6 months following bariatric surgery. The first model examined pre-surgical factors that increased the likelihood of hazardous drinking. Importantly, the second model examined the impact of changes in pre-surgical factors and their relationship to the increased likelihood of hazardous drinking.

Chapter 5

Chapter 5 was a secondary data analysis designed to expand upon Chapter 4 by examining the role of demographic, psychological and behavioural predictors of alcohol problems up to 10 years after bariatric surgery. Importantly, Chapter 5 also assesses the role of grazing to explore the possibility of post-surgical alcohol misuse representing a substitute coping mechanism from food pre-surgery to 'fill the void' (Hardman & Christiansen, 2018; Yoder et al., 2018). The study constructed three models; the first model explored the role of pre-surgical factors, the second model examined post-surgical factors, and the third model explored the possibility for a 'transfer' in coping strategies by comparing the presence of pre-surgical emotional eating and/or post-surgical negative events on the increased likelihood of post-surgical alcohol problems.

Chapter 6

Drawing upon findings from Chapters 2, 4 and 5, Chapter 6 aimed to apply the negative reinforcement model of alcohol misuse from Chapter 3 in a post-bariatric surgery population. It was predicted that the relationship between anxiety sensitivity, hopelessness and hazardous drinking would be mediated by drinking to cope, and the same would be true for anxiety sensitivity, hopelessness, grazing and eating to cope. Further, using evidence from Chapters 3 and 5, it was predicted that eating and drinking to cope would be separate coping strategies.

In conclusion, the present thesis addressed two critical aims: 1) to develop a model of problematic drinking and eating, mediated by coping, and 2) to gather empirical support for the model in a bariatric population and assess its application to post-surgical alcohol misuse. Review Figure 1.4 for an overview of the thesis' structure, aims and associated chapters.

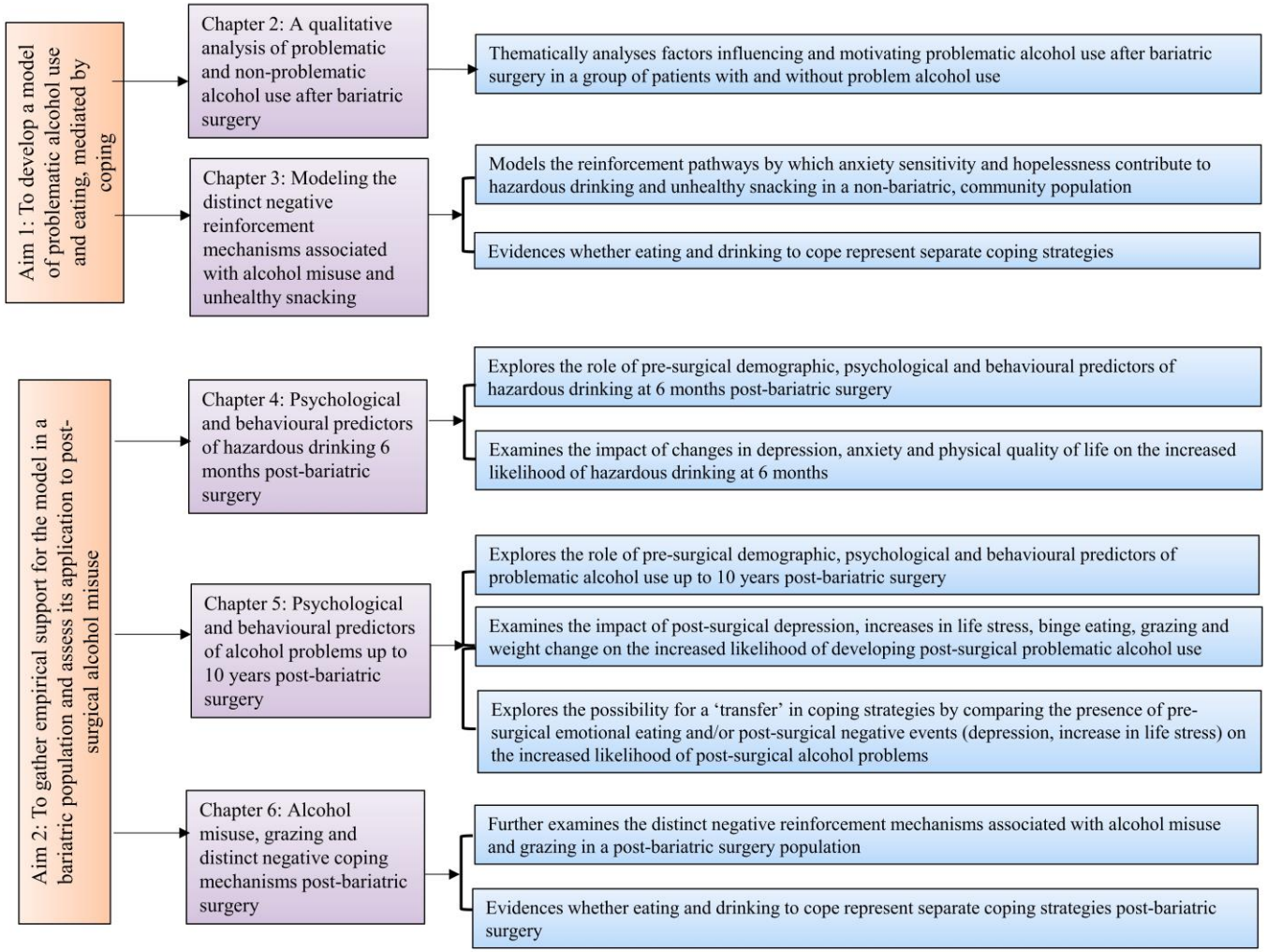

Figure 1.4. An overview of the thesis. Thesis aims are presented in orange boxes on the far left, chapter headings are depicted in the middle purple boxes, and chapter objectives are in the blue boxes.

Chapter 2: A qualitative analysis of problematic and non-problematic alcohol use after bariatric surgery

A version of the study reported in this chapter has been published as

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2.1 Abstract

Bariatric surgery is an effective weight loss tool, but an under-communicated side effect may include the increased risk for alcohol problems. Few studies have examined contributors towards alcohol problems following surgery using a qualitative approach. Therefore, the current study aimed to generate insight informed by participants with problematic alcohol use following bariatric surgery, in comparison to participants without. Participants (14; females, $N = 9$; males, $N = 5$) completed semi-structured interviews using questions relating to alcohol use, relationship to food, support and surgical experiences. Thematic analysis was conducted to provide insight into the factors which influenced drinking behaviours that participants engaged in following bariatric surgery, and motivations for drinking or limiting alcohol. Five core themes were identified between both participants with and without problematic alcohol use: 1) Drinking Motivations, 2) Self Image, 3) Impact of Restriction on Eating Behaviour, 4) Support Needs and 5) Surgical Preparedness. A sixth core theme ('Resilience') was identified specifically amongst participants without problematic alcohol use. Divergent experiences, cognitions and behaviours formed sub-themes within the five core themes and highlighted the differences between participants with and without problematic alcohol use within the core themes. This study is the first to qualitatively assess themes relating to the

development of problematic alcohol use after bariatric surgery while additionally using a comparison group without problematic alcohol use. The findings highlight key features which contribute to problematic alcohol use, as well as experiences and cognitions that may be helpful in preventing this phenomenon in bariatric populations.

2.2 Introduction

Identifying contributors to alcohol-related outcomes following surgery is critical to understanding psychological motivators of alcohol misuse. In general, bariatric candidates with known/suspected psychiatric illness, substance misuse or dependence are advised to eliminate alcohol after surgery to reduce the risk of alcohol misuse (Mechanick et al., 2013). While there remains a paucity of research examining to what extent patients follow this advice, alcohol misuse tends to manifest around 24 months post-surgery, and persists further onwards (Conason et al., 2013; King et al., 2012; Svensson et al., 2013). While some of these cases represent continued heavy drinking patterns from before surgery, there are also 'new onset' instances, where alcohol misuse is not observed until after surgery (Spadola et al., 2015). Evidence also indicates that some patients with 'high risk' drinking before surgery subsequently discontinue (Lent et al., 2013; Wee et al., 2014). While some theoretical causes of differing alcohol-related outcomes have been proposed (e.g., pharmacokinetic changes; Hagedorn et al., 2007), physiological changes are unlikely to increase alcohol use in isolation, as they are experienced by most individuals while only a (sizable) minority develop patterns of alcohol misuse.

Differing alcohol use may be the product of subtle underlying motivational processes that increase alcohol use when surgery-induced restriction disrupts usual

eating patterns. Coping is one of several identified motivations for eating foods with a high hedonic value (high-fat, sugar or calorie-dense foods) alongside social, conformity and sensation seeking. Eating to cope represents a behavioural response to mitigate negative states or circumstances, such as to forget about worries (i.e. negative reinforcement; Burgess, Turan, Lokken, Morse, & Boggiano, 2014). Interestingly, eating to cope is associated with a higher BMI, even while controlling for similar constructs like addictive-like eating or binge eating (Boggiano et al., 2015; Burgess et al., 2014). Critically, motivations to drink alcohol share characteristics with those driving hedonic eating (Burgess et al., 2014), and drinking to cope predicts alcohol consumption after a stressor when an individual has fewer adaptive coping strategies (Merrill & Thomas, 2013). Further, increasing alcohol use through drinking to cope has been observed in populations with specific personality traits or qualities, including higher anxiety, hopelessness and depression (Baines, Jones, & Christiansen, 2016; Holahan, Moos, Holahan, Cronkite, & Randall, 2003). These or related traits have similarly been named as risk factors towards emotional eating in obese individuals (Elfhag & Morey, 2008; Schneider, Appelhans, Whited, Oleski, & Pagoto, 2010). Therefore, psychologically pre-disposed individuals who engaged in eating to cope prior to bariatric surgery could be more likely to use alcohol as a substitute coping mechanism if other self-regulatory measures are not learned or employed.

Beyond drinking to cope, motivations to drink alcohol post-surgery may also shift according to changes in self-esteem and socialisation. Bariatric surgery changes multiple aspects of patients' lives, including psychological health, social ties, sexual lives, body image, eating behaviour and relationship with food (Coulman et al., 2017). Therefore, changes in alcohol use, including alcohol misuse, may also be

anticipated. Understanding the motivations driving alcohol misuse after surgery could also inform clinical interventions aiming to reduce these incidents, however studies using patient voice and insight are rare. Although few studies have employed qualitative approaches to understanding post-surgical alcohol misuse, the extant literature is nonetheless informative. One study identified several contributors to post-surgical substance misuse, including 'unresolved psychological problems' and 'addiction transference' (Ivezaj et al., 2012). Building upon this, Yoder and colleagues (2018) developed a theory using interviews from post-bariatric surgery patients with AUD specifically. Researchers constructed a 'filling the void' model, where patients' previous food-related coping strategies and unresolved psychological issues motivated the development of post-surgical AUD. Importantly, a comparison group of patients is lacking in these qualitative studies, which could reveal additional insight into key factors that differentiate participants with problematic alcohol use from those without in the post-surgery period. Therefore, the present study aimed to interview both individuals who do and do not have problematic alcohol use or misuse post-surgery to understand which factors influence the development of post-surgical alcohol misuse.

2.3 Method

2.3.1 Participants.

Fourteen participants completed an interview either in person (N = 6) or over the telephone for convenience (N = 8; see Table 2.1). Problematic alcohol use classifications were assigned using responses to interview questions. If a participant described drinking at hazardous levels, being advised by a medical professional to reduce their drinking, difficulty with controlling their intake, seeking assistance or

support to reduce their drinking, and/or expressed concern or guilt that alcohol had a prominent role in their lives and had not made efforts to discontinue or reduce their drinking, then their drinking was classified as 'problematic alcohol use' (PAU). At the time of the interview, four of the six participants with PAU had discontinued or modified their drinking habits independently or otherwise sought help through a general practitioner (GP), mental health or community service. Participants without problematic alcohol use were classified as 'non-problematic alcohol use' (NPAU). All participants were given a pseudonym, and identifiable details were omitted from the transcript.

Table 2.1. Participant characteristics for participants with (N = 6) and without problematic alcohol use (N = 8). Values are counts (gender, surgery type), means, 95% confidence intervals (CI), and effect size values for between group differences.

	With Problematic Alcohol Use	Without Problematic Alcohol Use	Effect size	95% CI (UL, LL)
Gender (female/male)	4/2	5/3	.04[b]	--
Surgery Type			.35[c]	--
Roux en Y Gastric Bypass	5	5	--	--
Sleeve Gastrectomy	--	1	--	--
Other	1	2	--	--
Age (y)	51.83	43.13	1.08[a]	(2.21, .05)
Years Since Surgery	8.83	5.06	.91[a]	(2.07, .20)
Current Weight (Kg)	105.79	98.06	.27[a]	(1.34, .79)
Post-Surgery Weight Loss (Kg)	47.09	56.25	.49[a]	(.58, 1.57)

Effect size values were calculated using [a]Cohen's d, [b]Phi (Φ) for nominal data, and [c]Cramer's V (φ_c) for nominal data with multiple categories. There was no effect (Φ = .04)

for gender between participants with PAU and NPAU. However, there was a medium effect (φ_c = .35) for surgery type, large (d = 1.08) for age, large (d = .91) for years since surgery, small (d = .27) for current weight, and medium (d = .49) for post-surgery weight loss. Therefore, all factors except gender held meaningful between-group differences for participants in this study, with participants with NPAU having a surgery type other than Roux en Y gastric bypass, being younger on average, having fewer years since surgery, lower current weight and greater post-surgery weight loss. However, due to small sample sizes any differences should be treated with caution.

2.3.2 Procedure

Ethical approval was obtained from the university research ethics committee. Participants were identified through advertising on a social media platform for bariatric support groups. After confirming interest, an initial telephone screening procedure was used to ensure all participants met the study criteria of 1) being 18 years or older, 2) receiving bariatric surgery at least 18 months prior as alcohol misuse tends to appear around this timepoint (Conason et al., 2013; King et al., 2012), 3) not being pregnant/breastfeeding, and 4) not having disclosed unmet mental health needs. Upon receiving informed consent, semi-structured interviews were conducted with participants using an interview schedule to guide the conversation (see Table 2.2). The open-ended and exploratory interview questions were developed by the research team and were informed by their expertise in qualitative research, eating behaviour and substance misuse. Following a literature review, specific question items were included to invite participants to reflect on their relationship with alcohol before and after surgery, with additional questions targeting possible triggers for problematic alcohol use (e.g., unmet expectations, life events) based on previous studies (Ivezaj et al., 2014; King et al., 2012; Kubik et al., 2013).

The in-person interviews took place in a familiar setting; including the participant's home, community location, or the university. Interviews were audio recorded, lasted approximately one hour, and all participants were offered £20 gift cards as compensation for their time and contribution to the study. Audio interviews were transcribed verbatim, anonymised, and imported into the qualitative data analysis software package NVivo10 (NVivo Qualitative Data Analysis Software, 2012). After each interview, participants were debriefed and invited to contact the principal investigator with additional concerns or questions regarding the study.

Table 2.2. Interview schedule for the present study, italicised questions are prompts to encourage further discussion.

1.	Demographic information *Age, Relationship status, Type of bariatric surgery received and when, Current weight, Weight loss since surgery*
2.	How would you describe your relationship to food (or 'eating style') before surgery? Has this changed now that you've had bariatric surgery? *How so?*
3.	Before your bariatric procedure, did you drink alcohol? *If yes – How often per week? How would you describe your pre-surgery relationship with alcohol?* *If no – Why not?*
4.	What were your expectations towards the results of your bariatric surgery? *Lose a specific amount of weight, feel a certain way, changes in areas of your life?* *Do you think your results have met those expectations?*
5.	Did you experience any difficulties adjusting to new habits or routines after your bariatric surgery? *If yes – What were some of those difficulties? Do you feel that you have overcome them? What helped you overcome them?* *If no – What made your adjustment go well?*
6.	Were there any major life events that occurred prior to your surgery, or afterwards, that you felt impacted your recovery and adjustment post-surgery? *If yes – What were they?*
7.	Have you drank alcohol since you have had weight loss surgery? *If yes – Does it affect you differently now than before the surgery? How would you describe your relationship with alcohol at present?* *If no – What are your reasons for not drinking alcohol?*
8.	Are you happy with the results of your surgery – would you, given the chance, do it all over again, knowing what you know now? *If yes – What factors influenced your answer?* *If no – What would you have done differently?*
9.	If you could give advice to someone considering bariatric surgery, what would you want to say to them? *What advice would you have for the clinical care team?*

2.3.3 Thematic Analysis.

The thematic analysis used in this study was informed by the inductive method described by Braun and Clarke (2006). First, transcripts were read iteratively to generate ideas through data immersion. Second, initial codes were systematically generated within and across the full dataset. The third and fourth phases of analysis involved collecting the codes (and relevant data) into potential themes, and reviewing themes for overlapping/dissimilar content, and further refining through separating or grouping themes between transcripts. This process generated a thematic 'map' of the analysis and ensured clear thematic distinction. The final themes were checked against the coded extracts and the full dataset. Once key themes had been identified, the final stage included defining which data qualities each theme captured, and a detailed analysis was written to describe the theme, including relevant sub-themes. To verify validity and reliability, a second author (Charlotte Hardman) coded a subset of the transcripts and compared overall agreement. The target level of 80% agreement was reached (K = .80) and discrepancies were resolved on a case-by-case basis until reaching full agreement (K = 1.00). A third author (Joanne Dickson) with expertise in qualitative methods reviewed the final thematic map and analysis.

2.4 Results

Participants provided insightful, descriptive accounts of their experiences before and after bariatric surgery. Five core themes were identified in both the participants with PAU and with NPAU, with a sixth core theme ('Resilience') identified specifically in participants with NPAU. Sub-themes within each major theme are further detailed and depicted in Figure 2.1.

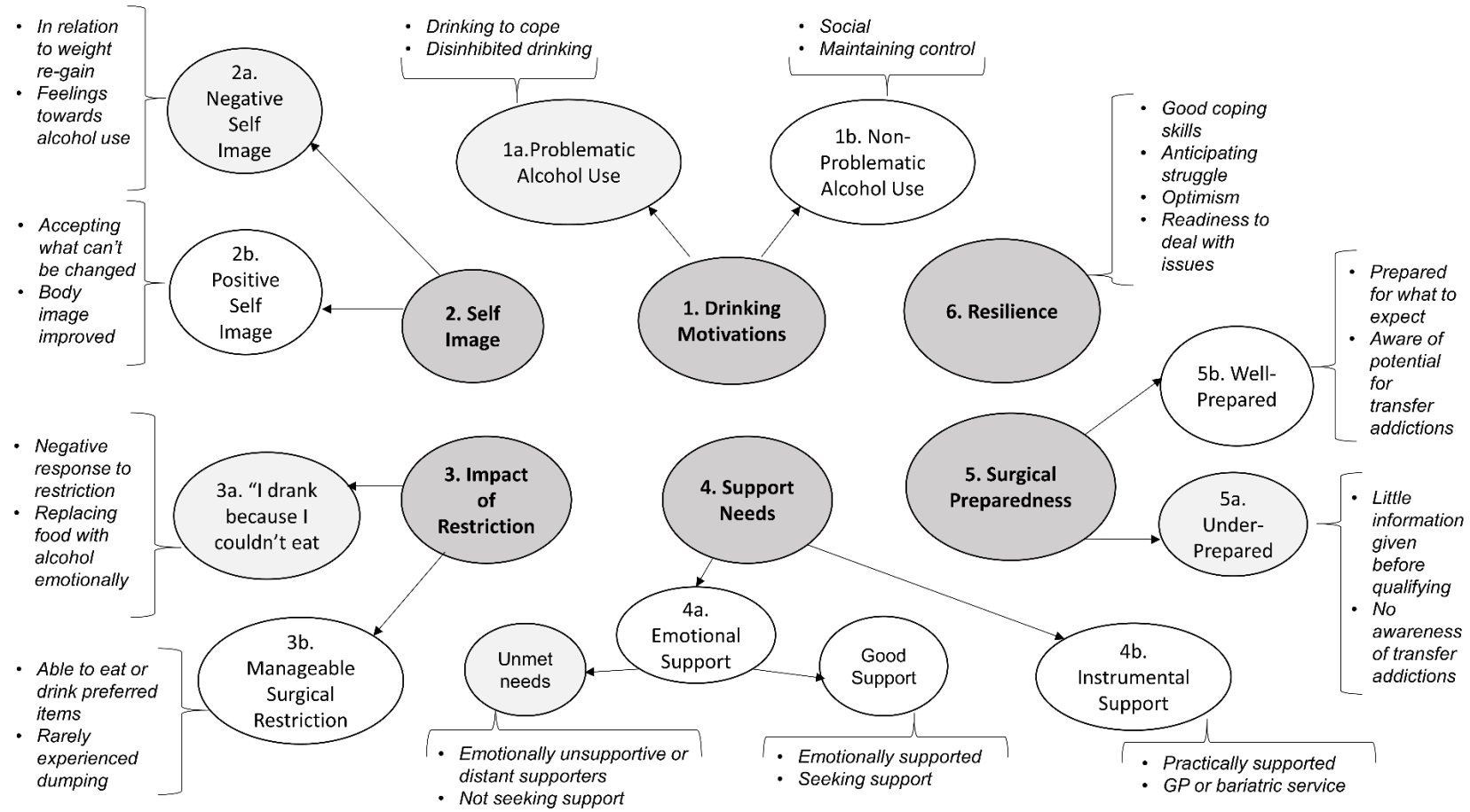

Figure 2.1. Themes and sub-themes assigned for participants with [PAU] and with non-problematic alcohol use [NPAU]. Themes are numbered and in bold, sub-themes are numbered and in non-italics, and codes are bullet-pointed and italicised. Sub-themes belonging to PAU are in light greyscale, and those for NPAU have no colour.

Theme 1: Drinking Motivations.

Drinking was often influenced by external factors such as negative life events or social occasions, with key differences appearing in motivations and behaviours between PAU and NPAU groups. While participants with PAU expressed drinking alcohol to cope with negative affect, surgical restriction, transferring their coping habits onto alcohol from food, and feelings of disinhibition, participants with NPAU endorsed social motivations or described strategies for maintaining control over drinking.

1a. Problematic Alcohol Use: Coping and Disinhibition

Overall, drinking to cope was a core motivation driving problematic alcohol use post-surgery, which had either been a habit continued from pre-surgery (two of the six participants with PAU) or had newly onset following surgery. For participants with PAU, drinking alcohol functioned as a coping mechanism to regulate negative affect, "*... the worst times [were] when I was using it as a coping strategy*" [Sandy, PAU]. In other narratives, this appeared to be a 'transfer' from previously food-oriented coping strategies before surgery to alcohol. One participant offered "*it's either there because I need a reward or ... because I need some comfort. I think maybe the feelings that I had with food goes into that glass of wine*" [Jane, PAU]. Disinhibition over drinking was another motivation, with several participants describing feeling intoxicated quickly once they began drinking, which led to feeling less able to control their intake or set limits for themselves after their drinking had started, which led to drinking more than anticipated, *"once I start drinking, if I have one or two drinks I lose the ability to not have any more"* [Sandy, PAU].

1b. Non-Problematic Alcohol Use: Social and Maintaining Control

Social drinking was endorsed by all but one participant and maintaining control over alcohol use appeared specifically within participants with NPAU. For participants who were socially-motivated like Jennifer [NPAU], spending time with people was the key motivator, "*…the focus wasn't on the drinking, it was on the meeting people and talking*." Also, many participants also felt as though drinking was not required in every social circumstance, and occasionally abstained from alcohol. Maintaining control was evident where four participants recognised the possibility of falling into a pattern of using alcohol to cope and explained their strategies for reducing their drinking when they felt vulnerable, including avoiding alcohol altogether. Bridget [NPAU] gave an example of avoiding alcohol when she felt upset, "*I was like '… what if alcohol becomes a problem' because I used to use food to control my emotions…and actually I haven't drunk since."* Altogether, some participants with NPAU indicated an awareness that drinking to cope was possible and kept their drinking mostly socially occasioned.

Theme 2: Self-Image.

The second theme associated with problematic alcohol use is drawn from the thoughts and feelings participants had about their outward appearances, internal dialogues and beliefs, conceptualised as a negative or a positive self-image. Participants with PAU endorsed more negative self-images, which stemmed from their alcohol use and body image. Participants with NPAU, on the other hand, endorsed more positive self-images, improvements in body image and self-acceptance.

2a. Negative Self-Image

For some participants with PAU, a negative self-image appeared connected to feeling disappointed about their problematic relationship with alcohol after surgery, and its consequences upon weight re-gain. Weight re-gain was a source of shame or frustration for half of the participants with PAU, and often led to negative feelings and self-consciousness. When looking at a photograph, Walter [PAU] described, "*…we're all post-surgery, but I felt I was the worst... thinking about it, I probably wasn't. Maybe I need to adjust that*." A couple of the transcripts revealed that not only did this negative self-image affect them personally, but also contributed to a less forgiving attitude towards others who have re-gained weight after surgery, although this was similarly observed in three of the interviews from participants with non-problem alcohol use. Nonetheless, there were instances of participants with PAU speaking positively about their surgical results or re-framing weight re-gain as acceptable. Taken together, negative self-image occurred in PAU narratives regarding drinking behaviours and related consequences, but also seemed continued from experiencing weight stigma before surgery.

2b. Positive Self-Image

Participants without problematic alcohol use drew their positive self-images from receiving encouragement from other patients, and positive feelings towards or acceptance of surgical results. Patrick [NPAU] articulated; "*… the dietician would say it hasn't been a total success because I haven't lost 100% of my excess weight… I would think the surgeons would be quite happy because I've lost over 25% of my body weight… and therefore, from their point of view, it's undoubtedly a success. And I'm very much in that camp…*"" Further, being treated like 'a normal person'

was cited by a couple of the participants with NPAU, which contributed to self-image improvements. This desire to be treated 'normally' was expressed by all participants and may have stemmed from internalising stigmatisation that many persons with obesity endure before surgery. Despite a few instances where participants with NPAU could be self-critical, generally they appeared optimistic that they could make positive changes through their own effort, or had access to help from outside sources, such as cosmetic surgery.

Theme 3: Impact of Restriction on Eating Behaviour.

Another contributor to problematic alcohol use was the impact of surgically imposed restriction on eating behaviour. All but one of the participants with PAU cited the inability to eat as underpinning drinking alcohol problematically, while most of the participants with NPAU reflected that their surgical restriction was more manageable, including being able to eat 'bad' foods and struggling to limit their emotional eating.

3a. "I drank because I couldn't eat"

Most participants with PAU described the impact restriction had upon their ability to eat foods that they would have previously used to comfort themselves, or commonly eaten foods (e.g., rice). Alcohol, on the other hand, did not pose the same pitfalls that over-indulging in these foods did, "*... I could eat a sweetie bar and be crippled over with pain [laughs], but I could drink a bottle of wine and be absolutely fine*" [Sandy, PAU]. In social eating circumstances, having small portions of less desired foods detracted from the pleasurable quality of the experience. Drinking, however, offered a solution to engage and find satisfaction, 'filling the gap' that having fewer food options left in their lives. "… *drinking became something you*

could do because it wasn't eating…I had a relationship with food that wasn't simple, and it was changed, and I wanted something to fill it" [Walter, PAU]. Not being able to eat as much, or the same foods, could foster a negative emotional response to the restriction that surgery imposed on participants with PAU.

3b. Manageable Surgical Restriction

Although participants with NPAU also experienced surgical restriction and 'dumping' (a reaction to foods high in sugar/carbohydrates comprised of nausea, sweating, fatigue and diarrhoea symptoms), nearly all described it as manageable. Two participants described finding ways around the restriction, including choosing specific foods less likely to cause dumping-related symptoms. Ben [NPAU] found himself still able to emotionally eat after surgery, which was something he made efforts to discontinue "*... and [I] stopped it, and I got back to my lowest weight. Definitely, looking back, I was on the track to go back to where I was*." Feeling deprived of the positive emotional experiences associated with food was a major difference between participants with PAU and NPAU. Participants with NPAU largely remained able to enjoy rewarding foods, even if they had to choose wisely or alter the amounts they could eat.

Theme 4: Support Needs.

Both participants with PAU and NPAU described having sources of support, including a partner, family members, communities or medical teams. Whether those structures offered the support that participants needed appeared to be a contributing factor towards problematic alcohol use. Participants with PAU tended to have unmet emotional support needs, while many participants with NPAU described seeking

sources of emotional support and receiving support as being essential throughout the surgical pathway.

4a. Emotional Support

All participants with PAU had supportive people in their lives, but the level of emotional support they received when their relationship to alcohol was problematic appeared inconsistent, insufficient or absent. Although many described their supporters as instrumentally helpful with food preparation or surgery recovery, emotional support needs continued - at times because they did not seek support when they were having difficulty coping "*…I felt awful keeping it from [family member]"* [Martha, PAU]. In other instances, participants with PAU felt unable to share their emotional experience with their supporters, which may have left them with unmet needs to be filled by alcohol. A few participants with NPAU described their supporters cheering them on or keeping their spirits up during difficult times; "*I think you're really lucky to find the right person… even when things are really tough, sitting there and having a giggle over things, because it's the way you get through*." [Jennifer, NPAU]. Relationships also changed for some participants after surgery, possibly to find more emotionally supportive partners. Seeking emotional support throughout the surgical experience was prominent within the narratives, and often participants with PAU began to address their relationship with alcohol after seeking emotional support.

4b. Instrumental Support

Both participants with PAU and NPAU alike had mixed experiences with instrumental support from their medical teams, including bariatric surgeons, dieticians and GPs. Many participants in both groups disliked the time-limited nature

of bariatric pathway support provision, "*Once those two years are up that's it, you know, they kind of cut the ties…"* [Martha, PAU]. Other participants had a positive experience, and some acknowledged that it felt like a lottery that they happened to be on the winning side of; "*[Surgeon]… his team is absolutely amazing, you can call them up for advice… I think should be mandatory for every place*." [Kristen, NPAU]. While there was a distinctive difference between the levels of emotional support participants received after surgery, instrumental support varied within both groups. Instrumental support was also received from closest people, and areas for assistance included food preparation and surgery recovery.

Theme 5: Surgical Preparedness.

Preparedness for the realities following bariatric surgery involved having sufficient information to help transition into a different lifestyle to accommodate restriction and being prepared for weight loss. Feeling under-prepared was a possible contributor towards problematic alcohol use, as many described not receiving enough information at their pre-surgical appointments or having any awareness of the possibility for 'addiction transference' to alcohol. Five in the NPAU group, however, felt they had prepared well for surgery through support group attendance, personal research or having a good experience in their bariatric service.

5a. Under-Prepared

Four individuals in the PAU group described not having enough information prior to bariatric surgery, leaving doubts regarding what to eat, what side effects to be wary of, and potential psychological adjustments "…*but I did feel completely lost at each stage and I didn't feel I really knew volumes*" [Jane, PAU]. A key component of feeling under-prepared for surgery included not knowing that alcohol could

become a problem. Half of the participants with problem alcohol use felt as though more information would have helped shape their expectations for how their relationship with alcohol would change "… *the surgeon didn't say to me once 'oh it could drastically affect the way your body absorbs alcohol'… It says in the leaflets… you can drink in moderation. Well no, I can't drink in moderation*" [Sandy, PAU].

5b. Well Prepared

For participants with NPAU, preparation came from multiple sources, including doing their own personal research, attending a support group, or having an informative bariatric pathway experience. Further to being aware of the changes and challenges following surgery, a few participants felt as though their personal research and inquiries informed the effort they later made to avoid over-consuming alcohol; "*… I did something like 2 years of research before I actually got my surgery… I was lucky because it was something that I was on the lookout for, rather than people who go into it blind*" [Jennifer, NPAU]. Going into surgery 'blind,' or under-prepared, was an experience that most participants with NPAU sought to avoid, and their efforts distinguished the two groups in terms of how prepared they felt they were for bariatric surgery and the potential for problematic alcohol use.

Theme 6: Resilience.

The sixth core theme was 'resilience,' characterised by the presence of self-confidence, readiness to address mental health, optimism and good coping skills, which increased the capacity for participants with NPAU to cope with difficulties, both surgery-related and in their personal lives. For some participants like Karen [NPAU] investing time in a mental health service helped to identify previous coping habits, "… *they helped me sort of realise… it's ok if everything not perfect all the*

time. Because that was a big thing – if something wasn't right, I would turn to food." Replacing the previous coping strategy of emotional eating with more effective, accessible coping skills was a key feature of resilient participants with NPAU. Throughout the transcripts, other skills included setting manageable goals, acceptance, identifying triggers, avoidance and connecting with others. For the participants with PAU, those that had later managed or resolved their problematic alcohol use through personal effort, a mental health service or a GP intervention described a mindset shift contributing towards changing their relationship to alcohol. After getting help, Martha [PAU] described feeling more empathetic towards others, and challenging the guilt she internalised for re-gaining weight, "*Who am I to judge? And it's just seeing first-hand what drugs and alcohol can do to people that I think 'hang on a minute, there's a lot more to life that matters…* "' In summary, participants with NPAU maintained resilience despite the adversities that follow the major life changes inherent to and outside of surgery. Also, cultivating a more resilient mindset may have helped some participants with PAU navigate away from coping maladaptively with alcohol.

2.5 Discussion

The current study aimed to understand what factors influence the development of alcohol misuse after bariatric surgery by interviewing participants with differing relationships to alcohol, and several informative themes emerged. Overall, participants with PAU cited drinking to cope and disinhibition as influential to developing problematic alcohol use. Conversely, participants with NPAU reduced their drinking when they became concerned, and mostly kept their drinking socially occasioned. In this way, including a comparison group revealed that some individuals were aware of this potential to misuse alcohol, and employed strategies to

manage the new effects of alcohol. Together, these themes emphasise the role that coping behaviours and awareness play in the development of post-surgical problematic alcohol use.

It has been suggested that post-surgery new-onset substance misuse reflects an 'addiction transference' from food to other substances (Spencer, 2006; Steffen et al., 2015). Themes identified in the present study go beyond the 'addiction transference' model and provide insight into the negative reinforcement mechanisms (i.e. drinking to cope) driving post-surgical alcohol misuse. This supports evidence where previously eating-centred coping mechanisms for unresolved psychological problems before surgery and experiencing a 'new buzz' from the rapid effects of alcohol post-surgery, contributed to drinking to cope (Yoder et al., 2018). Results also illustrate that disappointment with weight or surgical outcomes could motivate patients to consume alcohol as a coping strategy. Despite instances of positive perspectives, a comparatively negative self-image was described amongst participants with PAU. This was especially evident regarding weight re-gain and body image and extends the literature where increases in self-esteem correspond to reductions in BMI post-surgery (Burgmer et al., 2014). Drinking to cope was also influenced by surgical impacts upon eating behaviour, where all but one of the participants with PAU "*drank because* [they] *could not eat."* At times this appeared connected to dumping syndrome (up to 40% of patients may experience dumping after surgery; van Beek, Emous, Laville, & Tack, 2017), and some participants with PAU described alcohol as emotionally comforting. In both contexts, drinking alcohol 'fills the gap' created by losing the ability to eat these foods, whereas participants with NPAU mostly described their restriction as manageable. This provides new evidence for the potential to 'transfer' coping mechanisms from food to alcohol for

some whose ability to eat or relationship to food changes post-surgery (Hardman & Christiansen, 2018; Yoder et al., 2018).

In bariatric surgery literature, the role of social support and alcohol use is under-examined, as outcomes mainly target weight loss. Often, social support is linked to positive outcomes, with a wider network contributing to greater weight loss (Livhits et al., 2011). Studies in non-bariatric populations link receiving less social and emotional support to an increased likelihood to drink heavily (Strine, Chapman, Balluz, & Mokdad, 2008). The present study offers that unmet emotional support needs could similarly influence the development of problematic alcohol use post-bariatric surgery, possibly by maladaptively coping with the lifestyle, relational and psychological changes that arise. Similarly, high surgical expectations may be related to psychological distress if the expectations are unmet, and Kubik et al (2013) emphasised that the pre-surgical evaluation is an opportunity to identify patients needing more support and information. Narratives from participants with NPAU provide further insight on surgical preparedness, as many described conducting their own research, speaking with other patients and feeling informed from the bariatric pathway. Additional research would further illuminate the role of both support systems and surgical preparedness in the development of problematic alcohol use following surgery.

While providing external support is critical, fostering internal 'resilience' resources in bariatric patients is another purpose of professionals and support groups (Sarvey, 2009). Findings provides evidence for the role of resilience by identifying that participants with NPAU possessed self-confidence, readiness to address mental health issues, optimism and good coping skills. Together, these qualities may promote recovery from surgery-related and personal difficulties, thereby preventing

the development (and maintenance) of drinking to cope. Correspondingly, research comparing post-bariatric surgery patients found that individuals who developed substance use disorders (SUDs) reported more stressful life events following surgery and coping through substance use (Ivezaj et al., 2014). Results from the present study reflect a similar tendency, as drinking to cope motivated alcohol misuse or feeling concerned over drinking habits. Longer term follow-up is merited to investigate how resilience develops and changes post-surgery, as participants with PAU were interviewed at a comparatively longer time following surgery relative to participants with NPAU.

Clinical applications of the present study's findings could inform elements of a personalised pre- and post-surgical intervention strategy; for example, informing patients about the increased risk for alcohol misuse post-surgery, changes in alcohol's physiological effects, considering patients' existing coping strategies, and facilitating tailored psychological support during the post-surgical period (Hardman & Christiansen, 2018). Responses from the interviews highlighted a need for pre-surgical counselling, follow-up and service accessibility after surgery. Multidisciplinary teams could promote preparedness by offering pre-surgery counselling regarding lifestyle changes due to gastric restriction. Further, post-surgical support for patients experiencing feelings of deprivation around food could be helpful to mitigate the impact of surgical restriction and help to develop positive coping strategies. Based on the present study's findings, interventions within research and clinical settings could also investigate increasing patient resilience through addressing self-image, mental health and educating patients about available coping skills and strategies.

2.5.1 Limitations

A potential limitation is that six interviews were conducted in person (participants with PAU $N = 4$; NPAU $N = 2$), and eight were conducted over telephone (PAU $N = 2$; NPAU $N = 6$). While this strategy increased participation from patients who might have been restricted geographically or otherwise, there is potential for disadvantages including lack of visual cues or environmental distractions (Garbett & McCormack, 2001; Opdenakker, 2006). Telephone interviewing is described as a flexible data collection method of comparable quality to in-person interviews (Carr & Worth, 2001). Another limitation is the largely retrospective nature of accounts from participants, and a longitudinal design could better capture the developmental aspect of problematic alcohol use. Regardless, the findings insightfully draw upon the participants' reflective experiences of problematic and non-problematic alcohol use post-surgery. Participant responses were used to classify their problematic alcohol use group (with vs. without), as interview questions elicited responses about post-surgical alcohol use that external validation measures (e.g., questionnaire-based assessment of current alcohol use) might not have captured for those who had discontinued or modified their drinking habits at the time of the interview. However, despite its advantages, this classification method has limitations in terms of validity, and future research could address this limitation through identifying and applying external validation measures assessing alcohol misuse post-surgery. Moreover, potential group differences are illustrated in Table 2.1 where participants with NPAU appear more likely to have a surgery type other than RYGB, be younger, have fewer years since surgery, lower current weight and greater post-surgery weight loss compared to participants with

PAU. However, due to small sample sizes any differences should be treated with caution.

2.5.2 Conclusions

Results from the current study identify several themes implicated in the development of problematic alcohol use after bariatric surgery. Participants with problematic alcohol use endorsed drinking to cope and disinhibited drinking motivations, a more negatively perceived self-image, adverse impacts of surgical restriction, receiving less emotional support or having unmet needs, and feeling under-prepared for surgery in terms of expectations regarding alcohol use. Conversely, narratives from participants with non-problematic alcohol use were marked by social motivation or maintaining control over drinking, a more positive self-image, manageable surgical restriction, having sufficient emotional support, feeling more prepared for surgery and more resilience contributing to the capacity to endure difficulties following surgery.

Chapter 3: Modeling the distinct negative reinforcement mechanisms associated with alcohol misuse and unhealthy snacking

A version of the study reported in this chapter has been published as:

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3.1 Abstract

Chapter 2 revealed that coping can motivate post-bariatric surgery alcohol misuse. Results also indicated a relationship between negative affect-related processes and coping, supporting a motivational model of alcohol use (Cooper et al., 1995) and eating. Positive motivations (i.e. enhancement) may similarly mediate this association. Therefore, Chapter 3 aimed to develop a theoretical model of alcohol misuse and over-eating, mediated by coping, and to test this model in a non-bariatric, community population. The present study hypothesised that i.) drinking to cope and ii.) eating to cope would mediate the association between hopelessness/anxiety sensitivity and hazardous drinking/unhealthy snacking, respectively, and iii.) eating and drinking to cope would represent separate strategies. Participants were recruited via opportunity sampling through university schemes, social media, email and web page advertisements. Questionnaires included the Alcohol Use Disorders Identification Test, Substance Use Risk Profile Scale, Modified Drinking Motives Questionnaire Short Form, Palatable Eating Motives Scale and Snack/Meal Food Intake Measure. Participants were N = 198 undergraduates, weight-related research volunteers and the public (83% female; 90% university educated). The hypothesised

structural model fit the data well. As predicted, there were significant indirect associations between negative personality characteristics, hazardous drinking and unhealthy snacking via coping; specifically, individuals higher in anxiety sensitivity/hopelessness used food or alcohol to cope which, in turn, significantly predicted unhealthy snacking, and hazardous drinking, respectively. Importantly, drinking and eating to cope represented outcome-specific strategies. The current study demonstrates that coping motivations are critical to the relationship between negative personality characteristics and unhealthy behaviours and highlights the distinct negative-reinforcement pathways associated with hazardous drinking and unhealthy snacking in majority university-educated females from the U.K.

3.2 Introduction

As reviewed in Chapter 1, the causes of obesity are complex, with strong biological and environmental determinants. However, over-consumption, particularly in the absence of physiological need, is a behavioural phenomenon. One such behaviour is emotional eating, which is the tendency towards eating in response to negative emotions (Arnow, Kenardy, & Agras, 1995; Bennett, Greene, & Schwartz-Barcott, 2013; Oliver, Wardle, & Gibson, 2000). Consuming calorie-dense 'comfort foods' is a key feature of emotional eating, and individuals with high rates of emotional eating tend to have a higher BMI (Greene et al., 2011; Ozier et al., 2008). Notably a similar behavioural risk factor for developing alcohol use disorder is drinking alcohol to regulate negative affect, which is linked to both greater alcohol consumption, and more drinking problems (Carpenter & Hasin, 1999; Holahan, Moos, Holahan, Cronkite, & Randall, 2001; Holahan et al., 2003). In addition, alcohol is also a source of calories with little impact on satiety and it also disinhibits eating behaviour - promoting over consumption (Christiansen, Rose, Randall-Smith,

& Hardman, 2016; Rose, Hardman, & Christiansen, 2015). It is therefore critical to understand the common behavioural underpinnings of over-consumption of food and alcohol.

There are multiple psychological characteristics that have been implicated in the over- consumption of both alcohol and food. Notably, there is a robust association between negative affect, hazardous drinking and obesity. For example, anxiety sensitivity (i.e. distress resulting from the awareness of anxiety symptoms) and hopelessness (i.e. the expectation of negative events, and pervasive feelings of despondency) are related to patterns of substance use (Woicik, Stewart, Pihl, & Conrod, 2009). Moreover, related personality characteristics are also implicated in overconsumption of food and obesity (Davis et al., 2008; Gerlach et al., 2015). Taken together, this suggests that certain personality characteristics represent risk factors for over-consumption of alcohol, and obesity, although it is unlikely that they have a simple direct association.

Motivational models of alcohol use argue that the influence of personality characteristics on alcohol misuse is exerted indirectly via drinking motivations, due to motivations being shaped by individual differences in sensitivity to alcohol's negative (e.g., to decease negative affect) or positive (e.g., to increase positive affect) reinforcing qualities (Cooper, 1994; Stewart & Devine, 2000). Cooper (1994) argues that drinking motivations can be divided into positive motives; social (e.g., drinking alcohol to enjoy social gatherings, external reinforcement) and enhancement (e.g., because one enjoys the feeling, internal reinforcement), as well as counterpart negative motives; conformity (e.g., to not feel left out), and coping (e.g., to forget about negative emotions) (Cooper, 1994; Stewart & Devine, 2000). Critically, these

motivations underpinning alcohol use have also been shown to map directly upon the motivations for hedonic eating (Burgess et al., 2014).

There is evidence that drinking to cope (drinking to regulate negative affect) is one of the greatest predictors of increased alcohol consumption and alcohol-related problems (Holahan et al., 2003; Kuntsche, Knibbe, Gmel, & Engels, 2005; Merrill & Thomas, 2013). Drinking for enhancement (i.e. to prolong a positive feeling) also predicts increased alcohol use and alcohol problems (Hasking, Lyvers, & Carlopio, 2011; Tobin, Loxton, & Neighbors, 2014). However, those who drink to cope have a heightened risk for developing alcohol dependence, compared to those who drink for enhancement (Cooper et al., 1995; Holahan et al., 2001; Kassel et al., 2000; Merrill & Read, 2010). Similar evidence has been found in a study exploring the impact of motives on obesity, with stress positively associated with eating to cope and a higher BMI (Boggiano et al., 2015). Negative emotions may underscore coping motivations; individuals with elevated anxiety, stress, and depression symptoms reported having a 'food addiction,' and subsequently eating more confectionery, fast foods and unhealthy snacks (Burrows, Hides, Brown, Dayas, & Kay-Lambkin, 2017). Conversely, eating for enhancement (i.e. to experience pleasure) has also been associated with binge eating behaviour (Boggiano et al., 2014). But the literature appears equivocal, as although obesity has been associated with increased motivation to eat, it is not necessarily associated with more pleasure experienced from eating (Mela, 2006). Therefore, being motivated to seek enhancement from food may not be as strong a predictor of long-term over-consumption and obesity as eating to cope.

Taken together, there is considerable evidence to suggest that the personality characteristics (i.e. anxiety sensitivity, hopelessness) that predispose individuals to development of alcohol use disorders could also predict excessive food consumption

through their relationships with motivational schema. Behaviour-informed learning may also offer insight into the separate mediators of drinking or eating to excess. Fischer (2004) found that positive eating and alcohol expectancies were predictive of unhealthy eating and alcohol use respectively. However, these expectancies were specific to the outcome – alcohol expectancies correlated with alcohol-related problems, but not binge eating, and vice versa. Similarly, coping motives may also be related to specific behavioural outcomes (e.g. eating to cope predicts unhealthy eating but not alcohol use, and vice versa). Critically, no study to date has examined whether personality risk factors predispose individuals to common eating and drinking motives, or whether these pathways are used inter-changeably or exclusively (e.g., drinking to cope, but not also eating to cope).

3.2.1 Objectives

The present study aimed to examine the motivational pathways by which anxiety sensitivity and hopelessness may contribute to hazardous drinking and unhealthy snacking. It was hypothesised that (i) the relationship between anxiety sensitivity/hopelessness and hazardous drinking would be mediated by drinking to cope, and not by drinking for enhancement. Further, it was hypothesised that (ii.) the relationship between anxiety sensitivity/hopelessness and unhealthy snacking would be mediated by eating to cope, and not by eating for enhancement. Finally, it was hypothesised that (iii.) eating and drinking to cope would represent independent coping strategies.

3.3 Method

3.3.1 Participants

Participants were recruited from several sources, which included opportunity sampling through the University of Liverpool and University College London research participation schemes. Non-university related participants were recruited via an online panel of participants with registered interest in weight-related research, and members of the general community through advertisements on social media, email and public web pages. Inclusion criteria involved consumption of alcohol on at least one occasion in an average week and eating palatable, high calorie foods at least once a week, and participants were screened for these criteria based on their responses on two consumption frequency questions (e.g., 'How often do you consume tasty foods?' with responses ranging from 'Never' to 'Daily.' Participants who drank alcohol and ate tasty foods less than once a week were excluded). To capture snacking behaviour without weight management goals obscuring significant findings, individuals on a weight loss programme or actively calorie restricting, or those who had been advised by a medical professional to stop drinking were excluded. All participants provided informed consent before completing the survey, which was approved by the University of Liverpool's Research Ethics Committee.

3.3.2 Measures

The Alcohol Use Disorders Identification Test

The Alcohol Use Disorders Identification Test (AUDIT) was used to assess hazardous drinking (Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). The AUDIT consists of 10 fixed response questions regarding alcohol consumption and consequences of drinking, such as 'how often during the last year have you found that you were not able to stop drinking once you had started?' Scores on the AUDIT range from 0 to 40, with scores of 8 or above indicating hazardous or harmful

alcohol use. The AUDIT is a valid measurement tool for alcohol use in university settings and in the general population (Atwell, Abraham, & Duka, 2011), with good internal reliability within the dataset (Cronbach's α = .82).

The Substance Use Risk Profile Scale (SURPS)

This 23 item Likert scale questionnaire is based on a model of four personality risk factors for substance misuse – hopelessness (7 items), anxiety sensitivity (5), impulsivity (5) and sensation seeking (6) (Woicik et al., 2009). Responses on items such as *'I like doing things that frighten me a little,*' range on a four-point scale from strongly disagree (1) to strongly agree (4). Scores for each personality characteristic are analysed using reverse coding for selected items and computing the mean score for the relevant response items. Reliability and construct validity of the SURPS has been well established in the substance use literature (Krank et al., 2011), and the present study focused on the Hopelessness and Anxiety Sensitivity subscales which both had an internal reliability within the dataset of α = .84 and α = .60 respectively.

Modified Drinking Motives Questionnaire Short Form:

This 12 item self-report scale asks participants to endorse statements such as *'in the last 12 months, how often did you drink because it helps you enjoy a party?'* which relate to different motivations to drink on a Likert scale (Kuntsche & Kuntsche, 2009). Responses range from 1 (never/almost never) to 5 (always/almost always). The mean of the relevant items is calculated to compute a score for each motive subscale. The two subscales included in this study were Enhancement (drinking for the pleasant taste experience, 3 items) and Coping (drinking to reduce negative affect, 3 items). The Modified Drinking Motives Questionnaire Short Form

(MDMQ-R SF) showed good to excellent test-retest reliability in a sample of undergraduates who were relatively frequent drinkers *(*intraclass correlation coefficients at T1 and T2, *ps* <.001) (Grant et al., 2007; Grant, Stewart, O'Connor, Blackwell, & Conrod, 2009) and Cronbach's α scores from the present study were .74 (Enhancement) and .87 (Coping).

Palatable Eating Motives Scale

This 19-item self-report questionnaire is similar to the DMQ-R, in that participants endorse statements relating to different motivations to eat palatable foods, such as *'how often would you say that you ate tasty foods for the following reasons: to forget your worries?'* (Burgess et al., 2014). Responses are listed on a 5-point Likert scale, which ranges from 1 (never/almost never) to 5 (always/almost always). The mean of the relevant items is calculated to compute a score for each motive subscale. Similarly, to the MDMQ-R SF, the present study focused on the motivational subscales Enhancement (5 items) and Coping (5). This scale demonstrates good convergent, discriminant and incremental validity with related measures of eating pathology, and good internal reliability in the present dataset with Cronbach's α from .77 (Enhancement) to .89 (Coping).

Snack/Meal Food Intake Measure:

Snacking behaviour was assessed using a 22-item snack food subscale of the Snack/Meal Food Intake Measure (Brown, Ogden, Vögele, & Gibson, 2008). This questionnaire asks participants how often they have a serving of the snacks from the provided list in between breakfast, lunch and evening meals. On the list, there are 11 unhealthy snacks (e.g., cakes and crisps). Participants used an 8-point Likert scale (Never/Less than once a month; less than once a week; once a week; 2-4 days a

week; 5-6 days a week; once a day, every day; 2-3 times a day, every day; more than 3 times a day, every day). Scores on the identified 'unhealthy' items were summed to create a subscale for unhealthy snacks. All items on this measure were developed using the World Health Organisation 2001/2002 protocol (Currie, Samdal, Boyce & Smith, 2001), the Inchley et al. (2001) food frequency questionnaires, the 7-day food diary (Gregory et al., 2000) and consumer market research report data (Mintel, 2003). A version of this measure has been used to assess snacking behaviour in both adults and children, and has been shown as consistently reliable, with a Cronbach's α of .81 for unhealthy snacking in the present dataset (Brown, Ogden, Vögele, & Gibson, 2008; Brown & Ogden, 2004; Ogden, Dalkou, Kousantoni, Ventura, & Reynolds, 2016).

3.3.3 Procedure

The questionnaires were hosted using Qualtrics online software. Participants were provided with a generic link, where clicking upon the link directed them to an information sheet and a consent form. Participants were asked to confirm that they met the eligibility criteria by ticking a box, and eligible participants were then provided with the main surveys to complete. The order of the questionnaires was as follows: Demographics *(age, gender, marital status, ethnic group defined using pre-specified categories and open response option, height and weight, and highest level of qualification represented by pre-specified categories)*, SURPS, MDMQ-R SF, AUDIT, PEMS, and Snack/Meal Food Intake Measure. When the participants had finished completing the surveys, they were thanked and debriefed regarding the study's aims. Undergraduate participants from the University of Liverpool were offered compensation in the form of research credits to fulfil the requirement of their

psychology course. For non-UoL undergraduate participants there was a prize draw incentive of £25 and £50 for two winners.

3.3.4 Statistical Analysis

Structural Equation Modelling

The first analysis used a structural model to examine the motivational pathways by which anxiety sensitivity and hopelessness may contribute to hazardous drinking and unhealthy snacking. To reduce the skewness of the data affecting regression coefficients, generated variables were square root transformed prior to structural equation modelling (see Figure 3.1). Multiple indices of model fit were calculated to assess that the model represented a good fit for the data. Normed χ^2 values were calculated (χ^2/df). χ^2/df values between 1 and 5 are indicative of an acceptable model fit (Schumacker & Lomax, 2004). The Standardized Root Mean Square Residual (SRMR) absolute fit index was also used to assess model fit, as it is a more robust measure that deals well with non-normal distribution and kurtosis (Hu & Bentler, 1998). SRMR values under 0.08 are representative of a good model fit. Model fit was also estimated using non-centrality-based indices; the comparative fit index (CFI) and root mean square error of approximation (RMSEA). CFI values equal to, or greater than, 0.95 were used as cut offs for good model fit and greater than .90 for acceptable model fit. RMSEA values equal to, or lower than, 0.06, were used as cut offs for good model fit, with lower than .08 as acceptable model fit (Hu & Bentler, 1999). To describe specific relationships within the structural model, standardised regression coefficients are reported (See Figure 3.1, Tables 3.2 and 3.3). Bias-corrected bootstrapping was used to test the hypothesised indirect associations

between personality, hazardous drinking and unhealthy snacking via drinking/eating motivations, and gender was controlled for in the model.

Mediation Analyses

To investigate the hypotheses that i.) the relationship between anxiety sensitivity/ hopelessness and hazardous drinking would be mediated by coping and not an enhancement motivation, and ii.) the relationship between anxiety sensitivity/ hopelessness and unhealthy snacking would be mediated by coping and not an enhancement motivation, and iii.) to examine whether alcohol represents a specific coping strategy, PROCESS (Hayes, 2012) was used to explore the indirect associations within the square root transformed variables. PROCESS computes regression coefficients to conduct a mediation regression analysis, and bootstraps confidence intervals for the hypothesised indirect associations.

3.4 Results

3.4.1 Participants

The sample (N = 198) consisted of 32 males, 164 females and 2 who did not disclose their gender, aged 18 to 65 years (M = 29.09 SD ± 13.09) with 36.86% of participants classified as overweight or obese by calculating their BMI using the weight and height information given in the online questionnaire. This was compared to the definition given by the World Health Organisation (WHO, 2006) where a person with a BMI of 25kg/m² to 29.9 kg/m² has overweight, and 30kg/m² or higher indicates a person with obesity (See Table 3.1. for full descriptive statistics).

Table 3.1. Descriptive statistics of the sample, N = 198

Item	Category	Frequency	Percentage
Gender	Male	32	16.16
	Female	164	82.83
	Undisclosed	2	1.01
Marital Status	Single	141	71.21
	Married or Domestic Partnership	51	25.76
	Widowed, Divorced or Separated	6	3.03
Ethnicity*	Welsh/ English / Scottish / Northern Irish / British	155	71.43
	Irish	7	3.23
	White and Black African	4	1.84
	White and Asian	7	3.23
	Chinese	5	2.30
	Other (White and Black Caribbean, Indian, Arab, American, African, Australian, Dutch, German, Greek)	32	14.75
Education	Current postgraduate university student	17	8.59
	Current undergraduate university student	94	47.47
	University or college degree	58	29.29
	University qualification below degree	9	4.55
	Upper secondary school qualification	12	6.06
	Lower secondary school qualification	5	2.53
	None	3	1.52
Age Category	18 - 29 years	129	65.15
	30 - 39 years	15	7.58
	40 - 49 years	19	9.60
	50 - 59 years	15	7.58
	60 +	9	4.55
	Not Reported	11	5.56
BMI Category	Underweight (<.18.5)	10	5.05

Healthy Weight (18.5 - 24.9)	112	56.56
Overweight (25.0 - 29.9)	37	18.68
Obese Class I (30.0 - 34.9)	14	7.07
Obese Class II (35.0 - 39.9)	13	6.57
Obese Class III (> 40.0)	9	4.55
Not Reported	3	1.01

** Participants had the option to tick all the ethnicity categories they felt applied to them, which yielded a final N = 217 responses from N = 198 participants.*

3.4.1.1 Structural Model (Figure 3.1).

The structural model was found to be an excellent fit for the data on all model fit indices (χ^2/df = 1.03; SRMR = .02; RMSEA = .01; CFI = 1.00). As depicted in Figure 3.1, anxiety sensitivity was directly associated with drinking and eating to cope. Similarly, hopelessness was directly associated with drinking and eating to cope. In regard to alcohol use, direct associations were observed between drinking to cope, drinking for enhancement and hazardous drinking. Further, eating for enhancement and eating to cope were directly associated with unhealthy snacking. As hypothesised, no direct associations were observed between drinking to cope and unhealthy snacking, nor for eating to cope and hazardous drinking. Interestingly, there were no direct associations between anxiety sensitivity, hopelessness and enhancement motivations (for both eating and drinking). For this reason, bootstrapped mediation analyses for indirect associations on over-consumption involving enhancement motivations were not conducted (as there can be no evidence for mediation if the independent variable – mediator association is non-significant). Instead, mediation analyses were performed and reported below to examine the relationships between anxiety sensitivity, hopelessness, coping motivations,

hazardous drinking and unhealthy snacking, (with enhancement motives included as covariates)

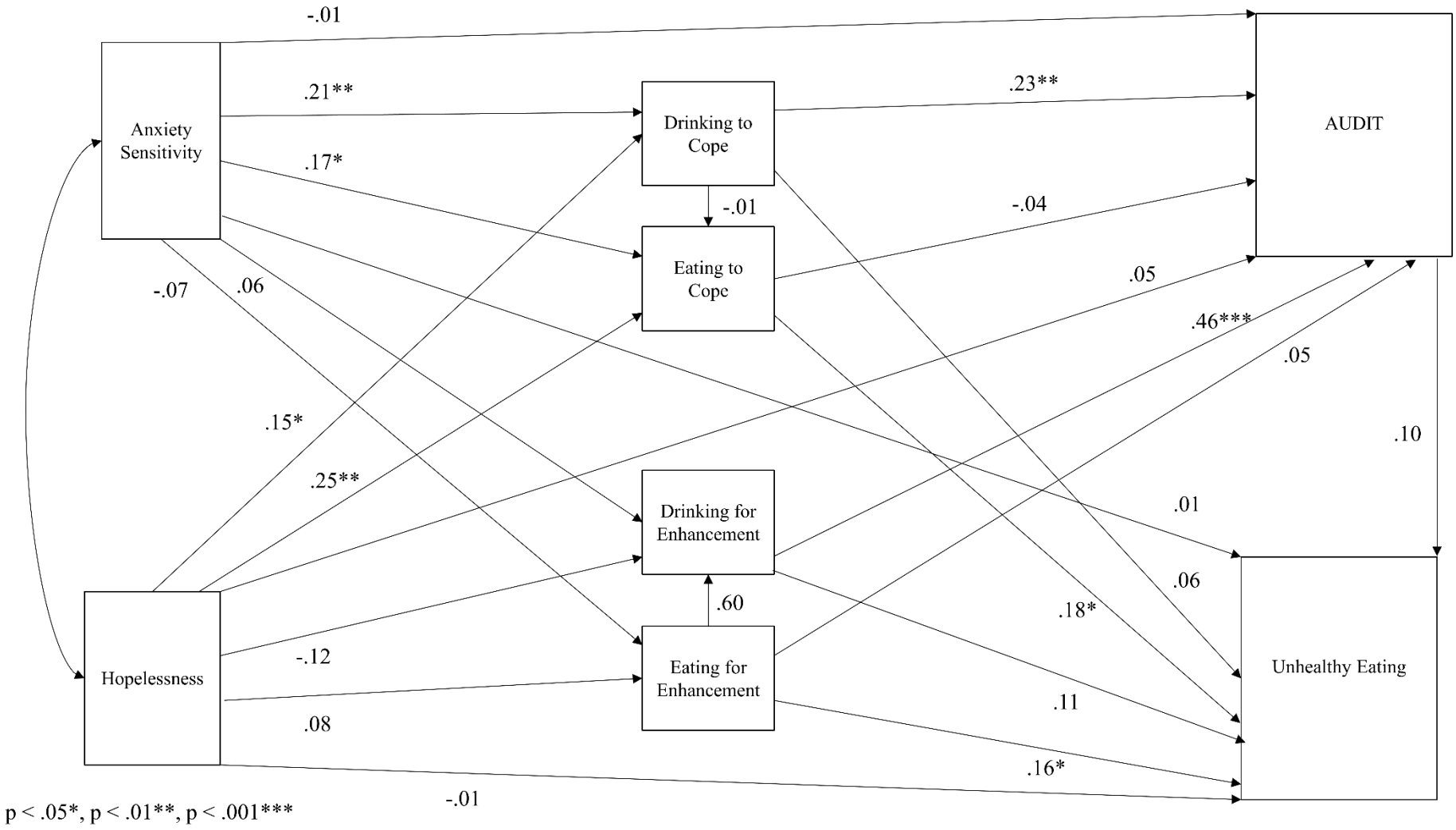

Figure 3.1. The structural model with unstandardized regression weights reported

3.5.1.2 Mediation Analyses

3.4.2. The mediating effect of drinking to cope on the association between anxiety sensitivity, hopelessness and hazardous drinking (Hypothesis i.).

There was no significant total effect of anxiety sensitivity on AUDIT scores (*b* = .11, SE = .17, p = .521, 95% CI = -.23 to .45). However, as hypothesised, there was an indirect association of elevated anxiety sensitivity on AUDIT scores through increased drinking to cope (*b* = .17, SE = .07, 95% CI = .07 to .34). There was a non-significant negative direct association between anxiety sensitivity and AUDIT scores after controlling for the indirect associations, indicating a suppression effect (Rucker, Preacher, Tormala, & Petty, 2011).

A similar pattern of results was found for hopelessness, where there was no total effect of hopelessness on AUDIT scores (*b* = .18, SE = .13, p = .165, 95% CI = -.07 to .43), and no direct effect (*b* = .09, SE = .13, p = .484, 95% CI = -.17 to .36). However, as hypothesised, an indirect association was found between elevated hopelessness and AUDIT scores through increased drinking to cope (*b* = .12, SE = .05, 95% CI = .04 to .25), indicating an indirect-only mediation effect (Zhao, Lynch, & Chen, 2010). These indirect associations are detailed below in Table 3.2.

Table 3.2. The indirect associations via coping motivations between anxiety sensitivity and hopelessness and **AUDIT scores** *(Bootstrapped SE and CI)*

	Effect	SE	LL 95%CI	UL95%CI
Anxiety Sensitivity				
Drinking to Cope*	.17	.07	.07	.34
Eating to Cope	-.03	.07	-.17	.09
Hopelessness				
Drinking to Cope*	.12	.05	.04	.25
Eating to Cope	-.04	.05	-.15	.04

* indicates a p value of < .05, *Standard Error = SE, Confidence Interval = CI, Lower Level CI = LL, Upper Level CI = UL*

3.4.3 The mediating effect of eating to cope on the association between anxiety sensitivity, hopelessness and unhealthy snacking (Hypothesis ii.).

There was no significant total effect of anxiety sensitivity on unhealthy snacking (*b* = .11, SE = .19, p = .547, 95% CI = -.26 to .48). However, as hypothesised, there was an indirect association between elevated anxiety sensitivity and unhealthy snacking through increased eating to cope (*b* = .11, SE = .07, 95% CI = .00 to .27). There was no total effect of hopelessness on unhealthy snacking (*b* = .13, SE = .14, p = .344, 95% CI = -.14 to .41), but an indirect association between elevated hopelessness and unhealthy snacking through increased eating to cope (*b* = .09, SE = .05, 95% CI = .01 to .22). There were non-significant negative direct associations between anxiety sensitivity, hopelessness and unhealthy eating after controlling for indirect associations, indicating a suppression effect in both analyses. These indirect associations are detailed below in Table 3.3.

Table 3.3. The indirect associations via coping motivations between anxiety sensitivity and hopelessness and **unhealthy snacking** *(Bootstrapped SE and CI)*

	Effect	SE	LL95%CI	UL95%CI
Anxiety Sensitivity				
Drinking to Cope	.07	.07	-.04	.24
Eating to Cope*	.11	.07	.00	.27
Hopelessness				
Drinking to Cope	.05	.05	-.02	.19
Eating to Cope*	.09	.05	.01	.22

* indicates a p value of < .05, *Standard Error = SE, Confidence Interval = CI, Lower Level CI = LL, Upper Level CI = UL*

3.4.4. Eating and drinking as independent coping strategies (Hypothesis iii.)

As hypothesised, there was no association observed between AUDIT scores and unhealthy snacking, suggesting that there are distinct pathways, via coping strategies, to these two outcome variables (*b* = .10, SE = .08, p = .189). To further investigate whether drinking or eating coping motivations were specific to hazardous drinking or unhealthy snacking behaviours, the indirect associations between eating or drinking to cope and over-consumption of food and alcohol were compared (Tables 3.2 and 3.3). Importantly, there were no indirect associations between anxiety sensitivity/hopelessness and hazardous drinking via eating to cope (see Table 3.2). Similarly, there were no indirect associations between anxiety sensitivity/hopelessness and unhealthy snacking via drinking to cope (see Table 3.3).

3.5 Discussion

The current study explored the motivational pathways by which anxiety sensitivity and hopelessness contribute to hazardous drinking and unhealthy

snacking. It was hypothesised that i.) the relationship between anxiety sensitivity, hopelessness and hazardous drinking would be mediated by coping and not enhancement motives, and ii.) the relationship between anxiety sensitivity, hopelessness and unhealthy snacking would be mediated by coping and not enhancement motives, and iii.) that drinking alcohol or unhealthy snacking would represent distinct coping strategies. In a majority female, university-educated group of participants from the United Kingdom, it was found that both anxiety sensitivity and hopelessness had a significant indirect association with hazardous drinking through drinking to cope. This significant association was also observed for unhealthy snacking through eating to cope. Finally, results from the mediation analysis indicated that the two coping strategies (drinking alcohol and unhealthy snacking) had distinct pathways (e.g., there were no indirect associations between anxiety sensitivity or hopelessness and unhealthy snacking via drinking to cope). This suggests that participants who reported drinking to cope did so specifically and did not also increase their unhealthy snacking. Similarly, participants who reported eating to cope did so specifically and did not also increase hazardous drinking.

As predicted in hypothesis i, there were indirect relationships between anxiety sensitivity, hopelessness and hazardous drinking through drinking to cope. Similarly, as predicted in hypotheses ii., there were indirect relationships between anxiety sensitivity, hopelessness and unhealthy snacking through eating to cope. Together, the current results support the critical role of motivation in drinking (Cooper, 1994; Stewart & Devine, 2000) and eating behaviour (Boggiano et al., 2015), as no direct associations between anxiety sensitivity or hopelessness on hazardous drinking or unhealthy snacking were observed, whereas accounting for a negative reinforcement motive – coping – revealed both direct and indirect

relationships between personality characteristics, motivations and over-consumption. Therefore, reporting higher trait anxiety sensitivity and/or hopelessness appears key to shaping negative reinforcement motivations for engaging in over-consumption of alcohol, and further underscores that coping motives play a key mediating role between hopelessness and alcohol use (Baines et al., 2016; Mackinnon, Kehayes, Clark, Sherry, & Stewart, 2014). Regulating negative affect via drinking to cope has been observed as a risk factor for AUD (Carpenter & Hasin, 1999), and the present study offers theoretical support that interventions teaching alternative methods of coping with negative affect could be effective in reducing alcohol use (Stasiewicz et al., 2013).

Consistent with hypotheses i. and ii., there was no evidence to support enhancement motivations mediating the relationship between personality characteristics and over-consumption due to personality characteristics and enhancement motivations being non-significantly associated in the structural equation model. Specifically, neither anxiety sensitivity nor hopelessness had a positive association with eating or drinking for enhancement. However, both eating and drinking for enhancement were positively associated with unhealthy snacking and hazardous drinking, respectively. This adds to the increasingly equivocal literature regarding the association between enhancement motivation and alcohol use outcomes (Cooper, Russell, Skinner, & Windle, 1992; Tobin et al., 2014). In light of these findings, it is possible that other personality characteristics, such as impulsivity, may drive enhancement motives and subsequent consumption, although these were not included in the analysis.

Importantly, the results support hypothesis iii., which suggests that there are distinct pathways to hazardous drinking and unhealthy snacking. This is evident from

there being no indirect associations between anxiety sensitivity, hopelessness and hazardous drinking via eating to cope, nor were there indirect associations between anxiety sensitivity, hopelessness and unhealthy snacking via drinking to cope. Therefore, participants did not have broad maladaptive coping strategies, which illustrates the key role that behaviour-specific learning plays in the development of over-consumption patterns. Moreover, while Fischer (2004) found that positive eating and alcohol expectancies were separately predictive of binge eating and alcohol-related problems, respectively, the present study highlights that specific coping motives are also key to driving over-consumption of food or alcohol, but not both together. This becomes important for bariatric surgery patients, another population with a female majority (Fuchs et al., 2015; Santry, Gillen, & Lauderdale, 2005). Indeed, the rate of AUD increases following the second post-surgical year (Chapter 1, section 1.2.1), which could indicate a possible shift between coping strategies from food to alcohol if non-consumption-based strategies for regulating negative affect are not implemented, where the patient previously relied on eating as a coping strategy (Hardman & Christiansen, 2018). Future research to explore why some individuals specifically choose food to cope over alcohol, and *vice versa*, would contribute further understanding to the development of expectancies and motivations and their role in over-consumption. Further, as this was a predominantly university educated female sample from the U.K., future studies with population representative samples are needed to assess the applicability of the findings.

3.5.1 Strengths and Limitations

A key strength of the present study was recruiting participants with a wide range of BMIs, which increased the likelihood of capturing coping motivations and over-eating behaviour, as over-eating has been observed to improve mood in obese

individuals (Leehr et al., 2015). Although gender was controlled for in the analysis, there were notably fewer male (31) than female participants (167), which limits the generalisability of the results. Indeed, evidence has suggested there might be gender differences in high volume drinking (Wilsnack, Wilsnack, Kristjanson, Vogeltanz-Holm, & Gmel, 2009) and emotional eating (Adriaanse, Evers, Verhoeven, & de Ridder, 2016), with women being more likely to report emotional eating. While there is evidence that emotion-related motivations such as eating to cope can predict unhealthy snacking, this study did not examine the association between eating to cope and binge eating behaviour, which has also been associated with specific affective disorders, such as depression and anxiety (Peterson, Latendresse, Bartholome, Warren, & Raymond, 2012; Rosenbaum & White, 2015; Swendsen et al., 2000). Examining unhealthy snacking rather than binge eating behaviour, however, captures sub-clinical problematic eating patterns that also contribute to obesity. Also, the cross-sectional nature of the study is a limitation as the relationships between variables were correlational, and inferences about specific causation cannot be made. Finally, the sample was largely comprised of participants from the UK, either pursuing or having obtained a degree in higher education, which restricts the generalisation of findings to populations from other countries and the UK as well.

3.5.2 Conclusion

The current study found that coping motivations mediate the relationships between anxiety sensitivity/hopelessness, and hazardous drinking and unhealthy snacking. Individuals high in both anxiety sensitivity and hopelessness and who are motivated to drink to cope to attenuate negative affect are at increased risk for hazardous drinking. Similarly, individuals high in both anxiety sensitivity and

hopelessness and who eat to cope may have a heightened risk for obesity due to greater consumption of unhealthy snacks. Interventions seeking to reduce drinking or unhealthy eating would do well to recognise that teaching alternative coping methods would be of significant value towards behaviour change.

Chapter 4: Psychological and behavioural predictors of hazardous drinking 6 months post-bariatric surgery

4.1 Abstract

Chapters 2 and 3 emphasise the motivational influence of negative affect in alcohol misuse. While there is a paucity of research examining negative affect and alcohol misuse after bariatric surgery, evidence indicates a role for mental health (King et al., 2017), life stressors and coping (Ivezaj et al., 2014). The present study aimed to gather empirical support for a negative reinforcement model of alcohol misuse 6 months post bariatric surgery. Data sources were self-reported and observational data from a longitudinal cohort study of bariatric surgery patients recruited within NHS trusts and private sectors in Scotland over a 5-year period from 2014-2019. Pre-surgical data were age, gender, surgery type (AGB, RYGB; and SG), physical quality of life, anxiety, depression, and alcohol use. Post-surgical data were changes in physical quality of life, anxiety, depression and alcohol use by 6 months after surgery. The AUDIT-C assessed drinking at baseline and 6 months. *N* = 55 participants were included (male *N* = 14, female *N* = 41; Age at surgery = 49.33 ± 18.10 years; AGB *N* = 9, pre-surgery BMI = 40.57 ±5.09 kg/m^2; RYGB *N* = 14, pre-surgery BMI = 43.76 ±5.62; SG *N* = 32; pre-surgery BMI = 45.80 ±7.58). Data were analysed using Firth's penalised likelihood regression, and two models of predicting post-surgical hazardous drinking were created. *The first model* utilised pre-surgical data and demonstrated that greater baseline alcohol consumption ($p < .001$; OR = 1.72), lower physical quality of life ($p = .011$; OR = 0.89) and surgery type (AGB compared to SG; $p = .018$; OR = 0.07) independently increased the likelihood of post-surgery hazardous drinking. *The second model* utilised post-surgical data and found that an increase in anxiety symptoms by 6 months ($p = .005$; OR = 1.38)

increased the likelihood of post-surgical hazardous drinking, while no relationship was observed between changes in depression symptoms or physical quality of life. Findings support that greater pre-surgical drinking, lower pre-surgery physical quality of life and increases in anxiety by 6 months increase the likelihood for hazardous drinking. Interestingly, AGB surgery type also raised the likelihood, relative to SG. Future research could examine the role of pre-surgical drinking and psychological variables in a larger cohort with longer-term follow up after surgery.

4.2 Introduction

As previously described in Chapters 1 and 2, one of the known adverse outcomes of bariatric surgery includes the increased risk for alcohol misuse in some patients. Chapters 2 and 3 support that negative affect-related traits (e.g., anxiety sensitivity, hopelessness) are implicated in alcohol misuse, especially when paired with drinking motives focused on coping with negative affect. This is particularly relevant given that rates of psychiatric disorders (i.e., anxiety, depression) are higher in bariatric surgery candidates compared to non-treatment seeking persons with obesity, and the general population (Malik et al., 2014), although direct comparisons are difficult due to methodological differences (Chapter 1, section 1.3.2.1). Building upon this evidence, Chapter 4 aimed to gather empirical support for a negative reinforcement model of alcohol misuse post-bariatric surgery. To do this, the first aim of the present study was to examine pre-surgery negative affect-related factors alongside demographic and behavioural characteristics.

Although baseline levels of psychopathology are one possible contributor, it is important to explore the extent to which changes in anxiety and depression following surgery may impact upon alcohol misuse. Bariatric surgery reliably affects

psychological aspects of patient's lives, as well as social, sexual, physical and food-related relationships (Coulman et al., 2017). Depression symptoms generally improve, however Burgmer and colleagues (2014) noted that a small subset of patients (18.5%) with less than 25% weight loss developed new depression symptoms after surgery. Moreover, anxiety symptoms improved in the short term (1-year post-surgery) in the Swedish Obese Subjects cohort, but initial improvements were not sustained in the years following (Karlsson et al., 2007). Taken together literature suggests that although reductions in psychopathology following surgery are relatively common, pre-existing symptoms can also worsen, or new disorders can present themselves, in a small percentage of patients. As lower mental health is a risk factor for post-surgery AUD (King et al., 2017), it may be that the risk of alcohol misuse is greatest in those patients for whom psychopathology does not improve or worsens after surgery.

Seeking an improvement in quality of life could motivate patients to elect for bariatric surgery. Schok and colleagues (2000) found that bariatric candidates typically score lower on most (or all) of the physical and mental components of a health-related quality of life assessment (the Short-Form Health Survey; SF-36) compared to age reference groups. Further, researchers found that *physical* quality of life continued to be significantly lower than the population average for up to 3 years after bariatric surgery, while the psycho-social aspects became comparable. As the present thesis focuses specifically on depression and anxiety (with the mental health quality of life subscale measuring similar constructs), physical quality of life merits separate examination in the association between quality of life and alcohol misuse. Indeed, a lower physical quality of life post-surgery may increase the likelihood of post-surgical alcohol misuse through using alcohol to cope, as it is correlated with

depression in bariatric patients (Dixon et al., 2003). Therefore, the second aim of Chapter 4 was to examine changes in anxiety, depression and physical quality of life post-surgery as predictors of hazardous drinking and thereby offer empirical support for a negative reinforcement model of post-surgical alcohol misuse.

4.2.1 Objectives

The present study was a secondary data analysis using observational and self-reported participant data, conducted in collaboration with the SurgiCal Obesity Treatment Study (SCOTS), a longitudinal cohort study on bariatric surgery outcomes in the UK. The database was comprised of web or paper-based patient questionnaires completed before surgery and 6 months post-surgery. Clinical data reporting participant weight at baseline were also included. In order to examine empirical evidence for a negative reinforcement model of alcohol misuse, the present study constructed two models to address the following objectives:

Objective 1 – To examine pre-surgical variables (gender, age, type of surgery, pre-surgical alcohol consumption, physical quality of life, anxiety and depression) as predictors of the likelihood of hazardous drinking post-surgery.

Objective 2 – To examine changes in physical quality of life, anxiety and depression at 6 months post-surgery (relative to pre-surgery) as predictors of the likelihood of hazardous drinking, while controlling for pre-surgical significant risk factors identified through the first model/objective.

4.3 Method

4.3.1 Study Design

This study was a collaboration between the University of Liverpool and University of Glasgow's SCOTS research team. The SCOTS study (ISRCTN47072588) is a long-term observational cohort study of patients undergoing weight loss surgery in Scotland (see Appendix A). Favourable ethical opinion was granted by the Proportionate Review Sub-committee of the Yorkshire and The Humber – South Yorkshire Research Ethics Committee (REC: 17/YH/0039) in February 2017. Further, the University of Liverpool Joint Research Office (JRO) gave their approval to act as Sponsor under the Department of Health's Research Governance Framework for Health and Social Care (Sponsor Ref: UoL001263).

The main data source for the current study was the SCOTS study database held by the Robertson Centre for Biostatistics, comprising of web-based patient questionnaires before surgery and 6 months post-surgery and clinical data reporting participant weight at baseline. The data were collected in NHS Scotland hospitals and in private healthcare institutions where weight loss surgery is performed, see Logue et al (2015) for an additional description of methods used by SCOTS. All data used for this analysis were accessed via secure data transfer with an anonymised 'study ID,' and represented a snapshot of the most current records entered before the date of the data transfer (August 2017). To address the objectives of the present study, SCOTS data were sorted according to the inclusion criteria as follows:

1) Whether participants had follow-up data 6 months post-surgery

2) Whether participants drank alcohol and had completed the AUDIT-C at 6 months

3) Complete cases for all selected variables of interest both pre and post-surgery, with types of surgery outside of the three most common types

performed in Scotland (AGB, RYGB or SG) omitted (Scottish Medical and Scientific Advisory Committee, 2005).

Complete observations on the selected variables were missing from N = 237 in the initial database, and these participants were excluded to give a final sample of N = 55 (See Figure 4.1 for study size selection process). One case was excluded due to having a different surgery type from the rest of the participants who had either AGB, RYGB or SG, making the final cohort AGB (N = 9), RYGB (N = 14) and SG (N = 32). Data were then analysed using Firth method of penalized likelihood regression.

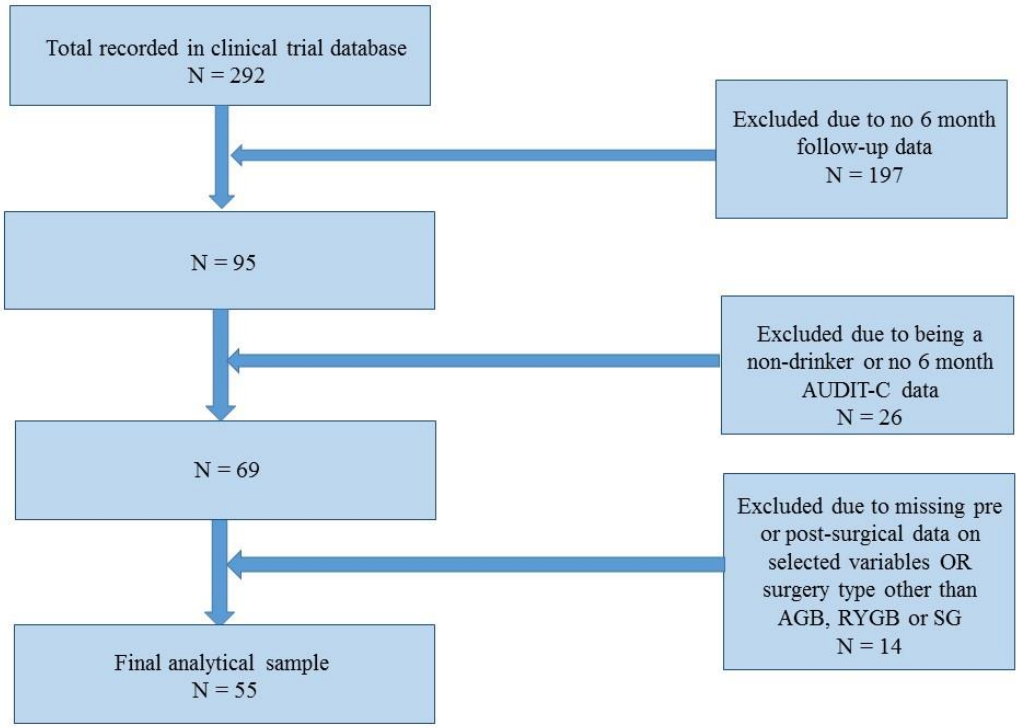

Figure 4.1. Flowchart showing the process of selecting the analytical sample for complete case analysis

4.3.2. Setting

The SCOTS cohort study is funded by the National Institute of Health Research Health Technology Assessment Programme (Ref 10/42/02) and was performed according to the Research Governance Framework for Health and Community Care, and World Medical Association Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects 1964. The SCOTS study aims to assess the long-term outcomes and complications of bariatric surgery by undertaking a 10 year follow up study of over 2,000 patients undergoing bariatric surgery in Scotland. All new bariatric surgery patients in the targeted regions of Scotland beginning in 2014 were initially screened for inclusion in SCOTS. Eligibility criteria for participation included 1) Age 16 years or older and undergoing their first bariatric surgery in NHS hospitals or private practice in Scotland (not repeat procedure at time of potential recruitment), 2) Capacity to consent, 3) Residing in Scotland, and 4) Written informed consent. For a detailed description on the SCOTS study design, recruitment strategy and list of all measures administered, please see the SCOTS study protocol described in Logue at al. (2015).

The database used for the present study was held by the administrators, and all patients scheduled to have bariatric surgery in the NHS and regional private sector were invited to participate. Clinically-derived data from patients who consented to participate were entered by clinical teams through a secure, web-based portal that was developed for the clinical study. In addition, participants who agreed to participate in the trial used the web-based portal to complete their questionnaire responses (or they could request a paper-based copy of the questionnaires). All clinical users of the portal were given a user ID and password, and role-specific training. Participants were given secure login information to use for the portal to

complete the questionnaires at their specified time points in the study. All identifiable participant information was stored separately from the clinical outcome data, and the information was linked using a database code, the use of which was regulated by study administrators. All data were protected using an anonymised 'study ID,' and no linkable identifiable information was included. Individuals able to access participant information for the purpose of sending reminder letters did not have access to clinical information, and clinical information had all participant contact details removed.

4.3.3 Measures

From the setting described above and using the articulated procedure, key variables were drawn from the dataset. Table 4.1 provides an overview of the study variables used for analysis.

Table 4.1. A description of all variables assessed at pre and post-surgery time points.

Pre-Surgical Variables	**Post-Surgical Variables**
Gender	Alcohol consumption
Age	Physical quality of life
Body Mass Index (BMI)	Depression
Surgery type	Anxiety
Alcohol consumption	
Physical quality of life	
Depression	
Anxiety	

4.3.3.1 Data Sources/Measurement

Demographic

Demographic information available via self-report by participants through the SCOTS web portal were age, surgery type, weight (kg) and height (cm) and ethnic group. As there were minor discrepancies between patient-entered weight (kg) and clinician-entered weight (kg) values pre-surgery, BMI was calculated for the current study using the patient-entered weight and height data. This was decided in order to maintain consistency between baseline, 1-month and 6-month outcome measures, as patient-entered weight was included in the online patient questionnaires via the SCOTS web portal, which also contained the other measures of interest detailed below.

Short Form Health Survey- (SF-12)

The SF-12 is a multipurpose 12-item short form assessing generic health status. It is a subset of the larger SF-36 scale, and is comprised of eight subscales – physical functioning, role limitations due to physical health problems, bodily pain, general health, vitality (energy/fatigue), social functioning, role limitations due to emotional problems and mental health (psychological distress and well-being). Scores for each of the eight subscales were calculated from responses to individual items. Questionnaire items 1 (general health), 8 (bodily pain), 9 (mental health) and 10 (vitality) were reverse scored, so that higher item values indicate better health. Following this, two summary measures were calculated within the database: 1) a physical component summary (PCS) comprising of physical functioning, role limitations due to physical health problems, bodily pain and general health subscales, and 2) a mental component summary (MCS) comprising of vitality, social

functioning, role limitations due to emotional problems, and mental health subscales. All scores were standardised using a z-score transformation and aggregated to estimate physical and mental summary scales. All summary scores ranged from 0 – 100, where higher scores indicated better quality of life (Ware et al., 1996). As the PCS and MCS were already calculated by the database administrators, Cronbach's α information on individual items was not available.

Patient Health Questionnaire for Depression (PHQ-9)

The Patient Health Questionnaire (PHQ-9) is a self-administered scale assessing depression, based on the Primary Care Evaluation of Mental Disorders (PRIME_MD) diagnostic instrument (Kroenke, Spitzer, & Williams, 2001). The responses to the DSM-IV criteria listed (for example "Over the past two weeks, how often have you been bothered with the following problems - feeling down, depressed or hopeless?") range from 0 (not at all) to 3 (nearly every day). The total score for the PHQ-9 is calculated by summing the responses to all 9 items. The possible range is 0-27, with higher scores indicating more severe depression. The categories include minimal depression (0-4), mild depression (5-9), moderate depression (10-14), moderately severe depression (15-19), and severe depression (20-27). This measure demonstrated good reliability (Cronbach's α = .90), and its validity and reliability for measuring depression in both clinical and research settings is well supported (Cameron, Crawford, Lawton, & Reid, 2008; Kroenke et al., 2001).

Generalised Anxiety Disorder Assessment (GAD-7)

The GAD-7 is a self-administered scale assessing anxiety developed by Spitzer et al (2006). The responses to the questionnaire items (for example "Over the last two weeks, how often have you been bothered by the following problems –

feeling nervous, anxious or on edge?") range from 0 (not at all) to 3 (nearly every day). The total score for the GAD-7 is calculated by summing the responses to all 7 items. The possible range is 0-21, with higher scores indicating more anxiety. The categories include minimal anxiety (0-5), mild anxiety (5-10), moderate anxiety (10-14) and severe anxiety (15-21). The GAD-7 had good internal consistency (Cronbach's $\alpha = .92$) and its validity and reliability for measuring anxiety in both clinical and research settings is well supported (Spitzer et al., 2006; Swinson, 2006).

Alcohol Use Disorder Inventory Test – Consumption (AUDIT-C)

The AUDIT-C is comprised of the first three items on the AUDIT (Saunders et al., 1993), and identifies hazardous drinking or harmful alcohol use using questions such as 'how often do you have a drink containing alcohol?' with possible responses ranging from 'never' to '4 or more times a week.' Scores on the AUDIT-C range from 0 to 12, with scores of 3 or more (in women) or 4 or more (in men) indicating hazardous or harmful alcohol use. The AUDIT-C is a valid measurement tool for alcohol use in medical and professional settings (Bradley et al., 2007; Osaki et al., 2014), and had acceptable internal consistency (Cronbach's α) of .75.

4.3.4 Statistical Analysis

Firth's penalized likelihood regression was used, due to its approach in reducing small-sample bias in maximum likelihood estimation. This method was implemented to reduce issues with model fitting and overcome the separation in the data that may occur. For details on this method, see Firth (1993); Heinze & Schemper (2002) and Wang (2014). Changes in anxiety, depression and quality of life scores were computed by subtracting each participant's baseline score from the 6-month score. Positive values for anxiety and depression indicated more anxiety and

depression at 6 months compared to baseline, while positive values for quality of life indicated a better quality of life at 6 months post-surgery relative to baseline.

4.3.5 Missing data and arriving at the final analytical sample

Following the transfer of the sub-set of clinical data to Liverpool, some participants had missing values for the variables of interest (See Table 4.2 for description of missing data). Therefore, a complete case only analytical approach was applied where those with any missing data for the variables of interest were removed from the final sample, rather than undertaking missing values replacement, in order to avoid the risk of a large amount of data imputation obscuring any significant statistical effects (Royston, 2004). The final analytical sample with complete data was $N = 55$ after excluding those with missing values or having a different surgery type ($N = 238$). Refer to Figure 4.1 for a description of the selection methods for the study sample.

Table 4.2. Number of missing data for each variable of interest within the sample before dropping due to insufficient follow-up data

Variable	Complete Data	Missing Data
Baseline		
Sex	292	0
Body Mass Index	270	22
Age	292	0
Surgery Type	176	116
Alcohol Consumption	212	80
Physical Quality of Life	270	22
Depression	274	18
Anxiety	268	24
6 Months		
Alcohol Consumption	70	222
Physical Quality of Life	89	203
Depression	94	198
Anxiety	94	198

4.4 Results

4.4.1 Participants

A total of $N = 55$ participants (AGB $N = 9$, RYGB $N = 14$, SG $N = 32$) were included in the analysis. See Table 4.3 below for all participant characteristics, grouped by type of surgery received.

Table 4.3. Participant characteristics, split by surgery type (figures are numbers per group, means, percentages and ± SD where indicated). P values were calculated using a one-way Welch's ANOVA to assess between-group differences.

Variable	Surgery Type			Between-group differences P value
	AGB ***N* = 9**	**RYGB** ***N* = 14**	**SG** ***N* = 32**	
Gender				
Male	3 (33.3%)	3 (21.4%)	8 (25%)	.820
Female	6 (66.7%)	11 (78.6%)	24 (75%)	.820
Ethnic Group				
Scottish	8 (88.9%)	12 (85.7%)	27 (84.4%)	--
British	1 (11.1%)	--	3 (9.4%)	--
Irish	--	--	1 (3.1%)	--
Any other white ethnic group	--	1 (7.1%)	1 (3.1%)	--
Mixed ethnicity	--	1 (7.1%)	--	--
Age at surgery (yr)	61.56 (± 39.18)	45.64 (± 6.95)	47.50 (± 10.09)	.080
Pre-Surgery BMI (kg/m²)	40.57 (± 5.09)	43.76 (± 5.62)	45.80 (± 7.58)	.126
Weight (kg)				
Baseline	115.57 (± 9.27)	122.87 (± 20.31)	124.01 (± 22.59)	.552
1 month	110.95 (± 15.22)	106.89 (± 18.47)	107.05 (± 18.43)	.855
6 months	99.41 (± 8.53)	94.36 (± 13.09)	99.21 (± 18.09)	.609
Overall weight change	- 16.16 (± 5.83)	- 28.51 (± 9.98)	- 23.95 (±15.61)	.097

4.4.2 Baseline Differences Across Groups

A one-way Welch's ANOVA indicated that the different surgery groups did not differ significantly in terms of depression ($F(2, 78.15) = 1.98$, $p = .144$), anxiety ($F(2, 71.01) = 1.68$, $p = .193$), physical quality of life ($F(2, 75.95) = .55$, $p = .577$), and alcohol consumption ($F(2, 54.10) = 1.91$, $p = .158$).

4.4.3 Objective 1: Pre-Surgical Predictors of Hazardous drinking

To address objective 1, a Firth regression was performed to determine the effects of gender, age, type of surgery, pre-surgical alcohol consumption, physical quality of life, anxiety and depression on the likelihood that participants would report post-surgical hazardous drinking. There was high multi-collinearity between pre-surgical SF-12 mental health component summary (MCS), depression ($p < .001$) and anxiety ($p < .001$), and post-surgical MCS, depression ($p < .001$), and anxiety ($p < .001$). To maintain consistency throughout the thesis which focuses specifically on depression and anxiety, the current study analysed these in place of the MCS subscale.

The model fit well to the data (likelihood ratio 26.54, $df = 9$, $p < .001$), see Table 4.4 for a summary of the regression. Pre-surgical hazardous drinking was a significant predictor of post-surgery hazardous drinking. Also, physical quality of life was a significant predictor of post-surgical hazardous drinking, such that lower quality of life scores at pre-surgery increased the likelihood of reporting post-surgical hazardous drinking. Finally, surgery type was a significant predictor, as receiving AGB increased the likelihood of reporting post-surgical hazardous drinking compared to receiving SG. However, there were no significant differences observed between having AGB compared to RYGB, or between RYGB and SG, on the

likelihood of reporting post-surgical hazardous drinking. Pre-surgical anxiety and depression were non-significant predictors of post-surgical hazardous drinking. Review Table 4.4 below for all pre-surgical predictors of the increased likelihood for hazardous drinking.

Table 4.4. Pre-surgical predictors (significant and non-significant) of increased likelihood of hazardous drinking 6 months post-bariatric surgery

Explanatory Variables	**Coefficient**					
	Estimative	**Standard Error**	**Lower CI**	**Upper CI**	**Chi-square**	**P value**
Gender	.77	.81	-.70	2.33	1.06	.304
Age (in years)	.00	.02	-.03	.10	.00	.986
Pre-Surgery BMI	.04	.06	-.05	.15	.68	.407
Surgery Type						
Comparing AGB to RYGB	-1.34	1.30	-4.03	1.03	1.20	.273
Comparing AGB to SG	-2.71	1.31	-5.71	-.42	5.59	.018
Comparing RYGB to SG	-1.37	.97	-3.47	.39	2.27	.131
Pre-Surgery hazardous drinking	.54	.18	.23	.95	12.99	<.001
Physical quality of life	-.11	.05	-.24	-.02	6.40	.011
Depression	.11	.10	-.07	.30	1.48	.224
Anxiety	-.21	.12	-.47	.01	.01	.062

4.4.4 Changes in Measures After Surgery

A one-way Welch's ANOVA indicated that the different surgery groups did not differ significantly post-surgically in terms of depression scores ($F(2, 45.98) = 1.19$, $p = .313$), anxiety scores ($F(2, 44.01) = .052$, $p = .949$) and physical quality of life scores ($F(2, 43.56) = 2.25$, $p = .117$). However, paired samples t-tests indicated that, in general, depression scores significantly improved at 6 months post-surgery ($t(54) = 3.36$, $p = .001$), while anxiety scores approached significance, but did not improve ($t(54) = 1.96$, $p = .055$). Physical quality of life scores at 6 months post-surgery also significantly improved relative to pre-surgery values ($t(54) = -9.24$, $p < .001$). There was no difference in improvements to depression ($F(2,19.71) = 2.06$, $p = .153$), anxiety ($F(2, 19.61) = 2.67$, $p = .094$) or physical quality of life ($F(2,20.92) = 1.75$, $p = .199$) between different surgery groups (i.e. depression was not more improved in one surgery type group over another, etc).

The outcome event 'hazardous drinking' was indicated from scores on the AUDIT-C, which was administered at baseline and 6 months following weight loss surgery. Overall, a 2 x 3 repeated measures ANOVA test indicated that there was a main effect of time (pre-surgery and post-surgery) on alcohol consumption, $F(1,52) = 4.69$, $p = .035$, $\eta_p^2 = .08$. A paired samples t-test indicated that in general, alcohol consumption significantly decreased at 6 months post-surgery ($t(54) = 3.08$, 95% CI = .28 to 1.32, $p = .003$, $d = 0.42$), with pre-surgical AUDIT-C scores averaging 0.8 points higher than post-surgical scores (SD $\pm$ 1.92). For a depiction of changes in AUDIT-C scores from pre-surgery to 6 months post-surgery, see Figure 4.2. There was no interaction between time and surgery type $F(2,52) = .94$, $p = .397$, $\eta_p^2 = .04$, therefore no post-hoc tests were conducted.

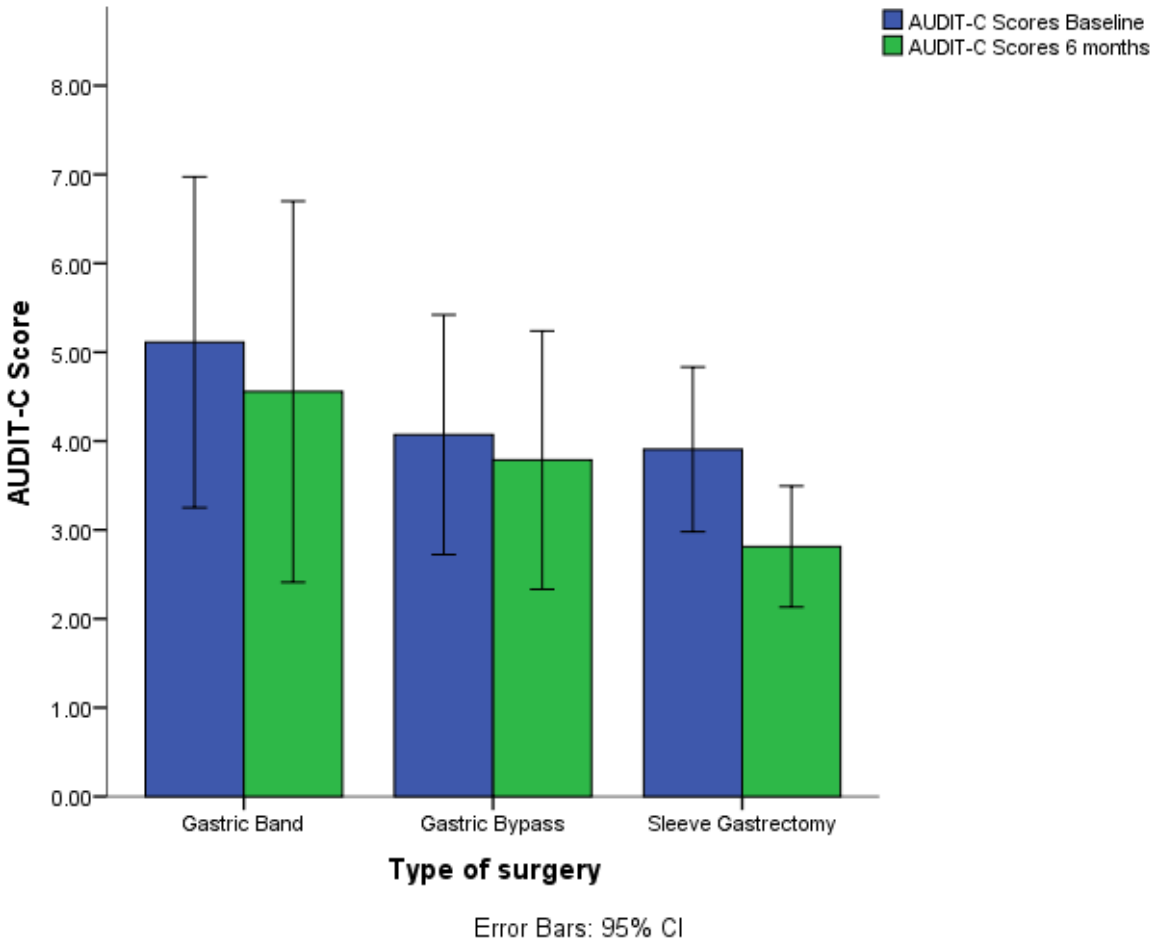

Figure 4.2. Changes in AUDIT-C scores from pre to post-surgery, stratified by surgery type

In the AGB group, *N* = 8 out of 9 (88.89%) had hazardous drinking 6 months post-surgery, as well as RYGB *N* = 9 out of 14 (64.29%) and SG *N* = 15 out of 32 (46.88%). A one-way Welch's ANOVA indicated that the groups did not differ significantly in terms of alcohol consumption ($F(2,26.44) = 1.41$, $p = .260$), or hazardous drinking at 6 months post-surgery ($F(2, 30.01) = 1.53$, $p = .231$).

Before surgery, a total of 18 (32.73%) of participants did not report hazardous drinking, and 37 participants (67.27%) did report pre-surgical hazardous drinking. After surgery, participants either continued with their pre-surgical non-hazardous drinking patterns (23.64%), developed new-onset hazardous drinking

(9.09%), continued their pre-surgical hazardous drinking patterns (49.09%) or discontinued hazardous drinking from pre-surgery (18.18%). Table 4.5 categorises the drinking patterns of all participants by comparing the scores on the AUDIT-C pre-surgery and 6 months post-surgery, grouping participants by gender and surgery type.

Table 4.5. Drinking Patterns Pre and Post-Surgery, grouped by surgery type (figures are number of participants in each category and percentages calculated from the total participant sample of *N* = 55).

Drinking Pattern ***N* = 55**	**Surgery Type**		
	AGB ***N* = 9**	**RYGB** ***N* =14**	**SG** ***N* = 32**
No Hazardous Drinking at either time point, *N* = 13 (23.64%)			
Male	--	2 (14.2%)	3 (9.3%)
Female	--	2 (14.2%)	6 (18.7%)
Post-Surgical New Onset Hazardous Drinking, *N* = 5 (9.09%)			
Male	1 (11.1%)	--	--
Female	--	1 (7.1%)	3 (9.3%)
Continued Hazardous Drinking from Pre-Surgery, *N* = 27 (49.09%)			
Male	4 (44.4%)	4 (28.5%)	4 (12.5%)
Female	3 (33.3%)	4 (28.5%)	8 (25.0%)
Discontinued Hazardous Drinking from Pre-Surgery, *N* = 10 (18.18%)			
Male	1 (11.1%)	--	3 (9.3%)
Female	--	1 (7.1%)	5 (15.6%)

4.4.5 Objective 2: Post-Surgical Predictors of Hazardous drinking

To address Objective 2, a second Firth regression was performed to determine the effect of post-surgical variables at 6 months (depression, anxiety and physical quality of life) on the likelihood of participants reporting post-surgical hazardous drinking. The model fit well to the data (likelihood ratio = 30.25, df = 7, $p < .001$), see Table 4.6 for a summary of the regression. Pre-surgical predictors of post-surgical hazardous drinking remained significant in this second model (i.e. hazardous drinking, low physical quality of life, and receiving AGB compared to SG, but not RYGB). After controlling for the significant pre-surgery predictors in model one, a further significant predictor of post-surgical hazardous drinking was change in anxiety, such that increasing anxiety scores 6 months after surgery raised the likelihood of hazardous drinking at the same time point. There was no significant risk associated with change in depression or physical quality of life.

Table 4.6. Post-surgical predictors (significant and non-significant) of increased likelihood of hazardous drinking 6 months post-bariatric surgery

	Coefficient					
Explanatory Variables	**Estimative**	**Standard Error**	**Lower CI**	**Upper CI**	**Chi-square**	**P value**
Significant Pre-Surgical Predictors						
Surgery Type						
Comparing AGB to SG	-2.96	1.33	-5.97	-.74	7.39	.007
Hazardous drinking	.62	.20	.27	1.09	14.06	<.001
Physical quality of life	-.11	.05	-.23	-.01	4.87	.027
Post-Surgical Predictors						
Change in depression	-.07	.09	-.25	.09	.83	.361
Change in anxiety	.32	.14	.09	.66	8.00	.005
Change in physical quality of life	.06	.05	-.07	.12	.22	.148

4.5 Discussion

Chapter 4 examined psychological, demographic and behavioural influences on the likelihood of reporting hazardous drinking 6 months after bariatric surgery using observational and self-reported participant data in a longitudinal cohort study in the UK. The primary aim was to examine pre-surgical negative affect-related factors, demographic and behavioural characteristics. A secondary aim was to build empirical support for a negative reinforcement model of post-surgical alcohol misuse through examining changes in anxiety, depression and physical quality of life post-

surgery as predictors of hazardous drinking. Key findings were that greater alcohol consumption before surgery, lower physical quality of life before surgery, receiving AGB vs. SG surgery type, and increasing anxiety scores after surgery raised the likelihood for hazardous drinking 6 months post-surgery.

Results from the present study support the literature where greater alcohol consumption before surgery increased the risk for post-surgery alcohol misuse (King et al., 2012; Lent et al., 2013). While hazardous drinking decreased overall at 6 months, results indicated a group wherein changes in hazardous drinking did not occur (N = 27, 49.09%, Table 4.5). This could lead to further problems, as Woodard and colleagues (2011) found that blood alcohol levels increased at 6 months post-surgery when consuming the same alcoholic drink from pre-surgery, which could lead to excessive consumption and subsequent loss of control. Therefore, physiological changes in absorption and related risks should be communicated to bariatric candidates. Also, findings offer some support for the 'reverse phenomenon' found by Wee and colleagues (2014); where high risk drinkers discontinued their drinking patterns after surgery, although this was observed in relatively few patients in the present study (N = 10, 18.18%). It is recommended that patients should avoid drinking alcohol for several months after surgery to facilitate healing (Mechanick et al., 2013), which may have promoted discontinuation as outcome measures were assessed at 6 months. Further, the new onset cases (N = 5, 9.09%) could represent patients using alcohol as a coping strategy, as increases in anxiety post-surgery were associated with hazardous drinking.

Although negative-affect related traits have been cited in the development of alcohol misuse (Chapter 1, section 1.3.1), results from the present study did not find this effect for depression. This supports evidence from the LABS-2 cohort, where

pre-surgery depression scores were not associated with alcohol misuse (King et al., 2012). Post-surgery findings could be related to a short-term improvement in depression, associated with weight loss and improvements in appearance evaluation (Dixon et al., 2003). Key findings were that anxiety did not improve after surgery, and increased anxiety by 6 months raised the likelihood of hazardous drinking. This contrasts with evidence supporting anxiety symptom improvement in the year following surgery (Karlsson et al., 2007). However, it is possible that anxiety symptoms may take longer than 6 months to improve in bariatric patients. Further, the relationship between anxiety and alcohol misuse may reflect less than adequate coping mechanisms, and less tolerance for anxiety symptoms (Cox, Swinson, Shulman, Kuch, & Reichman, 1993). Indeed, anxiety sensitivity and hazardous drinking occurred through drinking to cope in Chapter 3. Therefore, evidence from the present study could indicate coping with anxiety through hazardous drinking after bariatric surgery.

The present study supports that lower physical quality of life before surgery was associated with hazardous drinking at 6 months. This contrasts with evidence from King and colleagues (2012), who found no significant association with post-surgery AUD. As greater obesity has negative consequences on physical quality of life (Kushner & Foster, 2000), pre-surgery scores could be weight-related. Indeed, physical quality of life improved by 6 months, supporting conclusions from Burgmer and colleagues (2014), where improvements began the first year after surgery. Given these results, patients with reduced physical quality of life before surgery could benefit from alcohol-related support following surgery. Further research is needed to investigate the connection between physical quality of life and later alcohol misuse,

as these results were from short-term observations and did not reflect conclusions from the LABS-2 cohort with 2 years post-surgery outcomes (King et al., 2012).

An unexpected finding was that receiving AGB increased the likelihood of hazardous drinking, relative to SG. This contrasts with evidence supporting RYGB increasing the risk for AUD (Conason et al., 2013; King et al., 2012; Ostlund et al., 2013; Suzuki et al., 2012; Svensson et al., 2013). All but one AGB participant reported pre-surgery hazardous drinking, which could influence the evidence for surgery type as a predictor, therefore causality cannot be inferred. Additionally, most of the AGB surgeries were performed in the west of Scotland, while RYGB was mostly performed in the east. This aligns with geographical variations in Scotland for alcohol-related hospital admissions, with high rates in western regions (e.g., Greater Glasgow and Clyde), and larger percentages of income and health deprivation relative to other Scottish health boards (Information Services Division, 2016; Scottish Index of Multiple Deprivation, 2016). As the SCOTS study is not a randomised controlled trial, regional, cultural or socioeconomic differences could form the basis of this finding. Future study is needed, as sample size increase in a re-analysis could determine whether these effects persist, as well as including site data in the model.

4.5.1 Strengths and Limitations

A strength of the present study was assessing post-surgery hazardous drinking using the AUDIT-C. As this measure is comprised of three questions, it reduces the burden of questionnaire responses on patients and captures meaningful data akin to the 10-item AUDIT (where missing data occurred within this cohort) (Bradley et al., 2007). Completion was a limitation of the dataset; although there

were N = 292 participants initially, only N = 70 had 6-month post-surgical drinking data recorded, and fewer still could be included without pre-surgical AUDIT-C scores (See Figure 4.1). Another strength included measuring anxiety and depression across different time points, as this facilitated examining changes in scores over time, and whether these increased the likelihood of hazardous drinking (e.g. anxiety). Future research should further assess distal risk factors (i.e. stress and coping skills) on alcohol misuse, as these have been implicated in SUD for bariatric patients (Ivezaj et al., 2014). Future study exploring the relationship between pre-surgical emotional eating, grazing and a 'transfer' in coping mechanisms would reveal more about negative affect regulation following surgery, as these were not assessed in the present chapter. This would be especially relevant in a cohort with a long-term follow up, as hazardous drinking tends to appear 2 years post-surgery (Chapter 1, section 1.1.4).

4.5.2. Conclusion

Significant pre-surgical predictors included hazardous drinking, lower physical quality of life, and surgery type (where receiving AGB increased the likelihood compared to a SG, although these results should be interpreted cautiously given the few AGB cases in the sample, and possible regional differences). A significant post-surgical predictor was increasing anxiety by 6 months. Results are consistent with the wider literature on post-bariatric surgery alcohol use, where greater drinking before surgery increases the incidence of post-surgical alcohol misuse. Further, findings could also indicate the possibility of using alcohol to cope with increasing anxiety after surgery. Further, the role of a low physical quality of life in increasing the likelihood of hazardous drinking is a novel finding, and future

studies would benefit from examining this further in a larger cohort with longer-term follow up after surgery.

Chapter 5: Psychological and behavioural predictors of alcohol problems up to 8 years post-bariatric surgery

5.1 Abstract

Chapters 2-4 indicated a role for negative affect-related processes on alcohol misuse. Evidence in Chapter 4 was from 6 months post-surgery, or within the 'honeymoon period' of rapid weight loss (Lynch, 2016), improvements in depression, anxiety and quality of life (Dixon et al., 2003; Karlsson et al., 2007). Thus, Chapter 5 analysed clinical data with at least 2-year outcomes. Further, alcohol misuse could represent a substitute coping strategy from eating (Chapter 1). Therefore, Chapter 5 examined associations between pre-surgery emotional eating, post-surgery grazing, and alcohol problems. Chapter 5 used prospectively collected data from a UK hospital to examine predictors of post-surgical alcohol problems. Age, gender, surgery type (RYGB and SG), weight and alcohol use were extracted from a clinical bariatric database and health records. Clinical records were qualitatively reviewed and assigned a dichotomous 'present' (1) or 'absent' (0) code for depression or low mood, anxiety, emotional or binge eating, grazing/snacking, increase in post-surgical life stress, suicide idealisation or attempt, and post-surgical alcohol problems. N = 250 complete records were available (male N = 54, female N = 196; Age at surgery = 45.27 years $\pm$ (23.76); RYGB N = 120, SG N = 130). Alcohol problems were present in 5.6% of the cohort (14 cases; RYGB N = 7, SG N = 7). Data were analysed using Firth's penalized likelihood regression**.** *The first model* analysed pre-surgical data and demonstrated that suicide attempt/idealisation (p = .017; OR = 13.33), and heavy drinking compared to low drinking and not drinking (p = .042; OR = 5.81 and p = .034; OR = 7.24, respectively) predicted the likelihood of post-surgery alcohol problems. *The second* model used post-surgical data and found that

depression/low mood (p = .016; OR = 8.41) and increased life stress (p < .001; OR = 36.60) both predicted the likelihood of alcohol problems, while "grazing" or snacking had a negative relationship (p = .043; OR = 0.18). *The third model* examined combined effects of negative events and pre-surgical emotional eating and found that 1) having a negative pre or post-surgical event or pre-surgical emotional eating predicted the likelihood of alcohol problems (p = .030; OR = 3.82), and no difference was observed between having either, and having both (p = .276; OR = 2.53). Findings indicate partial support for a 'transfer' in coping mechanisms from eating to alcohol use.

5.2 Introduction

Chapters 2 and 3 highlight the role of negative-affect in alcohol misuse, and Chapter 4 supports both psychological (e.g., anxiety) and behavioural (e.g. hazardous drinking before surgery) contributors to the likelihood of hazardous drinking 6 months post-surgery. Importantly, the incidence of alcohol misuse appears to be time-sensitive, with observations of AUD symptoms rising significantly during the second-year post-surgery (King et al., 2012), and persisting over time (Svensson et al., 2013). Therefore, Chapter 5 aims to gather further empirical support for a negative reinforcement model of alcohol misuse in the long-term following surgery. The first and second aims of the present study were to examine pre and post-surgical psychological, demographic and behavioural influences on the likelihood of post-surgical alcohol problems in a cohort with 2-8 years of outcome data.

Evidence from Chapter 3 supports a motivational model of alcohol use (Cooper et al., 1995), wherein the relationship between negative affect (i.e. hopelessness and anxiety sensitivity) occurred specifically through using alcohol as a

coping mechanism. As described in Chapter 1 (1.3.2.1), negative affect (e.g., depression, suicide idealisation) appears uniquely prevalent in bariatric surgery candidates. In more severe cases, these psychological vulnerabilities can persist following bariatric surgery, as recipients have a higher relative risk of suicide and non-fatal self-harm relative to patients receiving usual care or intensive lifestyle modification treatment (Neovius et al., 2018). The connection between pre-surgical suicide idealisation or attempts and alcohol-related outcomes in bariatric patients has not, to our knowledge, been explored. However, it has been observed elsewhere that approximately 40% of individuals pursuing treatment for alcohol dependence reported at least one lifetime suicide attempt (Roy, 2003). Therefore, pre-surgical negative affect-related characteristics and more severe psychopathology (e.g., suicide idealisation) merit examination alongside post-surgical negative-affect related factors (e.g., life stress).

In Chapter 3, the association between negative affect-related characteristics and unhealthy snacking occurred through eating to cope. For bariatric patients, these maladaptive eating behaviours may manifest differently post-surgery due to changes in stomach restriction and surgery type. Patients who previously reported binge eating could be similarly prone towards post-surgical 'grazing' (e.g., repetitively eating small amounts of food) when there are new barriers to consuming large amounts of food (Colles et al., 2008; Conceição, Mitchell, Pinto-Bastos, et al., 2017). Moreover, post-surgery grazing has been associated with depression and lower mental health quality of life (Colles et al., 2008), suggesting a possible negative affect regulation strategy. Importantly, the ability to access binge or emotional eating could be ascribed to the type of surgery a patient receives. Freeman and colleagues (2014) compared pre-surgical obese controls, AGB, SG and RYGB patient groups

and observed that controls and post-surgery AGB patients ate significantly more high-calorie foods and had poorer weight loss outcomes. Further, Chapter 2 found that patients without problem alcohol use found their surgery restriction manageable, while patients with problem alcohol use 'drank because they couldn't eat.' These observations together suggest that an ability to maintain problematic or over-eating behaviours could potentially negate the need to seek alternative coping strategies, such as alcohol use, for regulating negative affect.

As reviewed in Chapter 1 and further evidenced in Chapter 4, both regular alcohol use and pre-surgical AUD symptoms have been associated with an increased risk for developing post-surgical AUD. Nevertheless, upwards of 20.8% of the bariatric patients who reported AUD post-surgery in a study by King and colleagues (2017) were also new onset. This suggests that some individuals could be using alcohol as a substitute coping strategy when the previous eating-centred coping strategy is no longer viable due to surgery-induced limitations on eating behaviours (Hardman & Christiansen, 2018; Steffen et al., 2015; Yoder et al., 2018). The presence of negative affect pre-surgery and increases in negative affect post-surgery are of key interest – importantly, Chapter 4 found that increased anxiety (from pre- to post-surgery) was associated with hazardous alcohol intake post-surgery. Patients who use food as a way of coping (i.e. through emotional eating pre-surgery), or those who experience negative events post-surgery, may therefore have an increased risk for alcohol misuse. The final aim of the present study was to more directly test the switch in coping mechanisms hypothesis by examining negative pre and post-surgical events (e.g., increase in life stress) *and* pre-surgical emotional eating as risk factors for post-surgical alcohol problems.

5.2.1 Objectives

The present study conducted a secondary data analysis of observational, routinely-collected health data held by a hospital in the UK (a recognised method for improving patient-oriented research and improving health care; Benchimol et al., 2015). It had the following objectives:

Objective 1 - To examine pre-surgical variables (i.e. age at surgery, weight, gender, surgery type, emotional eating or binge eating patterns, anxiety, depression or suicide idealisation/attempt, and alcohol Kcals) as predictors of the likelihood of post-surgical alcohol problems.

Objective 2 - To examine post-surgical variables (i.e. depression, increases in life stress, binge eating, grazing and weight change) predicting the likelihood of post-surgical alcohol problems, while controlling for significant pre-surgical variables.

Objective 3 - To examine the combined effects of negative events (i.e. pre-surgical suicide idealisation/attempt, post-surgical increase in life stress or post-surgical depression) and pre-surgical emotional eating on the likelihood of post-surgical alcohol problems.

5.3 Method

5.3.1 Setting

This study was a collaboration between the University of Liverpool and a hospital that performs bariatric surgery in the UK. Approval for an honorary contract with the hospital trust was awarded in December 2016. Favourable ethical approval for the secondary data analysis was granted by the University of Liverpool Institute of Psychology, Health and Society Research Ethics Committee (REF:2154) in October 2017. The main dataset used for the present study was created using an

extant bariatric database held by the hospital, which is regularly maintained and updated by local medical personnel. Clinically-derived data from patients were previously entered by clinical personnel. The bariatric database held hospital-created anonymised 'study ID numbers' that were linkable to patient hospital numbers, so that identification could be separate from their hospital number. Data held within the hospital database was dated beginning in August 2007 and continues to be updated regularly by the clinical personnel. For the present study only pre-surgery data collected from August 2007 – February 2015 were used, as 2 year follow up data were initially chosen due to this being the timeframe at which alcohol use becomes significantly higher in post-bariatric surgery patients, compared to the first-year post-surgery (King et al., 2012). All anonymised data from the created dataset were analysed at the University of Liverpool using the hospital joint research office-approved method of an encrypted NHS Trust-issued USB. All study findings have been reported using the RECORD method for reporting routinely-collected health data (Nicholls et al., 2015)

5.3.2 Measures

The key study variables were drawn from several sources within the hospital records. Review Table 5.1 for an overview of the study variables used for analysis.

Table 5.1. A description of all variables, and the data sources from which they were derived.

Pre-Surgical Variables	**Post-Surgical Variables**
Bariatric database	*Bariatric database*
Age	Weight (kg) 3 – 12 months post-surgery
Gender	Alcohol problems
Pre-surgical weight (kg)	
Surgery type	
Multidisciplinary team (MDT) notes	*Dietician clinic forms, Clinical notes, Psychotherapy outpatient letters and GP letters*
Emotional eating	
Binge eating	Grazing/Snacking
Depression	Binge eating
Anxiety	Depressed or low mood
Suicide idealisation/attempt	Increase in life stress
Pre-surgical alcohol use (Kcals)	Alcohol Problems

5.3.2.1 Pre-surgical data sources/measurement

Bariatric Database

Demographic variables were drawn from the anonymised database, which used anonymised 'study ID' numbers that were linked to patient hospital numbers. Age at the time of surgery was recorded in years. Gender was recorded pre-surgery as either female (1) or male (2). Surgery type was either RYGB (1) or SG (2). Pre-surgical weight (recorded on operation day) and weight changes at the follow-up appointments was recorded in kilograms, and this formed the computed Z-scored variable used to analyse 'overall weight change,' over their course of recovery from bariatric surgery (i.e., follow up weight subtracted from baseline weight). Any

indicators of alcohol misuse in the bariatric database or otherwise communicated by clinicians, dieticians or psychologists were dichotomously coded as either present (1) or absent (0).

Multi-Disciplinary Team (MDT) Notes

Before being given a surgery date, patient information was discussed at a multi-disciplinary team meeting comprised of a consultant, surgeon, nurse, dietician, physician, anaesthetist and occasionally a psychologist. These assessments were recorded in a paper-based and scanned or electronic 'Multi-Disciplinary Team Notes' (MDT) form, which was associated with the patient's medical record. Large parts of the MDT forms were comprised of the clinical nurse specialist (CNS) and Dietetic assessments, with notes made by the consultant, surgeon, physician, anaesthetist and psychologist. The researcher reviewed all accessible MDT forms, and excluded individuals from the larger bariatric database if they did not have a linked MDT form, or if the form was an outdated version which did not contain the variables of interest. These included any mention of pre-surgical Emotional or Binge eating, coded as either present (1) or absent (0). Further, mentions of Depression, Anxiety and Suicide idealisation or attempts were dichotomously coded as either yes (1) or no (0). Pre-surgical alcohol use was classified using four categorical levels based on the level of kilocalories (Kcals) the patient ingested each week from alcohol - Not Applicable (0), Low (1), Moderate (2) and High (3).[1]

[1] This scale was taken from the most recent versions of MDT forms on file (N = 159). When data from the dietetic assessment section of older versions (N = 147) of MDT forms differed (alcohol use; 0 = negligible, 1 = rarely, 2 = occasionally, 3 = moderate, and 4 = high), the scores 2 and 3 were collapsed into one score, which was then matched with the newer scale as a '2' (moderate), making the final scale comparable across both groups (0, 1, 2 and 3).

5.3.2.2 Post-surgical data sources/measurement

Dietician Clinic Forms, Clinical Notes, Psychotherapy Outpatient Letters and GP Letters

The post-surgery variables were dichotomously coded as either present (1) or absent (0) upon review of the paper-based and electronic case notes associated with each patient added by the dieticians, surgeons, GPs, psychologists or any combination of the aforementioned medical personnel at the hospital. As part of routine care, patients were regularly contacted by dieticians regarding their nutritional needs following surgery, and each time a visit occurred a dietician clinic note was added to the patient record. Further, surgeons regularly communicated with the patient's GP in the form of a GP letter after their follow up visit, and these communications were uploaded to the patient record. In some occasions, psychotherapy letters were included with the patient files when referrals to other services were recommended. This information is held in the hospital electronic Clinical Data Repository (CDR). All these document types were reviewed by the researcher for the identified variables of interest, which included 1) Binge eating, 2) Grazing/Snacking, 3) Increase in life stress, 4) Depressed or low mood, and 5) Alcohol problems.

Binge eating was recorded as either present or absent based on information in the associated clinic forms, notes or GP and psychotherapy letters (1 or 0), as was grazing or snacking (1 or 0). 'Increase in life stress' was a qualitatively ascertained variable (1 or 0) based on notes made in clinic forms, or in the letters written by members of the multidisciplinary team to the GP or received by the GP pertaining to the patient's circumstances or disclosures made by the patient, as was depressed or

low mood (1 or 0) and alcohol misuse (1 or 0). As the clinic notes were qualitative data, another researcher (Paul Christiansen) independently reviewed the anonymised alcohol-related clinic notes and their associated coding to address potential sources of bias, and the inter-rater reliability was found to be K = 1.00.

5.3.3 Procedure

The study data were collected onsite at the hospital in the UK. For the purposes of the present study, only the anonymised study ID numbers were used to create the dataset, and hospital numbers from the database population were used to look up data sources only, with no identifiable information recorded in the anonymised dataset from these sources. Using this information, data were sorted according to the inclusion criteria as follows

1) Whether patients received bariatric surgery more than 2 years previously.

2) Whether patients had an associated multidisciplinary (MDT) form in their pre-surgical health record, as these held the pre-surgical variables of interest.

The exclusion criteria involved not meeting the inclusion criteria. Lastly, the dietician clinic forms, clinical notes, psychotherapy outpatient letters and GP letters of these patients were reviewed within the hospital electronic records system clinical data repository (CDR) using the linked patient hospital number from the anonymised study ID. Complete observations on the selected variables were missing for $N = 56$ participants at this stage, and these participants were excluded from the final sample of $N = 250$ (see section 5.3.5 and Figure 5.1 below for a description of study size selection process).

5.3.4 Statistical Analysis

Firth's penalized likelihood regression was used, due to its approach in reducing small-sample bias in maximum likelihood estimation. The dependent variable 'alcohol problems at post-surgery' represented a rare event (N = 14 cases out of 250), therefore the method was implemented to reduce issues with model fitting and overcome the separation in the data that occurs with rare events. For details on this method, see Firth (1993); Heinze & Schemper (2002) and Wang (2014). A complete case only analytical approach was applied where those with any missing data for the variables of interest were removed from the final sample, rather than undertaking missing values replacement, in order to avoid the risk of a large amount of data imputation obscuring any significant statistical effects (Royston, 2004).

5.3.5. Missing data and arriving at the final analytical sample

Following data collection from the MDT forms, there were instances of missing data from the variables of interest (particularly weight data between 12- and 18-24-months post-surgery) that would have been derived from patients attending follow-up appointments (see Table 5.2 for description of missing data, 'Overall Weight Change'). The present study included complete cases with post-surgery variables (weight, binge eating, grazing/snacking, increase in life stress, depressed or low mood, and alcohol problems) up to 8 years post-surgery.

Table 5.2. Number of missing data for each variable of interest within the sample before dropping due to insufficient follow-up data (N = 306)

Variable	Complete Data	Missing Data
Pre-Surgery		
Age	306	0
Pre-surgical weight	291	12
Surgery Type	306	0
Emotional Eating	302	4
Binge Eating	306	0
Anxiety	301	5
Depression	301	5
Suicide Idealisation/Attempt	301	5
Alcohol Use (Kcals)	291	15
Post-Surgery		
Grazing/Snacking	306	0
Binge Eating	306	0
Increases in Life Stress	306	0
Depressed/Low Mood	303	3
Overall Weight Change	268	38
Alcohol Problems	306	0

Data were counted as 'complete' if data from all variables of interest were reported. The final analytical sample size with complete data was N = 250 after excluding those with missing values (N = 56). See Figure 5.1 for a description of the selection methods for the study sample.

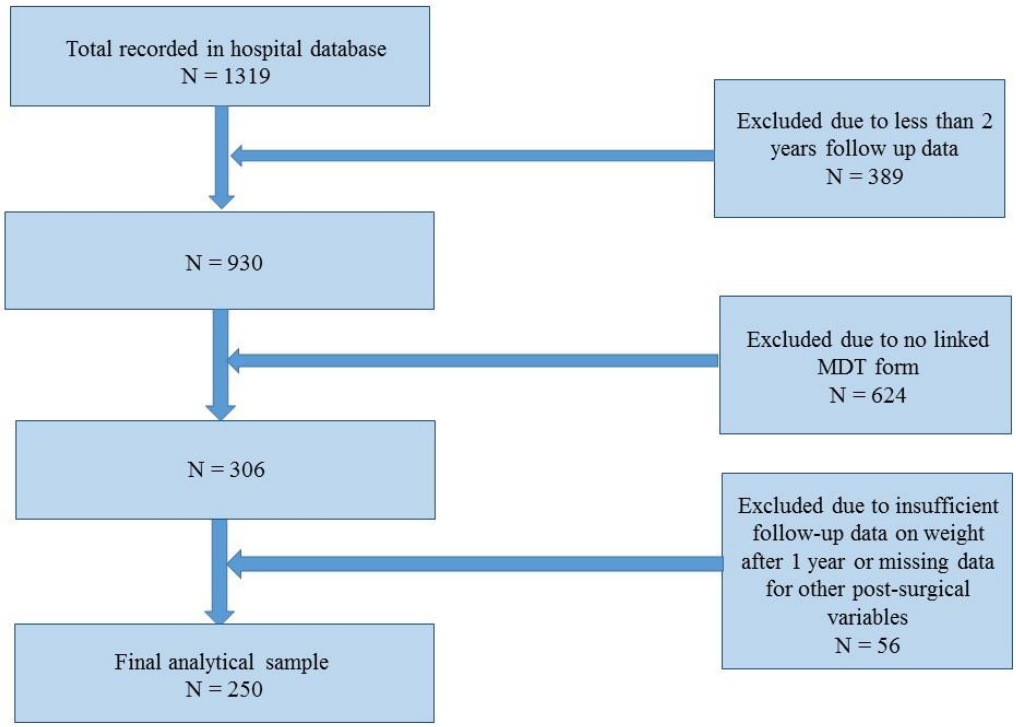

Figure 5.1 Flowchart showing the process of selecting the analytical sample for complete case cross-sectional analysis *(Multidisciplinary team = MDT).*

5.4 Results

5.4.1 Participants

Participants who underwent bariatric surgery procedures in the UK comprised the population for this study. A total of 250 patients (RYGB *N* = 120, Gastric sleeve *N* = 130) were included. Most patients were female (*N* = 196), and the entire sample had a mean age of 45.27 (± 11.23) years and an operation day weight of 126.15 kg (± 23.76). See Table 5.3 below for all participant demographic characteristics, grouped by type of surgery received.

Table 5.3. Participant characteristics, complete case analysis (*N* = 250) split by surgery type (figures are mean, percentage and + SD where indicated.)

Variable	Surgery Type		
	RYGB (*N* = 120)	**SG (*N* = 130)**	**P value**
Gender			
Male	23 (19.2%)	31 (23.8%)	.371
Female	97 (80.8%)	99 (76.2%)	.371
Ethnicity			---
British	85 (70.8%)	92 (70.8%)	---
Irish	3 (2.5%)	1 (0.8%)	---
Any other white background	7 (5.8%)	5 (3.8%)	---
White and black Caribbean	1 (0.8%)	2 (1.5%)	---
White and black Asian	0 (0 %)	1 (0.8%)	---
Any other mixed background	0 (0%)	3 (2.3%)	---
Indian	6 (5%)	4 (3.1%)	---
Pakistani	1 (0.8%)	2 (1.5%)	---
Bangladeshi	0 (0%)	1 (0.8%)	---
Any other Asian background	0 (0%)	1 (0.8%)	---
Caribbean	4 (3.3%)	2 (1.5%)	---
African	4 (3.3%)	6 (4.6%)	---
Any other black background	2 (1.7%)	6 (4.6%)	---
Any other ethnic group	5 (4.2%)	4 (3.1%)	---
Not stated	1 (0.8%)	0 (0%)	---
Age at surgery (yr)	46.51 (± 10.76)	44.13 (± 11.59)	.094
Pre-Surgery body-mass index	45.46 (± 5.63)	48.62 (± 7.54)	<.001
Weight (kg)			
Operation day	120.60 (± 20.06)	131.28 (± 25.75)	<.001

6 weeks	108.52 (± 18.43)	118.74 (± 24.82)	<.001
3 months	98.44 (±15.59)	108.34 (± 22.61)	<.001
6 months	89.93 (± 15.31)	100.55 (± 21.61)	<.001
12 months	83.80 (± 15.63)	95.89 (± 21.95)	<.001
Overall weight change	36.80 (± 12.98)	35.39 (± 15.15)	.434
Average years since surgery (range; 2-8)	5.55 (± 1.23)	5.53 (± 1.38)	.895

i. Percentages calculated from the total sample in each category). Significant differences between groups as assessed by a Welch's t-test are indicated.

5.4.2 Baseline differences across groups

A one-way Welch's ANOVA showed that there were several significant differences between surgery groups. Patients who received RYGB had a lower pre-op BMI, and pre-surgical weight than patients who received SG. There were no significant differences in gender distribution between groups. See Table 5.3 above for significance values.

Because many pre-surgery independent variables were categorical, a chi-squared test was conducted to test for significant pre-surgical differences. The two surgery groups did not significantly differ in terms of binge eating (χ^2 (1, N = 250) = .18, p = .667), depression (χ^2 (1, N = 250) = .40, p = .525), anxiety (χ^2 (1, N = 250) = .05, p = .828), suicide idealisation/attempt (χ^2 (1, N = 250) = .36, p = .546), and alcohol use (χ^2 (3, N = 250) = 3.77, p = .288). However, pre-surgical emotional eating was significantly different between individuals receiving RYGB and SG, with RYGB reporting more emotional eating pre-surgery χ^2 (1, N = 250) = 4.25, p = .039.

The outcome event 'alcohol problems at post-surgery' (N = 14 out of 250) was indicated from within the bariatric database or was otherwise ascertained using

the data from the dietician clinic forms, clinic notes, psychotherapy outpatient letters, and GP letters.

5.4.3 Objective 1: Pre-surgical predictors (significant and non-significant) of increased likelihood of alcohol problems post-bariatric surgery

A Firth regression was performed to determine the effects of age at surgery, gender, pre-surgical weight, surgery type, pre-surgical emotional eating or binge eating patterns, pre-surgical anxiety, depression or suicide idealisation/attempt, and pre-surgical alcohol Kcals on the likelihood of post-surgical alcohol problems. The model fit well to the data (likelihood ratio = 21.04, df = 12, p = .049), and significant predictors that had a positive association with post-surgical alcohol problems were suicide attempt/idealisation (B = 3.25, SE = 1.30, 95% CI = 0.72 to 6.27, p = .012), and being in the heavy pre-surgical drinking group compared to the non-drinking group (B = 1.89, SE = 0.93, 95% CI = 0.04 to 3.89, p = .045). Further analysis shows that the heavy drinking group also differed from the low group in terms of risk (B = 1.86, SE = 0.84, 95% CI = 0.14 to 3.54, p = .035), where increasing pre-surgical drinking was positively associated with a higher likelihood of post-surgical alcohol problems. Review Table 5.4 for all pre-surgical predictors on the increased likelihood for alcohol problems.

Table 5.4. Pre-surgical predictors (significant and non-significant) of increased likelihood of alcohol problems post-bariatric surgery

Explanatory Variables	Coefficient				Chi-square	P value
	Estimative	Standard Error	Lower CI	Upper CI		
Age at surgery	-0.02	0.02	-0.07	0.03	0.77	.381
Gender	1.18	0.66	-0.22	2.54	2.78	.09
Pre-surgical weight (kg)	-0.01	0.01	-0.03	0.02	0.46	.496
Surgery type	-0.53	0.57	-1.76	0.64	0.79	.375
Emotional eating	-0.96	0.67	-2.65	0.38	1.90	.168
Binge eating	-0.49	1.05	-3.44	1.42	0.20	.659
Anxiety	-1.75	2.14	-7.20	2.11	0.69	.405
Depression	0.34	1.06	-2.63	2.29	0.08	.774
Suicide idealisation/attempt	3.25	1.30	0.72	6.27	6.33	.012
Pre-surgical alcohol Kcals						
Comparing heavy to moderate	0.72	0.86	-1.03	2.39	0.69	.406
Comparing heavy to low	1.86	0.84	0.14	3.54	4.44	.035
Comparing heavy to non-drinking	1.89	0.93	0.04	3.89	4.01	.045
Comparing moderate to low	1.14	0.68	-0.27	2.59	2.54	.111
Comparing moderate to non-drinking	1.17	0.78	-0.41	3.01	2.11	.146

5.4.4 Differences in measures after surgery

A one-way Welch's t test revealed significant differences between the surgery groups after surgery, with RYGB patients losing more weight at 6 weeks, 3 months, 6 months and 12 months than patients who received a SG. Their overall weight change, however, did not significantly differ. Refer to Table 5.3 for specific values.

Further, as many post-surgery independent variables were categorical, a chi-squared test was conducted to determine significant post-surgical differences. The two surgery groups did not significantly differ in terms of binge eating (χ^2 (1, N = 250) = .01, p = .936), depression or low mood (χ^2 (1, N = 250) = 1.17, p = .279), increases in life stress (χ^2 (1, N = 250) = .90, p = .342), grazing or snacking (χ^2 (1, N = 250) = 2.33, p = .127), and alcohol problems (χ^2 (1, N = 250) = .024, p = .877).

5.4.4.1 Alcohol problems post-surgery

In the RYGB group N = 7 out of 120 (5.83%) had alcohol problems post-surgery, in addition to N = 7 out of 130 (5.38%) in the SG group. As mentioned above, the prevalence of alcohol problems did not differ significantly between groups. Table 5.5 below categorises the drinking patterns of all patients by comparing their alcohol use pre-surgery with whether they had alcohol problems post-surgery.

Table 5.5. Drinking patterns pre and post-surgery, split by surgery type and whether alcohol problems were present or absent post-surgery (figures are number of participants in each category and percentages calculated from the total participant sample of *N* = 250).

	Surgery Type	
Variable	**RYGB *(N = 120)***	**SG *(N = 130)***
Alcohol problems absent post-surgery *(N = 236)*		
N/A, low alcohol Kcals pre-surgery (N =188)		
Male	13 (5.2 %)	19 (7.6 %)
Female	78 (31.2 %)	78 (31.2 %)
Moderate alcohol Kcals pre-surgery (N = 38)		
Male	7 (2.8 %)	4 (1.6 %)
Female	12 (4.8 %)	15 (6 %)
High alcohol Kcals pre-surgery (N =10)		
Male	1 (0.4 %)	3 (1.2 %)
Female	2 (0.8 %)	4 (1.6 %)
Alcohol problems present post-surgery *(N = 14[a])*		
N/A, low alcohol Kcals pre-surgery (N = 6)		
Male	2 (0.8 %)	1 (0.4 %)
Female	2 (0.8 %)	1 (0.4 %)
Moderate alcohol Kcals pre-surgery (N = 5)		
Male	--	1 (0.4 %)
Female	3 (1.2 %)	1 (0.4 %)
High Alcohol Kcals pre-surgery (N =3)		
Male	--	3 (1.2 %)
Female	--	--

**N/A = Not applicable, Kcals = kilocalories, [a] 57% of patients with alcohol problems post-surgery had moderate or high alcohol Kcals at pre-surgery, while 43% appear to be new-onset cases.*

5.4.4 Objective 2: Post-surgical predictors of increased likelihood of alcohol problems

To address objective 2, a second Firth regression was performed to determine the effect of post-surgical variables on post-surgical alcohol problems, which included depression or 'low mood', post-surgical increases in life stress, post-surgical binge eating, grazing and weight change (Z scored to indicate how many standard deviations the weight change is above or below the mean). Although 'anxiety' was a pre-surgical variable, this information was not available in post-surgical records, therefore it could not be included. The model further controlled for significant pre-surgical variables (suicide idealisation/attempt, pre-surgical alcohol Kcals). The model fit well to the data (likelihood ratio = 46.80, df = 9, $p < .001$), and significant predictors that were positively associated with post-surgical alcohol problems were pre-surgical suicide attempt/idealisation (B = 3.54, SE = 1.11, 95% CI = 1.32 to 5.85, p = .003). Also, pre-surgical alcohol Kcals remained significant, with a higher risk of post-surgical alcohol problems arising from being in the heavy drinking group compared to the non-drinking group (B = 4.73, SE = 1.32, 95% CI = 2.28 to 7.83, $p < .001$), and the low drinking group (B = 2.98, SE = 0.96, 95% CI = 1.12 to 5.02, p = .002). Further analysis showed that the risk for post-surgical alcohol problems were higher for those in the moderate drinking group compared to the non-drinking group (B = 3.03, SE = 1.13, 95% CI = 0.96 to 5.65, p = .003) in this second model.

Additional variables that were positively associated with the likelihood of post-surgical alcohol problems were depression/low mood (B = 2.13, SE = 0.88, 95% CI = 0.40 to 3.97, p = .016), and increased life stress (B = 3.60, SE = 0.81, 95% CI = 2.08 to 5.41, p < .001). There was also a negative relationship with grazing, such that more post-surgical grazing was associated with a reduced likelihood for alcohol problems (B = -1.69, SE = 0.90, 95% CI = -3.73 to -0.48, p = .043). Post-surgical binge eating and weight change were not associated with an increased likelihood for alcohol problems. For all predictors included in the post-surgical model, please review Table 5.6.

Table 5.6. Post-surgical predictors (significant and non-significant) of increased likelihood of alcohol problems

Explanatory Variables	Coefficient					
	Estimative	**Standard Error**	**Lower CI**	**Upper CI**	**Chi-square**	**P value**
Significant Pre-Surgical Predictors						
Suicide attempt/idealisation	3.54	1.11	1.32	5.85	8.77	.003
Pre-surgical alcohol Kcals						
Comparing heavy to low	2.98	0.96	1.12	5.02	9.29	.002
Comparing heavy to non-drinkers	4.73	1.32	2.28	7.83	14.85	.000
Comparing moderate to non-drinkers	3.03	1.13	0.96	5.65	8.70	.003
Significant Post-Surgical Predictors						
Depression or low mood	2.13	0.88	0.40	3.97	5.79	.016
Increased life stress	3.60	0.81	2.08	5.41	22.10	.000
Grazing	-1.69	0.90	-3.73	-.048	4.09	.043
Non-Significant Post-Surgical Predictors						
Binge Eating	-0.89	1.93	-6.04	1.93	0.32	.570
Weight Change[i]	-.05	.34	-0.78	0.64	0.02	.881

i. Weight change was Z scored to indicate how many standard deviations the weight change is above or below the mean.

5.4.5 Objective 3: Combined Effects of Negative Events and Emotional Eating

To address the objective 3, a third Firth regression was conducted to determine whether the combination of negative pre and post-surgical events (pre-surgical suicide idealisation/attempt, post-surgical increase in life stress or post-surgical depression or low mood, presence of each coded as '1' and summed to make a single variable, 'Negative Event'), and pre-surgical emotional eating (coded '1' as present, and '0' as absent) increased the likelihood for post-surgical alcohol problems. This analytical approach yielded three groups for analysis:

Group 0 = no negative events AND no emotional eating

Group 1 = A negative event OR emotional eating

Group 2 = A negative event AND emotional eating

Importantly, the model controlled for weight change, grazing, and pre-surgical alcohol Kcals. The final model fit well to the data (likelihood ratio of 17.47, df = 7, p = .015). When comparing group 0 to group 1, having a negative event or pre-surgical emotional eating significantly positively increased the likelihood of post-surgical alcohol problems (B = 1.34, SE = 0.64, 95% CI = 0.13 to 2.80, p = .003). Comparing group 0 to group 2 also revealed that having a negative event and pre-surgical emotional eating was positively associated with increased likelihood of post-surgical alcohol problems (B = 2.27, SE = 0.93, 95% CI = 0.32 to 4.16, p = .025). Finally, comparing group 1 to group 2 indicated that there was no difference between having either a negative event or pre-surgical emotional eating, and having both (B = 0.93, SE = 0.81, 95% CI = -0.85 to 2.44, p = .276).

Table 5.7. Combined effects of negative events and emotional eating on the increased likelihood of alcohol problems post-bariatric surgery

Explanatory Variables	**Coefficient**					
	Estimative	**Standard Error**	**Lower CI**	**Upper CI**	**Chi-square**	**P value**
Group 0 compared to Group 1	1.34	0.64	0.13	2.80	4.71	.003
Group 0 compared to Group 2	2.27	0.93	0.32	4.16	5.04	.025
Group 1 compared to Group 2	0.93	0.81	-0.85	2.44	1.19	.276

5.6 Discussion

Chapter 5 aimed to gather further empirical support for a negative reinforcement model of alcohol misuse in a post-bariatric surgery cohort with 2-8 years of outcome data. The first and second aims were to examine pre and post-surgical psychological, demographic and behavioural influences on the likelihood of post-surgical alcohol problems. The third aim was to test the switch in coping mechanisms hypothesis by examining negative pre and post-surgical events *and* pre-surgical emotional eating as risk factors for post-surgical alcohol problems. Key findings were that pre-surgery suicide attempt/idealisation and greater drinking were significant predictors of post-surgery alcohol problems. Post-surgical predictors of alcohol problems were depression/low mood, increased life stress, and grazing (such that more grazing was associated with a reduced likelihood for alcohol problems). Finally, having a negative event (i.e. pre-surgical suicide idealisation/attempt or post-

surgical depression/low mood or life stress) and/or pre-surgical emotional eating significantly increased the likelihood of post-surgical alcohol problems, but there was no difference between having one or both.

Regarding pre-surgical risk factors, Chapter 5 provides novel evidence that more severe psychopathology (i.e., a lifetime history of suicide idealisation or attempt) increases the likelihood for later alcohol problems in a bariatric population. This supports observations from the wider literature, where nearly half of individuals pursuing treatment for alcohol dependence reported at least one lifetime suicide attempt (Roy, 2003). Consistent with Chapter 4, greater drinking was another pre-surgery risk factor for post-surgery alcohol problems, supporting observations in the bariatric surgery literature (King et al., 2012; Lent et al., 2013)**.** Results in Table 5.5. indicate that among the group of patients with post-surgical alcohol problems, the majority had high or moderate drinking pre-surgery (*N* = 8, 57%), however a sizeable proportion developed new-onset alcohol problems (*N* = 6, 43%). There were also patients (*N* = 10) with higher drinking pre-surgery who did not have evidence of alcohol problems post-surgery. This supports findings from Wee and colleagues (2014), where a small percentage (7%) of bariatric surgery patients similarly reported new-onset high risk alcohol use 1 year after surgery, while more than half of pre-surgical high-risk drinkers discontinued their pattern. This suggests that bariatric surgery has the potential to both resolve or exacerbate pre-surgical alcohol problems.

The findings further support the role of depression, low mood and increases in life stress as predictors of post-surgery alcohol use in bariatric patients. This is consistent with evidence from previous studies detailed in Chapter 1 (section 1.3.1), and mirrors the evidence from Chapter 4, where increased anxiety post-surgery was associated with hazardous drinking. Moreover, stressful life events following surgery

have also been linked to increased post-surgery SUD (Ivezaj et al., 2014). Chapters 2 and 3 also found that drinking to cope was a critical motivator of alcohol misuse both in a community sample and in post-bariatric surgery patients. Therefore, post-surgery alcohol problems could represent using drinking as a coping strategy for negative affect (i.e., increased stress, anxiety or depression).

The current study also revealed a novel, negative relationship between post-surgery grazing and alcohol problems, such that alcohol problems were less likely to occur for patients who were still able to eat continuously in small amounts. It has been previously shown that patients who grazed pre and post-surgery ate in response to emotional distress from negative moods (Colles et al., 2008). Therefore, it is possible that some patients in the present study were engaging in grazing to cope with negative affect, which negated the need to employ additional coping mechanisms (i.e. drinking alcohol). Only two surgery types were included in the current study (RYGB and SG) and including other surgery types in future samples could provide additional insight. For example, evidence points to AGB as having no increased risk towards alcohol misuse relative to controls (Svensson et al., 2013). Notably, individuals with AGB tend to continue binge eating patterns, feel hungrier and lose less excess weight after surgery (Himpens et al., 2006; Lang et al., 2002). The present study assessed grazing by coding the presence or absence of 'snacking,' 'grazing' or similar phrases (related to repeatedly eating small or modest amounts of food not in response to hunger or satiety) in clinical notes, consistent with the definition offered by Conceição and colleagues (2014). In future studies, using the Rep(eat)Q - a questionnaire assessing grazing - would add depth to the understanding of how grazing and its subtypes (i.e. compulsive, non-compulsive) are associated with post-surgical alcohol misuse.

Results from the present study partially support the theory that post-surgery alcohol misuse represents a substitute behaviour (or 'transfer' in coping mechanisms) from pre-surgery emotional eating to later alcohol misuse (Hardman & Christiansen, 2018; Yoder et al., 2018). Emotional eating was a non-significant predictor in the first model, however this could be because other included pre-surgical variables (e.g., binge eating) accounted for the same variance. In the third model, pre-surgery emotional eating and negative events (i.e. pre-surgery suicide idealisation/attempt, post-surgery depression/low mood or increased life stress) were separate predictors of alcohol problems, but there was no significant difference between having one predictor or having both together. The substitute behaviour model would theoretically predict that patients with both negative events *and* pre-surgery emotional eating should be at increased risk for post-surgery alcohol misuse, as the need for a substitute eating-centred coping strategy for a negative event would re-emerge following surgery (Yoder et al., 2018). Therefore, the results provide only partial support, as there was no increased likelihood of alcohol problems for patients who engaged in emotional eating pre-surgery *and* had a negative life event. However, it is possible that qualitatively-derived data is limited in its ability to capture post-surgery depression, low mood or life stress from clinical notes. Importantly patients could have engaged in 'impression management' (Fabricatore et al., 2007) if they viewed their responses as impacting their candidacy for bariatric surgery, which could have also impacted findings in the final analysis, as it examined pre-surgery emotional eating and history of suicide idealisation/attempt.

5.6.1 Strengths and Limitations

A strength of the current study is the length of time post-surgery that patients could be followed up (i.e., up to 8 years of follow up data, with an average of 5.54

(±1.31) years). Most studies with bariatric surgery patients cover approximately 2 years (see Chapter 1). Therefore, the current study could identify alcohol problems that appeared more than 2 years after surgery, which is approximately when this phenomenon appears (King et al., 2012). A limitation is that data were categorical in nature (i.e. dichotomous variables assigned from qualitative clinical notes), and individual variability and more complex underlying factors could not therefore be examined. Further, qualitative data did not assess the severity of post-surgery depression, low mood or life stress. In future, administering validated and more in-depth questionnaires based on the identified variables would yield more robust results, and these should be viewed by the patient as an independent evaluation process to control for impression management. These could include; sources of life stress, magnitude of depression or what sub-types of maladaptive eating patterns pre-surgery could increase the risk for a 'transfer' to alcohol misuse. Alcohol use was also assessed in the present study using categorical Kcal variables (high, med, low, none or *N*/A) and post-surgical alcohol problems were identified either by the staff or researcher as 'present' or 'absent' based on their follow-up appointments and related information. Future research could benefit by using the AUDIT (Saunders et al., 1993), as this is more sensitive to changes in alcohol use and gives clear diagnostic criteria. Another limitation is the relative homogeneity of the sample studied, as most of the bariatric patients were British. To support further generalisability of these results, data from collaborating centres in other global locations should be examined.

5.6.2. Conclusion

The present study examined predictors of post-surgery alcohol problems by analysing up to 8 years of health data from a bariatric service. Pre-surgical predictors were suicide attempt or idealisation and being in the heaviest pre-surgical drinking

group relative to low and non-drinkers. Post-surgical predictors were post-surgery depression/low mood, increased life stress, and grazing, where post-surgical grazing was associated with a reduced likelihood for alcohol problems. Finally, having a negative event and/or pre-surgical emotional eating significantly increased the likelihood of post-surgical alcohol problems, however there was no difference between having one or having both together. Results are consistent with the wider literature on alcohol misuse following bariatric surgery, and partially support a substitute behaviour model (‘transfer’ in coping mechanisms) for some patients from emotional eating to problem drinking.

Chapter 6: Alcohol misuse, grazing and distinct negative coping mechanisms post-bariatric surgery

This chapter represents an independent study conducted in collaboration with another PhD student, Eugenia Romano. My supervisory team and I designed the study described in this chapter. The questionnaires for this study were included together with additional measures not relevant to this chapter in an online survey platform. I worked in collaboration with Eugenia to develop the questionnaire platform and to recruit participants. The data analysis and writing detailed in this chapter is the result of my own work.

6.1 Abstract

Negative affect-related characteristics and coping motivations may be implicated in post-surgical alcohol misuse and/or grazing. Building upon evidence from Chapters 2-5, the present study hypothesised that the relationship between anxiety sensitivity/hopelessness, hazardous drinking and grazing would be mediated by i.) drinking and ii.) eating to cope, respectively, and iii.) eating and drinking would represent separate coping strategies. Post-bariatric surgery patients (N = 238; 93.3% female) were recruited via opportunity sampling through relevant UK-based social media platforms. Online questionnaires included the Alcohol Use Disorders Identification Test, Substance Use Risk Profile Scale, Modified Drinking Motives Questionnaire Short Form, Palatable Eating Motives Scale and the Repetitive Eating Questionnaire. As predicted in hypotheses i and ii, anxiety sensitivity and hopelessness were indirectly associated with hazardous drinking through drinking to cope, and with grazing through eating to cope. Anxiety sensitivity and hopelessness were also indirectly associated with hazardous drinking via a negative pathway through eating to cope (i.e. those who eat to cope were *less* likely to drink

hazardously). However, both anxiety sensitivity and hopelessness were indirectly associated with grazing via a positive pathway through drinking to cope (i.e. those who drink to cope were *more* likely to graze) thereby partially supporting hypothesis iii. Results indicate that coping is critical to the relationships between negative affect, hazardous drinking and grazing in post-bariatric surgery participants. While these may represent distinct strategies in the context of hazardous drinking, the relationship between negative affect and grazing eating behaviours appears indicative of general maladaptive coping.

6.2 Introduction

Chapter 1 identified personality traits and negative affect-related psychological disorders (e.g., depression, anxiety) that are associated with obesity and alcohol misuse in non-bariatric populations. Psychological risk factors - particularly affective disorders - are prevalent in pre-surgery bariatric candidates (Malik et al., 2014), and receiving surgery is associated with varying improvements in depression and anxiety symptoms (Dawes et al., 2016; De Zwaan et al., 2011; Karlsson et al., 2007). However, new onset and rebounding symptoms can also occur (Burgmer et al., 2014; Karlsson et al., 2007). Importantly, increased anxiety, life stress and depression were positively associated with post-surgery alcohol problems in Chapters 4 and 5. Drawing upon findings from Chapters 2 and 3, intervening factors (i.e. 'drinking to cope') may explain the association between negative affect and alcohol misuse in bariatric populations. However, this has not yet been tested or quantitatively modelled in post-bariatric surgery patients.

Chapter 3 found that the relationship between negative affect-related characteristics and unhealthy snacking occurred through eating to cope in a

community sample. Eating to cope could result in grazing eating behaviours following bariatric surgery due to surgery's impact on food intake (i.e. ability to consume large food portions is severely restricted). In support, it has been observed that patients with prior binge eating engaged in post-surgical grazing to accommodate restriction (Colles et al., 2008; Conceição, Mitchell, Pinto-Bastos, et al., 2017). Further, grazing has been associated with depression and lower mental health (Colles et al., 2008). Therefore, patients who can maintain negative affect-related coping strategies by grazing may be less likely to drink alcohol as a method of affect regulation (Hardman & Christiansen, 2018). This was supported qualitatively in Chapter 2, where participants with problematic alcohol use reported that they 'drank because [they] could not eat.' Critically, Chapter 5 found partial support for this substitute behaviour model, as patients with pre-surgery emotional eating had an increased risk for post-surgery alcohol problems (but not more so when paired with a negative event). Post-surgery grazing also reduced the likelihood of alcohol problems. In this way, the accessibility of grazing as a coping mechanism could negate seeking alcohol as a substitute behaviour for patients with negative affect regulation tendencies previously centred on food. Chapter 3, in the community sample, also found evidence that drinking and eating to cope represent distinct pathways predicting over-consumption of alcohol and food, respectively. Taken together, the role of coping in the pathway of post-surgical alcohol use and grazing merits further examination.

Building on the findings from bariatric populations in Chapters 2, 4 and 5, the current study examined key post-surgical variables implicated in alcohol misuse (e.g., anxiety, depression, grazing) in a model of food and alcohol over-consumption

motivated by coping. It also sought to assess whether these pathways are used exclusively or inter-changeably in individuals who received bariatric surgery.

6.2.1 Objectives

This study applied the model of distinct negative-reinforcement mechanisms associated with alcohol misuse and over-eating depicted in Chapter 3 to individuals who had previously received bariatric surgery. It was hypothesised that; (i.) the relationship between anxiety sensitivity/hopelessness and hazardous drinking would be mediated by drinking to cope (ii.) the relationship between anxiety sensitivity/hopelessness and grazing would be mediated by eating to cope, and (iii.) eating and drinking to cope would represent independent coping strategies.

6.3 Method

6.3.1 Participants

Participants were recruited using opportunity sampling through social media webpages of several bariatric surgery support groups. Inclusion criteria involved 1) currently attending a bariatric support group (online or in person), 2) having received bariatric surgery, 3) 18 years or older, 4) English fluency and 5) residing in the UK. Individuals who did not meet these criteria were excluded. All participants were directed to a Qualtrics webpage with an informed consent document, which required consent before beginning the survey. The study received favourable ethical approval from the University of Liverpool's Research Ethics Committee. Further, a local support group assisted in co-design by reviewing study materials and implementing the study through communication in support groups and clinical networks.

6.3.2 Measures

Substance Use Risk Profile Scale: SURPS (Woicik et al., 2009)

The Hopelessness and Anxiety Sensitivity subscales were used, which had an internal reliability within the dataset of α = .92 and α = .75 respectively. This questionnaire is described in Chapter 3.

Modified Drinking Motives Questionnaire Short Form: MDMQ-R SF: (E Kuntsche & Kuntsche, 2009).

The Coping motivational subscale for drinking (i.e., drinking to reduce negative affect) was used. Within the present study, Cronbach's α for Coping was .92. This questionnaire is described in Chapter 3.

Palatable Eating Motives Scale: PEMS (Burgess et al., 2014)

The Coping motivational subscale for eating (i.e., eating to reduce negative affect) was used. Within the present study, Cronbach's α for Coping was .95. This questionnaire is described in Chapter 3.

Alcohol Use Disorder Identification Test: AUDIT (Saunders et al., 1993)

The AUDIT was used to assess hazardous drinking. Within the present study, Cronbach's α for AUDIT was .89. This questionnaire is described in Chapter 3.

Repetitive Eating Questionnaire: Rep(eat)-Q (Conceição, Mitchell, Machado, et al., 2017)

The Rep(eat)-Q was used to assess grazing, which is comprised of two sub-scales: 1.) Compulsive grazing (6 items) and 2.) Repetitive eating (6 items). The average is calculated from scores on a 7-point Likert scale with responses ranging

from ‘Never’ to ‘Every Day.’ The Rep(eat)-Q assesses how often, over the past four weeks, individuals have engaged in specific behaviours or attitudes, with example questions being “Did not want to eat, but felt that you could not avoid eating,” and “Felt upset after snacking on food.” Within the present study, Cronbach’s α was .97.

6.3.3 Procedure

The Qualtrics online software platform was used to host the questionnaires. Participants were initially provided with a generic link through a post on social media, where clicking upon the link directed them to an information sheet and a consent form. Before proceeding to the survey, participants were asked to tick the box indicating consent to participate and confirm that they met the eligibility criteria. After completing demographics questions (*age, gender, ethnicity, personal education level, current height and weight, date of surgery, type of surgery, weight prior to surgery and amount of weight re-gained since surgery)* the order of the questionnaires was randomised. Participants completed the questionnaires described in the Measures section and additional measures not relevant to the purpose of the current thesis chapter in collaboration with another study. When the survey was completed, participants were thanked and debriefed regarding the aims of both studies. Participants were given the opportunity to be entered into a prize draw for three possible prizes (£100, £50 and £50) providing they included their email address.

6.4.4 Statistical Analysis

Structural Equation Modelling

The first analysis used a structural model to examine the distinct negative-reinforcement mechanisms associated with alcohol misuse and grazing. To reduce

skewness in the data affecting regression coefficients, generated variables were square root transformed prior to structural equation modelling (see Figure 6.1). Multiple indices of model fit were calculated to assess that the model represented a good fit for the data. Normed χ^2 values were calculated (χ^2/df). χ^2/df values between 1 and 5 are indicative of an acceptable model fit (Schumacker & Lomax, 2004). The Standardized Root Mean Square Residual (SRMR) absolute fit index was also used to assess model fit, as it is a more robust measure that deals well with non-normal distribution and kurtosis (Hu & Bentler, 1998). SRMR values under 0.08 are representative of a good model fit. Model fit was also estimated using non-centrality-based indices; the comparative fit index (CFI) and root mean square error of approximation (RMSEA). CFI values equal to, or greater than, 0.95 were used as cut offs for good model fit and greater than .90 for acceptable model fit. RMSEA values equal to, or lower than, 0.06, were used as cut offs for good model fit, with lower than .08 as acceptable model fit (Hu & Bentler, 1999). To describe specific relationships within the structural model, standardised regression coefficients are reported (See Figure 6.1, Tables 6.2 and 6.3). Gender was controlled for in the model. Bias-corrected bootstrapping was used to test the hypothesised indirect associations between personality traits, hazardous drinking and grazing via drinking/eating to cope motivations.

Mediation Analyses

To investigate the hypotheses that i.) the relationship between anxiety sensitivity/ hopelessness and hazardous drinking would be mediated by drinking to cope and ii.) the relationship between anxiety sensitivity/ hopelessness and grazing would be mediated by eating to cope, and iii.) to examine whether alcohol use represents a specific coping strategy, PROCESS (Hayes, 2012) was used to explore

the indirect associations within the square root transformed variables. PROCESS computes regression coefficients to conduct a mediation regression analysis, and bootstraps confidence intervals for the hypothesised indirect associations.

Multivariate Analysis of Variance

Further, a multivariate analysis of variance (MANOVA) test was performed to determine the effect of surgery type on the square root transformed model variables.

6.4 Results

6.4.1 Participants

The sample (*N* = 238) consisted of 16 males and 222 females, aged 23 to 69 years (M = 46.05 SD ± 9.77) with 88.7% of participants classified as overweight or obese by calculating their BMI using the weight and height information given in the online questionnaire and compared to the WHO (2006) definition. See Table 6.1. for full descriptive statistics. Participants received surgery from 1 month to 15.75 years prior to completing the questionnaire (M = 3.49 years, SD ± 3.92 years).

Table 6.1. Descriptive statistics of the sample, N = 238

Item	*Category*	*Frequency*	*Percentage*
Gender	Male	16	6.7
	Female	222	93.3
Ethnicity	Welsh/ English / Scottish / Northern Irish	215	90.3
	Irish	6	2.5
	White and Black Caribbean	4	1.7
	Other white background	7	2.9
	Other *(Bangladeshi, Caribbean, African, Other Black/African/Caribbean background, Mixed/Multiple ethnic background)*	6	2.4
Education	University or college degree, postgraduate	49	20.6
	University or college degree, undergraduate	41	17.2
	University qualification below degree	61	25.6
	Upper secondary school qualification	38	16
	Lower secondary school qualification	46	19.3
	Not Reported	3	1.3
Age Category	18 - 29 years	7	2.9
	30 - 39 years	68	28.5
	40 - 49 years	77	32.2
	50 - 59 years	61	25.5
	60 +	25	10.5
Current BMI	Underweight (<.18.5)	1	0.4

	Healthy Weight (18.5 - 24.9)	26	10.9
	Overweight (25.0 - 29.9)	56	23.5
	Obese Class I (30.0 - 34.9)	61	25.6
	Obese Class II (35.0 - 39.9)	49	20.6
	Obese Class III (> 40.0)	45	18.9
Surgery Type	Roux en Y Gastric Bypass	134	56.3
	Gastric Sleeve	64	26.9
	Gastric Band	23	9.7
	Other (*mini gastric bypass, duodenal switch, conversion, etc.)*	17	7.1
Time Since Surgery	Less than 6 months	43	18.1
	6 months – 1 year	43	18.1
	1 – 2 years	44	18.5
	2 to 4 years	37	15.5
	4 to 8 years	34	14.3
	8 + years	37	15.5

6.4.2. Structural Model (Figure 6.1)

The structural model was found to be an excellent fit for the data on all model fit indices (χ^2/df = .55; SRMR = .01; RMSEA = .00; CFI = 1.00). As shown in Figure 6.1, there was a positive association between anxiety sensitivity and eating to cope, but not between anxiety sensitivity and drinking to cope, grazing, or hazardous drinking, respectively. Further, hopelessness was positively associated with drinking to cope and grazing, but not with hazardous drinking or eating to cope. For the coping motivations, there were positive associations between eating to cope and grazing, and between drinking to cope and hazardous drinking. As hypothesised, no

direct associations were observed between drinking to cope and grazing, and there was a negative association between eating to cope and hazardous drinking.

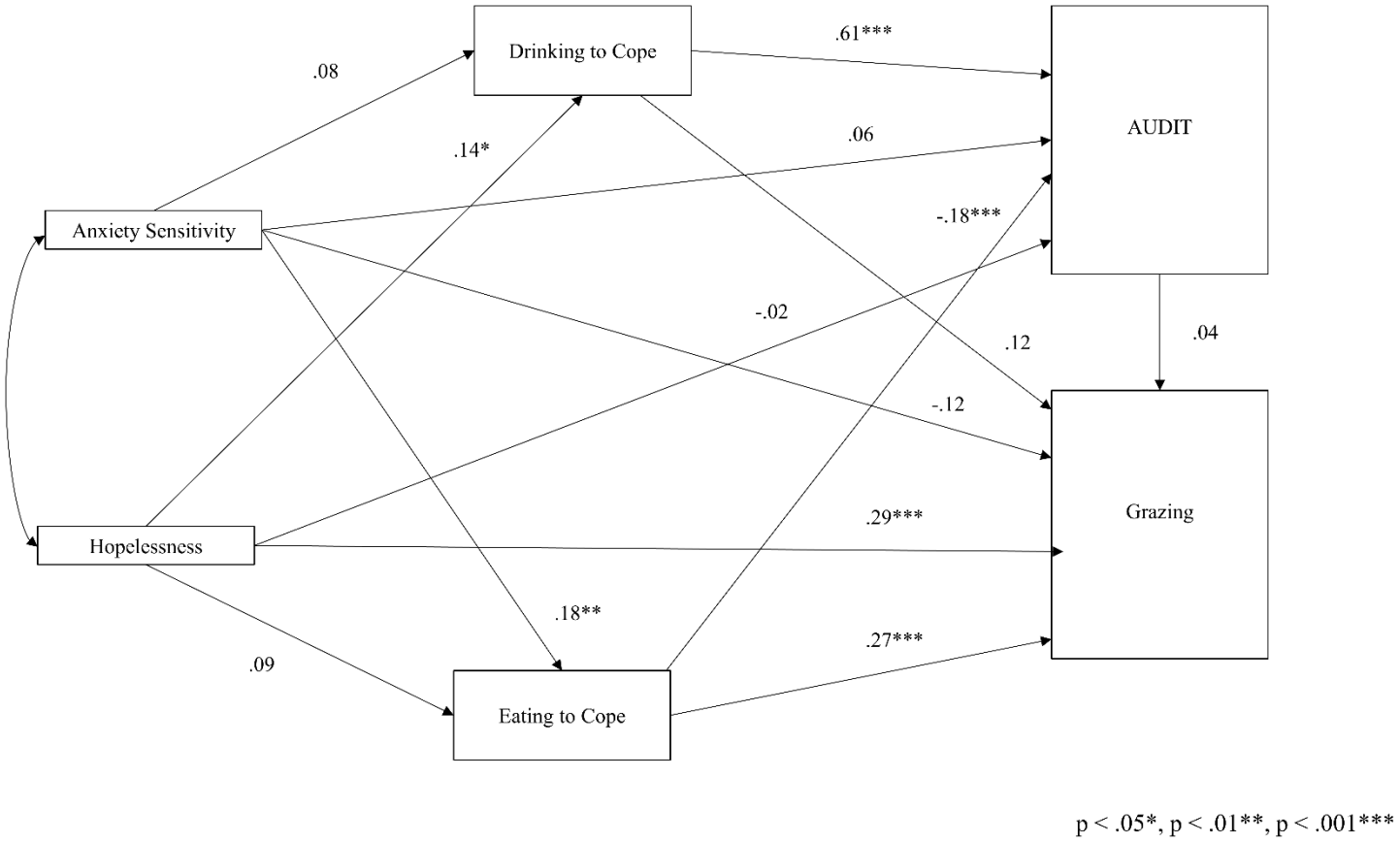

Figure 6.1. The structural model illustrating the direct and indirect associations between personality, motivation, hazardous drinking and grazing (values are standardised regression coefficients, β). Gender covariance not displayed in this simple model

6.4.3. Mediation Analyses

The mediating effect of drinking to cope in the association between anxiety sensitivity, hopelessness and hazardous drinking (Hypothesis i.).

There was no significant total effect of anxiety sensitivity on AUDIT scores (*b* =.34, SE = .24, 95% CI = -.14 to .80), and no direct effect after controlling for the indirect associations (*b* = .18, SE = .20, 95% CI = -.21 to .56). As hypothesised, there was an indirect association between elevated anxiety sensitivity and AUDIT scores through increased drinking to cope (*b* = .31, SE = .14, 95% CI = .05 to .60), indicating an indirect-only mediation effect.

There was no significant total effect of hopelessness on AUDIT scores (*b* = .17, SE = .15, 95% CI = -.12 to .46), and a non-significant negative direct effect after controlling for the indirect associations (*b* = -.00, SE = .12, 95% CI = -.24 to .23). As hypothesised, there was an indirect association between elevated hopelessness and AUDIT scores through increased drinking to cope (*b* = .24, SE = .09, 95% CI = .06 to .44). See Table 6.2 for indirect associations.

Table 6.2. The indirect associations via coping motivations between anxiety sensitivity and hopelessness and **AUDIT scores** *(Bootstrapped SE and CI)*

	Effect	SE	LL 95%CI	UL95%CI
Anxiety Sensitivity				
Drinking to Cope*	.31	.14	.05	.60
Eating to Cope*	-.15	.07	-.32	-.04
Hopelessness				
Drinking to Cope*	.24	.09	.06	.44
Eating to Cope*	-.06	.03	-.14	-.01

* indicates a p value of < .05, *Standard Error = SE, Confidence Interval = CI, Lower Level CI = LL, Upper Level CI = UL Note: the eating to cope indirect association is in a negative direction.*

The mediating effect of eating to cope in the association between anxiety sensitivity, hopelessness and grazing (Hypothesis ii.).

There was no significant total effect of anxiety sensitivity on grazing (*b* = .14, SE = .11, 95% CI = -.07 to .35), and a non-significant negative direct effect after controlling for indirect associations (*b* = -.01, SE = .10, 95% CI = -.21 to .20). As hypothesised, there was an indirect association between elevated anxiety sensitivity and grazing through increased eating to cope (*b* = .10, SE = .04, 95% CI = .03 to .20).

There was a significant total effect of hopelessness on grazing (*b* = .30, SE = .06, 95% CI = .18 to .43), and a significant direct effect after controlling for indirect associations (*b* = .24, SE = .06, 95% CI = .12 to .36). As hypothesised, there was a significant indirect association between hopelessness and grazing through increased

eating to cope (*b* = .04, SE = .02, 95% CI = .01 to .08). See Table 6.3 for indirect associations.

Table 6.3. The indirect associations via coping motivations between anxiety sensitivity and hopelessness and **grazing** *(Bootstrapped SE and CI)*

	Effect	SE	LL95%CI	UL95%CI
Anxiety Sensitivity				
Drinking to Cope*	.04	.02	.00	.10
Eating to Cope*	.10	.04	.03	.20
Hopelessness				
Drinking to Cope*	.02	.01	.00	.05
Eating to Cope*	.04	.02	.01	.08

* indicates a p value of < .05, *Standard Error = SE, Confidence Interval = CI, Lower Level CI = LL, Upper Level CI = UL*

Eating and drinking as independent coping strategies (Hypothesis iii.)

There was no association between AUDIT scores and grazing in the structural model, initially suggesting distinct pathways, via coping strategies, to these two variables (*b* = .02, SE = .03, p = .576).

To further investigate whether drinking and eating coping motivations were specific to hazardous drinking and grazing (respectively), the indirect associations between eating or drinking to cope and over-consumption of food and alcohol were compared. There was a significant indirect association between anxiety sensitivity and AUDIT scores via eating to cope, but critically this pathway was in a negative direction (*b* = -.15, SE = .07, 95% CI = -.32 to -.04). These results indicate that those who ate to cope with anxiety were *less* likely to drink alcohol, thereby supporting

hypothesis iii (see Table 6.2). An identical pattern of results was found for hopelessness, eating to cope and AUDIT scores (*b* = -.06, SE = .03, 95% CI = -.14 to -.01).

There was a significant indirect association between anxiety sensitivity and grazing via drinking to cope but this pathway was in a positive direction (*b* = .04, SE = .02, 95% CI = .00 to .10) There was also a significant indirect association between elevated hopelessness and grazing through drinking to cope in a positive direction (*b* = .02, SE = .01, 95% CI = .00 to .05) (see Table 6.3). These results indicate that those who drank to cope were *more* likely to engage in grazing eating behaviour. Therefore, hypothesis iii can only be partially supported, as although drinking and eating to cope appear to be separate strategies in the context of alcohol use, both had an indirect effect in the context of increased grazing.

The effect of surgery type on model variables

To investigate whether there were differences between the type of surgery (AGB, RYGB, SG or other) on the key variables, a multivariate analysis of variance (MANOVA) was performed. There was no statistically significant effect of surgery type on personality characteristics, coping motivations, grazing and hazardous drinking $F(18, 693) = .75$, $p = .756$; Pillai's Trace = .06, $\eta_p^2 = .02$.

6.5 Discussion

Chapter 6 aimed to validate a model of distinct negative-reinforcement mechanisms associated with alcohol misuse and grazing in a post-bariatric surgery population. It was hypothesised that (i.) the relationship between anxiety sensitivity/hopelessness and hazardous drinking would be mediated by drinking to cope, and (ii.) the relationship between anxiety sensitivity/hopelessness and grazing

would be mediated by eating to cope, and (iii.) eating and drinking to cope would represent independent coping strategies.

Results supported hypothesis (i.) as both anxiety sensitivity and hopelessness had a significant indirect association with hazardous drinking through drinking to cope. Significant indirect associations were also observed between anxiety sensitivity, hopelessness and grazing through eating to cope, supporting hypothesis (ii.). There was also a direct association between hopelessness and grazing (after controlling for the indirect effect), indicating partial mediation. Finally, the results indicated that the two coping strategies (eating and drinking) were distinct in the context of hazardous drinking, where individuals who reported eating as their coping motivation were significantly *less* likely to consume alcohol excessively. However, both eating and drinking to cope had an indirect effect in the context of grazing. In this way, grazing appeared to represent a broader coping strategy, therefore, hypothesis (iii) can only be partially supported.

The persistence of anxiety and depression-like qualities post-surgery is relevant in the context of alcohol use, as less improvement in (or worsening) mental health has been associated with increased risk for post-bariatric surgery AUD (King et al., 2017). In Chapter 3, the relationship between these negative affect-related traits and hazardous drinking occurred through drinking to cope. While this theme was identified via qualitative data in Chapter 2, this is the first time that coping motivations have been quantitatively assessed in a bariatric population. The present study therefore provides novel evidence that negative affect-related characteristics are associated with hazardous drinking through drinking to cope. This is consistent with previous findings in the thesis, where post-surgery increased anxiety symptoms (Chapter 4) and depression (Chapter 5) increased the likelihood of hazardous

drinking or alcohol problems, respectively. The finding that anxiety sensitivity, hopelessness and hazardous drinking share a relationship via drinking to cope supports negative reinforcement models of alcohol use (Castellanos-Ryan & Conrod, 2012; Cooper et al., 1995), where the ability to relieve negative affect maintains the over-consumption of alcohol. Importantly, findings from the present study support the application of a negative reinforcement model to understand motivations driving alcohol misuse after bariatric surgery.

It has been previously observed that bariatric candidates who compulsively graze report more psychological distress (anxiety, depression) and disordered eating behaviours (Goodpaster et al., 2016). Findings from the present study indicate that these relationships could be mediated by coping post-surgery. This builds upon other evidence citing significant associations between post-surgery grazing, anxiety and stress in AGB patients (Colles et al., 2008), and suggests that this relationship reflects a negative reinforcement mechanism through coping. Hopelessness and grazing were both directly associated, and indirectly associated through eating to cope, indicating a partial mediation. This contrasts with Chapter 3, where hopelessness and unhealthy snacking were not directly associated, whereas accounting for eating to cope revealed their indirect relationship. Taken together, these findings provide insight regarding coping forming a potential negative reinforcement pathway between anxiety and depression-like characteristics and post-surgical grazing in bariatric patients. Also, the present study highlights hopelessness as an independent predictor of post-surgical grazing.

In the context of hazardous drinking, results partially support hypothesis iii, as eating and drinking appeared to be separate coping strategies for post-bariatric surgery patients with negative affect-related personality characteristics. Specifically,

the current results offer new evidence that bariatric participants eating to cope in response to emotional distress were *less* likely to concurrently drink alcohol. Previous findings from this thesis indicated that post-surgery 'grazing' reduced the likelihood for alcohol problems (Chapter 5), and the present study suggests that this could occur through eating to cope.

However, negative affect-related characteristics and grazing were indirectly associated through *both* drinking and eating to cope, thereby only lending partial support to hypothesis iii. This contrasts with Chapter 3, where eating and drinking represented distinct coping strategies. For post-bariatric surgery patients higher in negative affect-related traits, the use of both coping motivations being associated with grazing could indicate a broader maladaptive coping style, whereas hazardous drinking appears specific to drinking to cope. This could also be related to eating disorder pathology, as Luce, Engler & Crowther (2007) found that women with binge eating disorder or bulimia nervosa were more likely to report drinking to cope than women without an eating disorder (or with an eating disorder *not otherwise specified*). Future research could identify whether other compulsive behaviours (e.g., shopping, exercise) (Bak, Seibold-Simpson, & Darling, 2016) function as a coping mechanism, and whether they are distinct from grazing after surgery. Patients with anxiety or depression-like qualities could also benefit from implementing cognitive behavioural interventions to improve maladaptive eating patterns post-surgery, which is recommended to increase adaptive coping skills (Atwood, David, & Cassin, 2016).

6.5.1 Strengths and Limitations

The present study presents new evidence for the role of negative affect-related personality characteristics and coping motivations in both hazardous drinking

and grazing following bariatric surgery, and addresses research priorities raised by Steffen and colleagues (2015). A limitation is that there were significantly fewer male (6.7%) than female participants. Also, the study population was recruited from within the UK and many participants identified as Welsh, English, Scottish, Northern Irish or British, which limits the generalisability of the findings to bariatric surgery patients from other counties. Importantly, the cross-sectional study design is a limitation, as the relationships between variables were correlational, and specific causal inferences cannot be made. This is an important distinction, as evidence suggests that bariatric patients with a lifetime history of AUD were more likely to report an AUD after surgery (Suzuki et al., 2012). As the present study did not assess for lifetime prevalence of AUD, it is unknown whether post-surgical hazardous drinking represents a continued or 'new onset' behaviour. Although this was assessed in Chapters 4 and 5, future research should longitudinally explore alcohol use patterns and coping.

6.5.2 Conclusion

The current study found that post-bariatric patients who drink to cope with distress were more likely to have hazardous drinking. Similarly, patients who eat to cope were more likely to engage in grazing eating behaviours. Interestingly, patients who eat to cope were *less* likely to have hazardous drinking. However, patients who drink to cope were also *more* likely to engage in grazing. Clinicians and researchers aiming to address the rise in alcohol misuse post-surgery should aim to teach alternative coping methods for negative affect, which could also bear a positive impact upon grazing and its associated weight outcomes.

Chapter 7: General Discussion

7.1. Review of thesis aims

As detailed in Chapter 1, bariatric surgery has been identified as a useful treatment for obesity, although an unexpected outcome of surgery is the increased percentage of patients (2.3 – 20%) reporting post-surgical alcohol misuse (King et al., 2012; Parikh, Johnson, & Ballem, 2016; Svensson et al., 2013). Several risk factors have been identified; including male gender, receiving RYGB surgery, and greater alcohol consumption before surgery (1.2.1). Further, some theoretically relevant contributors have been proposed; including pharmacokinetic changes from surgery (1.2.2.1), shared neural systems driving overeating and addictive behaviours (1.2.2.2), increased reward value of alcohol post-surgery (1.2.2.3) and a broader 'food addiction' transference theory (1.2.2.4). However, the explanatory value of each of these theories fall short, as they do not sufficiently examine the negative reinforcement mechanisms driving alcohol misuse (1.3.1). Therefore, **the first aim of the present thesis was to develop a model of problematic alcohol use and eating, mediated by coping**. Chapters 2 and 3 addressed this aim using mixed-methodological approaches.

Though qualitative evidence has pointed to the role of negative reinforcement (i.e., psychological problems and coping; section 1.3.3) in post-bariatric surgery alcohol misuse, this remained under-studied quantitatively. Therefore, **the second aim of this thesis** was to quantitatively assess the negative reinforcement model in a bariatric population, and to evaluate its application to post-surgical alcohol misuse. Chapters 4 and 5 examined the evidence for demographic, psychological and behavioural predictors both pre and post-surgery, and identified the role of negative

affective characteristics (depression, anxiety) in the increased likelihood for alcohol misuse post-surgery. Drawing upon results from Chapters 3-5, Chapter 6 applied a negative reinforcement model of alcohol misuse to a bariatric population.

The overarching aim of the present thesis was to extend the current understanding of post-bariatric surgery alcohol misuse and its association with psychological and motivational contributors through exploring the aforementioned aims. Together with the literature review conducted in Chapter 1, evidence from studies in Chapters 2-6 achieved this through identifying both psychological and motivational risk factors, as well as some demographic considerations. Theoretical implications of these findings are discussed, as well as strengths and limitations, practical applications, and future directions in the present chapter.

7.2. Negative affect, coping and alcohol misuse after bariatric surgery

7.2.1. The role of pre-surgery mental health in post-bariatric surgery alcohol misuse

Chapters 4 and 5 examined the effect of pre-surgery mental health on the risk for post-surgery alcohol misuse. Findings from both chapters indicated that neither pre-surgery anxiety nor depression increased the risk for post-surgery alcohol misuse. One possible explanation could be that the bariatric surgery candidates in these studies under-emphasised mental health concerns if they perceived these responses to psychological evaluations would be a barrier to receiving surgery (Sarah Malik, Mitchell, Engel, Crosby, & Wonderlich, 2014). Indeed, evaluations independent of surgery approval typically reveal a higher prevalence of psychiatric disorders (Kalarchian et al., 2007; Mitchell et al., 2012; Mühlhans, Horbach, & de Zwaan, 2009). Noteworthy, however, is that a lifetime history of suicide idealisation

or attempt increased the likelihood of post-bariatric surgery alcohol problems in Chapter 5. A limitation in assessing a lifetime history is that mental health status at the time of the assessment cannot necessarily be deduced. Results from Chapter 5 are nonetheless meaningful, as suicidal behaviour in non-bariatric populations is associated with maladaptive strategies for regulating emotion (Pisani et al., 2013; Wyman et al., 2009). In summary, neither pre-surgery anxiety nor depression predicted post-surgery alcohol misuse; however, a lifetime history of more severe psychopathology appeared to increase this risk, which invites examination for the role of coping in the pathway to alcohol misuse (section 7.2.2 below).

7.2.2. The role of post-surgery mental health in alcohol misuse

Chapter 4 found that increased anxiety at 6 months after surgery (relative to pre-surgery) was associated with a higher likelihood of reporting hazardous drinking. Further, depression scores generally improved by 6 months in Chapter 4's cohort, therefore it follows that post-surgery depression did not impact on hazardous drinking. Critically, post-surgery depression and increased life stress increased the likelihood for alcohol problems in Chapter 5, which analysed outcomes ranging from 2 to 8 years post-surgery. Altogether, while depression may improve in the short-term following surgery, these improvements may not be stable over time or unilaterally observed, which could lead to use of alcohol as a coping strategy for negative affect. Findings from Chapters 4 and 5 extend the evidence from King and colleagues (2017), where less improvement or worsening mental health increased the likelihood for post-bariatric surgery AUD. Further, evidence from Chapter 5 is similar to observations by Ivezaj and colleagues (2014), where bariatric patients with SUD (AUD inclusive) reported a greater number of stressful life events following their surgery, relative to those without.

Importantly, Chapter 6 cross-sectionally assessed post-surgery bariatric participants and found that negative affect-related traits (e.g., anxiety sensitivity and hopelessness) were not directly associated with hazardous drinking. However, accounting for drinking as a coping motivation explained this relationship, similar to findings in Chapter 3 (section 3.4.2). Overall, Chapters 4 and 5 indicate that post-surgery anxiety, depression and increased life stress increases the likelihood of alcohol misuse, especially in the long-term following surgery. Results from Chapter 6 indicate that alcohol could function as an affect regulation strategy for patients higher in negative affect-related traits, which is detailed further in the next section.

7.2.3. The role of drinking to cope in alcohol misuse and evidence for behavioural substitution post-surgery

In Chapter 2, 'drinking to cope' with negative affect-related experiences *(negative self-image, emotional support needs, and under-preparedness for surgery)* was a key distinction between individuals with post-bariatric surgery problematic alcohol use, and those without. Further, the presence of '*resilience*' in participants with non-problematic alcohol use reflected a repertoire of adaptive coping strategies (e.g., identifying triggers, setting manageable goals), which conversely supported maladaptive coping as a contributor to alcohol misuse post-surgery. Indeed, findings from Chapters 3 and 6 evidenced that negative affect-related traits and alcohol misuse outcomes do not have a simple direct association, but rather occur through drinking to cope as an affect-regulation strategy in both non-bariatric and bariatric populations. This is a novel contribution of the present thesis, as there is a dearth of quantitative evidence on the role of coping in post-bariatric surgery alcohol misuse.

Importantly, findings from Chapters 2 and 6 support qualitative evidence from Yoder and colleagues (2018), where the need for an external coping strategy with 'unresolved psychological issues' re-emerged after the 2 year 'honeymoon' period following surgery. In this study and in Chapter 2, it was thematically identified that alcohol misuse was connected to eating to cope no longer being accessible due to surgery-induced stomach restriction. Therefore, eating and drinking as separate behavioural strategies was modelled in Chapter 3, and further explored in bariatric populations in Chapters 5 and 6.

7.2.4. Drinking and eating as distinct coping motivations and behavioural strategies

Findings in Chapter 3 indicated that eating and drinking to cope were separate behavioural strategies. Specifically, individuals who reported drinking to cope did not also report greater unhealthy snacking, nor did individuals who used eating to cope also report hazardous drinking. Bariatric patients may similarly engage in eating to cope after surgery, as has been implied by previous studies (Colles, Dixon, & O'Brien, 2008). Given the evidence for the separate nature of these coping strategies in Chapters 2 and 3, Chapter 6 quantitatively modelled this distinct negative reinforcement relationship. Findings indicated that both eating and drinking to cope were distinct in the context of hazardous drinking, where those who reported eating as their coping mechanism were significantly *less* likely to over-consume alcohol. This was not observed for grazing, however. Therefore, Chapter 6 provided novel evidence that hazardous drinking occurs specifically through drinking to cope in bariatric patients, whereas grazing could represent a broader coping strategy post-surgery. Taken together, evidence from Chapters 2, 3 and 6 supports negative reinforcement models of alcohol use (Castellanos-Ryan & Conrod, 2012;

Cooper et al., 1995), and a novel finding includes the specificity of drinking as a coping mechanism for bariatric patients after surgery.

7.2.5 Alcohol misuse as post-surgery behavioural substitution

The uptake of drinking as substitute behaviour post-surgery follows from the evidence in Chapter 3 in a non-bariatric population, where eating and drinking to cope appeared to function as separate motivations with distinct behavioural outcomes. In Chapter 2, '*I drank because I couldn't eat"* emerged as a sub-theme for post-bariatric surgery participants with problematic alcohol use in Chapter 2, alongside '*drinking to cope*.'

The role of pre-surgery emotional eating and post-surgery grazing in alcohol misuse were addressed in Chapter 5. Pre-surgery emotional eating and having a negative event (i.e. pre-surgery suicide idealisation/attempt or post-surgical depression/low mood or life stress) were separate predictors of post-surgery alcohol problems. The substitute behaviour model of post-surgery alcohol misuse theoretically predicts that patients with both negative events *and* pre-surgery maladaptive eating coping strategies would be at increased risk for post-surgery alcohol misuse, as needing a substitute coping strategy for a negative event would re-emerge after surgery (Hardman & Christiansen, 2018; Yoder et al., 2018). Results from Chapter 5 provided partial support for this model, as there was no difference between having one or both in increasing the likelihood of alcohol problems. Further, Chapter 5 found a negative relationship between post-surgery grazing and alcohol problems, such that those who were still able to eat continuously in small amounts were less likely to misuse alcohol. Taken together, Chapters 2 and 5 provide partial support that post-surgery alcohol misuse represents a substitute behaviour (or

'transfer' in coping mechanisms) from pre-surgery emotional eating to later alcohol misuse and highlights that engaging in post-surgery grazing decreases the likelihood of alcohol misuse.

7.3 Evidence for demographic characteristics implicated in alcohol misuse

7.3.1 Gender and age

Chapter 1 (section 1.2.1.1.) detailed the conflicted evidence for demographic characteristics (i.e. male gender and younger age) associated with post-bariatric surgery alcohol misuse. In the present thesis, neither gender nor age significantly predicted post-surgical alcohol misuse in Chapters 4 and 5. Further, gender was controlled for (and age was not included) in the model in Chapter 6. In this way, the present thesis does not support gender or age as raising the likelihood of post-bariatric surgery alcohol misuse. This should be interpreted bearing in mind the majority of bariatric participants across Chapters 4 – 6 were female. Gendered participation trends were consistent with demographic characteristics of those who undergo bariatric surgery, as approximately 80% are female (Fuchs et al., 2015; Santry et al., 2005). Therefore, these results may still be considered generalisable to a bariatric population. Future directions should aim to further assess the effect of gender on post-surgery alcohol misuse by including more males and increase participation from individuals across a broad range of ages.

7.3.2 Surgery type

Results from Chapter 4 pointed to receiving AGB surgery type as increasing the risk for hazardous drinking, relative to SG. Cautious extrapolation should be made, as there were also fewer AGB participants in the SCOTS cohort (relative to RYGB and SG), as well as a high prevalence of pre-surgery hazardous drinking

within the AGB group (section 4.5.4). Surgery type did not significantly predict alcohol misuse in Chapter 5. Further, there was no difference in prevalence of alcohol problems between RYGB and SG (see Table 5.5). Interestingly, RYGB patients reported significantly more pre-surgical emotional eating than SG patients. This finding could provide additional insight into the connection between RYGB and post-surgical alcohol misuse in the literature (Chapter 1, section 1.2.1.1), possibly through behavioural substitution (section 7.2.5). Surgery type was not included as a predictor in the model from Chapter 6, and there was no effect of surgery type on hazardous drinking in a subsequent MANOVA test. Altogether, while receiving RYGB increased the risk for post-surgical alcohol misuse in other studies (Chapter 1, section 1.2.1.1.), the present thesis finds limited evidence for surgery type as a predictor.

7.3.3 Pre-surgery weight status and post-surgery weight change

The present thesis examined weight as a risk factor, given the equivocal evidence on the inter-relationship between weight (loss or re-gain) and post-surgical alcohol misuse (Chapter 1, section 1.2.1.1). Critically, neither pre-surgery BMI nor weight (kg) predicted post-surgery alcohol misuse in Chapters 4 and 5, respectively. Neither did post-surgery weight change increase the likelihood of alcohol problems in Chapter 5. Consistent with Chapter 3, weight was not modelled in Chapter 6. Overall, the present thesis did not support any significant effects of weight on alcohol misuse. Interestingly, lower physical quality of life before surgery increased the likelihood of post-surgery hazardous drinking in Chapter 4, which could be weight-related as greater obesity has negative consequences on physical quality of life (Kushner & Foster, 2000). Results contrasted with other evidence bearing no significant association between physical quality of life and post-surgery AUD (King

et al., 2012). Further, weight re-gain could be an effect of – rather than a contributor to – using either eating or drinking as a coping mechanism. Indeed, participants with problematic alcohol use in Chapter 2 cited weight re-gain as a source of frustration (i.e. *'negative self-image'*). Given that alcohol is a source of calories with minimal impact on satiety which disinhibits eating behaviour and promotes over consumption (Christiansen et al., 2016; Rose et al., 2015), further research examining this association would lend insight on the directionality between weight and alcohol misuse post-surgery.

7.3.4 Pre-surgery drinking patterns

Chapters 4 and 5 point to high pre-surgery drinking as a risk factor for post-surgery alcohol misuse. Thematically, Chapter 2 offered that some participants were continuing pre-surgery drinking patterns. This is consistent with evidence from other bariatric studies, (King et al., 2012, 2017; Lent et al., 2013; Suzuki et al., 2012). Identifying maladaptive drinking patterns before surgery forms a research priority given that upwards of 80% of patients at risk for problematic drinking still go on to receive bariatric surgery (Kudsi et al., 2013). However, candidates are also advised to eliminate alcohol after surgery to reduce the risk for alcohol misuse for candidates with known/suspected psychiatric illness, substance misuse or dependence (Mechanick et al., 2013). Therefore, post-surgery alcohol misuse could represent a continuation of or relapse into previous drinking behaviours for some individuals, and strategies to attenuate these pre-surgery drinking patterns throughout the bariatric pathway are needed.

Given these findings, causal mechanisms for continued or worsened pre-surgery drinking patterns are critical to elucidate, beginning with factors increasing

the risk for relapse of alcohol misuse identified in non-bariatric populations. In a study by Moos and Moos (2006), individuals who were less likely to view their drinking as a significant problem, had less self-efficacy, and relied on drinking to reduce tension were more likely to relapse intro alcohol misuse after a period of remission. This supports Marlatt and Gordon's (1985) relapse model, which emphasises the role of low self-efficacy and fewer effective coping skills on the increased risk for relapse. In this way, the connection between greater pre-surgery alcohol consumption and post-bariatric surgery alcohol misuse could be explained in part by the continued use of alcohol as a coping mechanism. Importantly, there was also evidence of new onset cases of alcohol misuse in both Chapters 4 and 5. Therefore, greater pre-surgery drinking represents a possible contributor to some, but not all, cases of post-surgery alcohol misuse. Future research priorities in bariatric populations should begin by examining the inter-relationship between self-efficacy, alcohol outcome expectancies and coping motivations as increasing the likelihood of post-surgical alcohol misuse for both continued and new onset cases.

7.4. Strengths

A key strength of the present thesis is the mixed-methodological approach applied to understanding post-surgery alcohol misuse in a bariatric population. In Chapter 2, a qualitative approach was used to centre the experience of patients in the context of the research question in order to make informed subsequent research decisions for Chapters 3-6. This approach is consistent with guidance from the Patient Empowerment Network (Ennis-O'Connor, 2016), and future work in this area should similarly recognise the value of patient insight. This can be achieved by building upon the approaches used in the present thesis, where patient responses during interviews in Chapter 2 assisted in defining later research questions. Further, a

local support group assisted in co-designing the study for Chapter 6 through reviewing materials and implementing the study through communication in support groups and clinical networks.

An additional strength of the present thesis is that two experimental chapters are the result of collaborations with clinical partners – the SurgiCal Obesity Treatment Study (SCOTS) and a bariatric service in the UK. From these collaborations, longitudinal insights could be derived using pre and post-surgery data, drawing from both quantitative (Chapter 4) and qualitative-based (Chapter 5) data sources. Importantly, the length of follow-up (i.e., up to 8 years) in Chapter 5 is substantial, as two of the largest longitudinal studies on surgery outcomes show that prevalence rates of post-surgical AUD do not deviate from pre-surgery until the second year (King et al., 2012; Svensson et al., 2013). Together with Chapter 4, the differing lengths of time assessed post-surgery lend valuable insight regarding both the short-term and long-term alcohol misuse outcomes and its associated pre and post-surgical contributors. Further, partnering with clinical sites lent itself to recruitment opportunities outside of a university or patient support group context, which facilitated larger sample sizes as well as longitudinal comparison in Chapters 4 and 5.

7.5 Limitations

7.5.1 Measurement of negative affect

Different measures of anxiety and depression were used in Chapters 4, 5 and 6 due to accessible information from external collaborators. Measures in Chapter 4 assessed anxiety and depression symptom severity using self-administered scales at pre and post-surgery (GAD-7 and PHQ-9, respectively) (Kroenke et al., 2001;

Spitzer et al., 2006). Conversely, Chapter 5 could not account for symptom severity due to the evidence being qualitatively-derived. Another limitation included 'anxiety' not being identifiable from the post-surgical data sources (Chapter 5, section 5.4.3), alongside the possibility that 'depression' and 'low mood' could have indicated sub-clinical levels. Chapters 3 and 6 measured 'anxiety sensitivity' and 'hopelessness' as personality traits implicated in the risk for substance misuse (SURPS; Woicik, Stewart, Pihl, & Conrod, 2009). Altogether, comparing the evidence drawn from these different measures should be treated cautiously. Future research should aim to implement similar measures of negative-affect related psychological contributors to post-surgery outcomes to facilitate meaningful comparison between cohorts and time points across the surgical pathway.

7.5.2 Measurement of alcohol misuse

As detailed in Chapter 1, the definition of alcohol misuse tends to vary across the bariatric literature, which poses difficulties in making precise comparisons (Parikh et al., 2016). The present thesis encountered a similar challenge; Chapters 2 and 5 qualitatively assessed alcohol misuse post-surgery, termed 'problematic alcohol use' and 'alcohol problems,' respectively (Chapter 1, Table 1.3) in absence of a specific assessment tool. Comparison between Chapters 2 and 5 should be made considering that 'problematic alcohol use' was determined using participant interview responses in Chapter 2 (section 2.4.2), while 'alcohol problems' in Chapter 5 were dichotomously coded using qualitative indicators of alcohol misuse from the bariatric database or otherwise communicated by clinicians, dieticians or psychologists (section 5.4.3.1). Using qualitative data was a strength of the present thesis, as it facilitated examining contributing factors to alcohol misuse in the absence of quantitative evidence. However, this also created a distinction between

participant-informed vs medical personnel-determined alcohol problems between groups.

To measure alcohol misuse quantitatively, Chapters 3, 4 and 6 utilised the Alcohol Use Disorder Inventory Test (AUDIT; Saunders, Aasland, Babor, de la Fuente, & Grant, 1993). While Chapters 3 and 6 had sufficient data to support analysing responses from all ten items of the AUDIT, Chapter 4 had a significant amount of missing data from the last seven items (Figure 4.1). The present thesis accommodated this by analysing the first three items, which comprise a sub-scale of the full questionnaire - the AUDIT-C (Consumption). Future research should address contributors to non-response rates for alcohol questionnaire items, which could have gender effects or design-related considerations; such as requesting participants additionally report on positive behaviours (Fowler & Stringfellow, 2001; Stueve & O'Donnell, 1997).

7.5.3 Missing data and sample size

The datasets available from the collaborators were initially larger in Chapters 4 (N = 292) and 5 (N = 1319), but complete case analyses were necessitated by the rare events regression methodology, which reduced the data that could be included (Chapter 4 N = 55; Chapter 5 N = 250). Missing data appeared related to the time point in the surgical pathway, attendance of follow-up appointments, or completion of the questionnaires (see Figures 4.1 and 5.1). Missing data from Chapters 3 and 6 was similarly due to incomplete responses on the online surveys. While some of the missing data from Chapters 4 and 5 was due to the participant's time point in the surgical pathway, future research should address whether identified contributors to respondent attrition in the non-bariatric literature also applies to bariatric

populations. These may include gender effects, study design, questionnaire length or the perception of relevant content (Hochheimer et al., 2016; McCambridge et al., 2011; Ross, Daneback, Månsson, Tikkanen, & Cooper, 2003).

7.5.4 Generalisability

As referenced in section 7.3.1, the majority female population throughout each of the experimental chapters bears implications for the generalisability of the results to males. Nevertheless, results may still be generalisable to a bariatric population in general, as approximately 80% of individuals who undergo bariatric surgery are female (Fuchs et al., 2015; Santry et al., 2005). An additional consideration for generalisability of results from the present thesis is the relative homogeneity of the samples studied in Chapters 3, 4, 5 and 6; where the majority of the bariatric patients were Welsh, English, Scottish, Northern Irish or British. While this represents the ethnic composition of the United Kingdom (Office for National Statistics, 2016), it nonetheless limits the applicability of the results to more diverse ethnic groups. Future studies could improve upon this with the inclusion of additional collaborators from differing cultural settings (e.g., the United States), or focused recruitment efforts to include under-represented individuals. This also applies as a critique of bariatric surgery in general, as individuals who undergo surgery are only a modest percentage of those who are eligible, while African Americans, men and socially disadvantaged persons remain under-represented as bariatric candidates (Flegal, Carroll, Kit, & Ogden, 2012; Nguyen et al., 2004; Santry et al., 2005).

7.6. Practical Implications

Findings from the present thesis have several practical implications for bariatric service providers and clinicians. The present thesis supports the premise that coping is a predictor of hazardous drinking (Holahan et al., 2003; Kassel et al., 2000; Kuntsche & Kuntsche, 2009; Merrill & Thomas, 2013). It provides evidence that inadequate coping mechanisms should be included as a critical item in the repertoire of known risk factors (alongside demographic, psychological and behavioural characteristics) for the purpose of identifying patients that need psychological support to proceed with surgery. This follows from recommendations from Sogg (2017) that patients should be screened for known risk factors for alcohol and substance misuse post-surgery at the pre-surgical evaluation. Moreover, these recommendations also emphasise adequate pre-surgical education and preventative efforts to reduce risk, which could include reducing drinking before surgery. Chapter 2 highlights this as a key difference between problem and non-problem drinkers, where problem drinkers felt '*under-prepared'* and did not know their relationship to alcohol could change after surgery. Further, to reduce the likelihood of patients exaggerating or suppressing their psychological distress to gain approval for surgery, or 'impression management' (Fabricatore et al., 2007), pre-surgical screening measures assessing maladaptive coping strategies should be independent of the approval process. Instead, screening should function to identify patients needing additional psychological support in order to proceed with surgery.

As well as informing screening practices, findings from the present thesis could also form the basis of a personalised pre-and post-surgery intervention strategy. For example, Hardman and Christiansen (2018) recommend facilitating tailored psychological support during the post-surgical period. Evidence from

Chapter 2 could be used to create psychological interventions and support focused on increasing patient resilience through addressing self-image, mental health and educating patients about available coping skills and strategies. Further, Chapters 4, 5 and 6 highlight the differing roles that post-surgery anxiety, depression, eating and drinking to cope play in increasing the risk for alcohol misuse, and post-surgical monitoring and tailored psychological support would benefit from prioritising these items. Finally, Sogg (2017) points out that the increased risk for alcohol misuse typically occurs at the time point when patients are in infrequent contact with their bariatric centres (i.e., after 2 years post-surgery). Therefore, findings from the present thesis should further inform efforts made by the bariatric-focused community to educate non-bariatric professionals who also work with bariatric patients (e.g., mental health providers, general practitioners), and prioritisation should be placed on negative affect-related assessment, coping strategies and monitoring for alcohol misuse.

7.7. Future directions

Future research could build upon the current findings by examining additional risk factors implicated in greater alcohol consumption or developing later alcohol problems, such as poor family support, low self-control, impulsivity (Chartier, Hesselbrock, & Hesselbrock, 2010), or potentially traumatic events, which may be more salient in women (Berenz et al., 2016). Investigating negative-affect related contributors to post-surgical alcohol misuse could further encompass other identified contributors to lifetime AUD, such as PTSD or panic disorder (Grant et al., 2015). Although many of these constructs have been studied in adolescents, persons with current alcohol misuse or the general population, how these contributors relate to alcohol misuse remains under-studied in bariatric populations.

While the present thesis focused on the role of coping in the increased likelihood of alcohol misuse post-surgery, additional risk factors have also been identified in non-bariatric populations. Namely, elements of social learning theory have been integrated into models of drinking behaviour, which include interactions between coping, self-efficacy and drinking expectancies (Armeli, Carney, Tennen, Affleck, & O'Neil, 2000; Hasking & Oei, 2004; Marlatt, Bowen, & Witkiewitz, 2009; Skutle, 1999). Interviews in Chapter 2 support the role of self-efficacy (e.g., '*well-prepared'* for surgery) and positive coping in protecting against problematic alcohol use post-surgery, as those without problem drinking described having '*resilience,'* (i.e., self-confidence, readiness to address mental health, optimism and good coping skills) throughout their interviews. Positive social drinking motives and coping through seeking social support have also been identified by Karwacki and Bradley (1996) as possible protective factors from increased alcohol use or drinking complications, which is similarly emphasised in Chapter 2 where '*social'* motives were cited by those without problem alcohol use, alongside having their *'emotional support'* needs met. Likewise, King and colleagues (2017) found that less social support was predictive of post-surgery AUD. Therefore, future research examining post-surgical alcohol misuse in bariatric populations would benefit from examining the interactions between coping, self-efficacy, drinking expectancies and the role of social support. For example, examining access to and participation in peer support groups through multiple formats (e.g., in person, online) would be informative.

7.8. Overall conclusion

The present thesis aimed to extend understanding of post-bariatric surgery alcohol misuse and its association with psychological and motivational contributors through developing, informing and validating a model of negative reinforcement

mechanisms. Findings indicate that pre and post-surgical negative affect-related vulnerabilities raise the likelihood for alcohol misuse, which could manifest if eating is an unavailable coping mechanism. Indeed, pre-surgical emotional eating predicted post-surgery alcohol misuse and post-surgery eating to cope, and grazing *reduced* the likelihood of alcohol misuse. From a theoretical standpoint, the present thesis partially supports that post-surgery alcohol misuse represents a substitute coping mechanism from emotional eating to alcohol use for some individuals. However, greater pre-surgery drinking also predicted post-surgery alcohol use indicating that, for some patients, this represents a continuation of pre-existing drinking behaviours. Future research should utilise a mixed-methodological approach to examine these constructs longitudinally in bariatric cohorts and explore interventions to reduce post-surgery alcohol misuse guided by these findings. Practical applications could assess coping mechanisms at pre-surgery to identify patients needing psychological support, and inform the support given post-surgery.

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Appendix A.

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