A Systematic Review Demonstrates that Patient Focussed Outcomes are Infrequently Reported in Randomised Trials of Health Information Technologies Conducted in Paediatric Healthcare Settings

Dr Matthew T Neame1,2 MBChB, Mr Jerry Chacko2, Dr Jamie J Kirkham3 PhD, Dr Ian P Sinha2\* PhD, Dr Daniel B Hawcutt2,4\* MD

\*Joint senior author

Affiliations:

1: Global Digital Exemplar Programme, Alder Hey Children’s Hospital, Liverpool, UK

2: Department of Women’s and Children’s Health, Institute of Translational Medicine, University of Liverpool, UK

3: Centre for Biostatistics, Manchester Academic Health Science Centre, University of Manchester, Manchester, United Kingdom

4: NIHR Alder Hey Clinical Research Facility, Liverpool, UK

### Corresponding author:

Daniel B Hawcutt, University of Liverpool, Alder Hey Children’s Hospital, Eaton Road, Liverpool, L12 2AP. Email: Dhawcutt@liverpool.ac.uk Tel: 0044 1512284811

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# ABSTRACT

## Objective

Billions of dollars have been invested in Health Information Technologies (HITs), and Randomised Controlled Trials (RCTs) have been conducted to identify the effects of these interventions. Our objective was to identify the types of outcomes that were measured and reported in these RCTs.

## Study Design and Setting

We completed a systematic review (MEDLINE, EMBASE and CENTRAL databases) of RCTs involving children (< 18 years) and utilising HIT interventions.

## Results

We identified 45 RCTs involving 323,945 children. Most studies reported process outcomes (n = 40/45 (88.9%)) but did not include patient-focused outcomes such as Patient/Carer Functioning (n = 12/45 (26.7%)), Clinical/Physiological health (n = 10/45, 22.2%), Quality of Life (n = 3/45, 6.7%) or Mortality (n = 1/45, 2.2%). Only 3/45 (6.7%) studies reported an evaluation of adverse events. In only 14/45 (31.1%) studies was it clear that all outcomes that were measured were reported.

## Conclusions

It is difficult to use RCTs to fully evaluate the benefits and risks of using HIT interventions in paediatric healthcare settings because patient focussed outcomes and adverse events are rarely reported. Measures to improve the quality of future trials may include the publication of study protocols and the development of an outcome reporting framework or core outcome set.

# Key Words:

Pediatrics

Evidence Based Medicine

Medical Informatics

# What is new?

* Paediatric Health Information Technology (HIT) Randomised Controlled Trials (RCTs) tend to report process outcomes and tend not to report patient focused outcomes (such as quality of life) or adverse events.
* In most paediatric HIT RCTs it was not clear that all the outcomes that were measured were reported in the final publication.
* Current outcome reporting limitations make it difficult to use RCTs to fully evaluate the benefits and risks of using HIT interventions in paediatric healthcare.
* Measures to improve the quality of paediatric HIT RCTs may include the publication of study protocols and the development of an outcome reporting framework, or Core Outcome Set.

# BACKGROUND

Internationally, billions of dollars have been invested in Health Information Technologies (HITs)1,2. The aims of these investments are to increase the efficiency of healthcare systems, and improve the outcomes experienced by patients and their families 3-5. However, it is not clear if these objectives have been achieved 6-9, and trials of the effects of HITs have been conducted to ensure that the most beneficial interventions are selected for use in clinical practice.

Although HITs are now frequently used in children’s healthcare settings10, they often require adaptation to be successfully implemented in these environments 11-15. Similarly, the quality of pediatric research is improved when the specific needs of children and families are taken into consideration 16,17. When the types outcomes utilised in pediatric trials are not well considered, important factors such as effects on growth, or longer-term developmental outcomes can be missed18-21. Therefore, in order for pediatric studies to influence clinical practice or policy decisions, they should evaluate outcomes of importance and interest to key stakeholders (including children affected by illness, parents and families, healthcare professionals, and policy makers)22.

The issue of outcome selection and reporting in Randomised Controlled Trials (RCTs) is of particular relevance. These studies are considered as the gold standard investigation for determining the effects of interventions 23, they are more likely to be published in high impact journals, and evidence from RCTs is viewed favourably by investigators appraising data from systematic reviews and meta-analyses 24. Furthermore, RCTs are always conducted prospectively. This should allow investigators to adhere to recommendations regarding the appropriate identification and reporting of outcomes18,25 in a way that cannot always be achieved with observational study designs (where investigators may rely upon using routinely collected data to determine the effects of an intervention).

Another consideration is that when trials are published, it should be clear that investigators have reported all of the results. Failure to do this can lead to a biased representation of the overall effects (outcome reporting bias). This can significantly affect conclusions about whether an intervention is beneficial or not, as demonstrated in a series of Cochrane reviews 26,27.

Detailed considerations of outcome selection and reporting practices have, therefore, been advocated as a method for promoting improvements in the quality of research23,28. Most specifically, systematic reviews of outcome selection and reporting have been recommended as an important first step to enable the development evaluation frameworks including Core Outcome Sets (COS) 28,29. COS are agreed, standardised, outcomes that should be measured and reported in all trials in a particular research area 30,31. Although COS have most frequently been developed for use in trials involving participants with particular health conditions, there is recognition that standardising the types of outcomes reported across trials involving specified interventions, or conducted in specified healthcare settings, may also be beneficial 32-34. In these instances, the development of a COS can ensure that studies report the most relevant outcomes, reduce the risk of outcome reporting bias and facilitate meta-analysis22,28,35.

Although one previous investigation has systematically evaluated the types of outcomes reported in studies of HIT interventions, this review did not specifically include trials involving children, did not focus on RCTs and a formal assessment of outcome reporting bias was not performed 36. The objectives of this study are, therefore, to undertake a systematic review of the types of outcomes reported in RCTs of HIT interventions, conducted in pediatric healthcare settings, and to formally assess the included studies for evidence of outcome reporting bias. These objectives reflect the prominent role that RCTs play in influencing decision making; the necessity to consider pediatric focussed outcomes in research involving children; and the increasing utilisation of HITs within pediatric healthcare settings.

# METHODS

## Search Strategy

A study protocol was developed in accordance with PRISMA guidelines 37 and was registered on the PROSPERO database 38. The MEDLINE, EMBASE and Cochrane CENTRAL databases of controlled trials were searched from inception until June 2018. We included randomised controlled trials, involving children (aged 0-17 years) receiving healthcare interventions based on the use of Information Technologies (as defined by the Cochrane Effective Practice and Organisation of Care taxonomy39; the full search strategy is available in the supplementary data file). Reference lists were hand searched to identify additional relevant studies. Conference abstracts were included, and no date or language exclusion criteria were applied.

Title and abstract screening and full text reviews were conducted independently by two reviewers (MN & JC). Where discrepancies were noted, consensus regarding final inclusion or exclusion was reached following discussion. Data were extracted and validated by two reviewers (MN and DH). Any discrepancies were resolved by a further review of the included trials and discussion between the reviewers.

## Outcome Measures

We identified the outcomes reported in the included RCTs. We also recorded whether outcome measures were categorised as primary or secondary outcomes and we identified the timing and effects measures that were utilised in each study. We employed an existing taxonomy framework to categorise the outcomes 40 . This taxonomy grouped outcomes under four major domain headings which included a total of 38 outcome categories divided between them. The major domain headings were:

* Mortality/Survival
* Physiological Clinical
* Functioning
* Resource Use

Within this taxonomy, functioning outcomes included both measures of patient/carer functioning (e.g. Quality of Life measures) and measures of healthcare provider/healthcare institution functioning (e.g. adherence to clinical practice guidelines; termed “Delivery of Care” outcomes in the Williamson/Clarke taxonomy40). For clarity, we chose to sub-categorise functioning outcomes relevant to these groups separately. This allowed us to describe the groups of outcomes within the taxonomy that measured the direct experiences of individuals affected by health conditions (including mortality and physiological outcomes). For the purposes of this review we used the broad term “patient focussed” outcome to describe these measures and to distinguish them from the “Delivery of care” and “Resource Use” outcomes that were also described in the taxonomy. During the categorisation process we defined adverse events as “instances which indicate or may indicate that a patient has received poor quality care”41.

## Quality Assessment

We assessed included studies for risk of outcome reporting bias using the methods described in the selective outcome reporting domain in the Cochrane Collaboration’s assessment tool for RCTs 42. For each study we searched trial registries to identify study protocols and identified whether the pre-specified outcomes had been reported in the pre-specified way. The risk of outcome reporting bias was classified as being “unclear” when the trial protocol was unavailable and as “high” when outcomes had not been reported in the pre-specified way.

## Data Analysis

We calculated the proportion of studies reporting at least one measure from each of the identified outcome categories. We also expressed the frequency with which individual measures from each outcome category were reported. We conducted an unplanned analysis of whether the types of outcomes reported in trials changed over time. We tested the significance of the observed trends using the Mann-Whitney U test (IBM® SPSS Statistics® V25).

# RESULTS

## Description of the Included Studies

We identified 45 RCTs for inclusion (see figure one for PRISMA flow diagram; see supplementary data file for a list of studies excluded following a review of the full text). The included RCTs involved 323,945 children and young people. The unit of randomisation was either the child, young person or their parent (n = 21 studies), the practice providing care (n = 20 cluster randomised studies), the clinician providing care (n = 3 studies) or the family unit (n = 1 study).

RCTs were conducted in community healthcare/primary care settings (n = 25 studies), hospitals (n = 15), or mixed primary/secondary healthcare settings (n= 2). In the remaining three studies the setting was not clear. The health conditions that were most frequently investigated were asthma (n = 7), obesity (n = 4) and type 1 diabetes (n = 3) (see Table 1 in the supplementary data file for more details including the year of publication and summarised population, health condition and intervention data). HIT interventions most frequently related to the use of electronic health records (n = 22). The types of interventions evaluated in the studies are shown in Table 1.

|  |  |
| --- | --- |
| **HIT Platforms Utilised for Delivering the Intervention** | |
| *Platform Type* | *Number of studies (percentage)* |
| Electronic Health Record | 24 (53.3) |
| Mobile application | 10 (22.2) |
| Automated Communications Software (SMS or speech calls) | 6 (13.3) |
| Standalone Software (Web-based/Desktop PC/ED Triage Kiosk) | 5 (11.1) |
| Health Information Exchange | 2 (4.4) |
| Patient Portal | 2 (4.4) |
| Computerised Provider Order Entry System | 1 (2.2) |
| Electronic Prescribing System | 1 (2.2) |
| **Types of HIT Interventions Delivered Via Platform** | |
| *Intervention Type* | *Number of studies (percentage)* |
| Clinical Decision Support | 33 (57.8) |
| Notifications/Alerts/Reminders | 20 (31.1) |
| Automated Reports for Clinician Feedback/Audit | 8 (17.8) |
| Electronic Communication (Patient to Provider) | 5 (11.1) |
| Patient Education or Therapy | 7 (13.3) |
| Provider Education | 4 (8.9) |

**Table 1: HIT platforms and interventions delivered in the RCTs (some trials utilised more than one HIT platform or intervention type)**

## Categories of Outcomes Measured in the Studies

Within studies, functioning outcomes were the most frequently reported, with 44/45 (97.8%) of RCTs including at least one Functioning Outcome. The most frequently reported functioning outcomes related to Healthcare Provider Functioning Outcomes (‘Delivery of Care outcomes’). These were reported in 40/45 (88.9%) studies. Other outcome categories were reported much less frequently. Resource Use was reported in 13/45 (28.9%) studies, Patient/Carer Functioning Outcomes were measured in 12/45 (26.7%) studies and Physiological/Clinical outcomes in 10/45 (22.2%) studies. Mortality/Survival outcomes were only measured in 1/45 (2.2%) study. Details of the frequency with which outcome categories were reported within studies are shown in Table 2.

|  |  |
| --- | --- |
| **Outcome Category** | **Number of Studies Reporting at Least One Outcome from the Outcome Category (% of studies)** |
| **Functioning Outcomes** | **44/45 (97.8)** |
| **Healthcare Provider Functioning Outcomes** | **40/45 (88.9)** |
| **Patient/Carer Functioning Outcomes** | **12/45 (26.7)** |
| Perceived Health Status | 5/45 (11.1) |
| Emotional | 4/45 (8.9) |
| Global Quality of Life | 3/45 (6.7) |
| Physical | 3/45 (6.7) |
| Cognitive | 1/45 (2.2) |
| Role | 1/45 (2.2) |
| Social | 1/45 (2.2) |
| **Resource Use Outcomes** | **13/45 (28.9)** |
| Hospital Use | 8/45 (17.8) |
| Need for Further Intervention | 5/45 (11.1) |
| Economic | 4/45 (8.9) |
| Adverse Events (Secondary to HIT Intervention) | 3/45 (6.7) |
| Carer Burden | 1/45 (2.2) |
| Adverse Events (Unrelated to HIT Intervention) | 1/45 (2.1) |
| **Clinical/Physiological Outcome** | **10/45 (22.2)** |
| Endocrine | 3/45 (6.7) |
| Metabolic | 3/45 (6.7) |
| Blood/Lymphatic | 1/45 (2.2) |
| Infection/Infestation | 1/45 (2.2) |
| Nervous System | 1/45 (2.2) |
| Respiratory | 1/45 (2.2) |
| Psychiatry | 1/45 (2.2) |
| **Mortality/Survival Outcomes** | **1/45 (2.2)** |
| Mortality | 1/45 (2.2) |

**Table 2: Number of studies (total studies n = 45) reporting at least one outcome measure from the specified outcome category**

## Overall Categorisation of Outcomes

The included studies reported a total of 181 outcomes (full details shown in Table 3). The most frequently reported outcome measures were categorised as functioning outcomes (n = 122/181, 67.4%). The most frequently reported functioning outcomes were categorised as healthcare provider functioning outcomes (n = 94/181, 51.9%). Mortality/Survival outcomes were the least frequently reported category of outcome measure (n = 1/181, 0.6%).

|  |  |  |  |
| --- | --- | --- | --- |
| **Outcome Categories** | **Total Number of Outcome Measures (% of total reported outcomes)** | **Number of Primary Outcome Measures (% of Primary Measures)** | **Number of Secondary Outcome Measures (% of Secondary Measures)** |
| ***All Functioning Outcomes*** | | | |
| **Total** | **122 (67.4)** | **42 (82.4)** | **80 (61.5)** |
| ***Healthcare Provider Functioning Outcomes (Delivery of Care)*** | | | |
| **Total** | **94 (51.9)** | **35 (67.3)** | **59 (45.4)** |
| Process Implementation and Service Measures | 58 (32.0) | 24 (47.1) | 34 (26.2) |
| Appropriateness of Treatment | 14 (7.7) | 6 (11.8) | 8 (6.2) |
| Acceptability and Availability | 13 (7.2) | 2 (3.9) | 11 (8.5) |
| Adherence/Compliance | 4 (2.2) | 3 (5.9) | 1 (0.8) |
| Satisfaction/Patient Preference | 5 (2.8) | 0 (0.0) | 5 (3.8) |
| ***Patient/Carer Functioning Outcomes*** | | | |
| **Total** | **28 (23.0)** | **7 (13.7)** | **21 (16.2)** |
| Perceived Health Status | 10 (5.5) | 1 (2.0) | 9 (6.9) |
| Emotional/Wellbeing | 6 (3.3) | 3 (5.9) | 3 (2.3) |
| Social | 4 (2.2) | 0 (0.0) | 4 (3.1) |
| Physical | 3 (1.7) | 2 (3.9) | 1 (0.8) |
| Global Quality of Life | 3 (1.7) | 1 (2.0) | 2 (1.5) |
| Cognitive | 1 (0.6) | 0 (0.0) | 1 (0.8) |
| Role | 1 (0.6) | 0 (0.0) | 1 (0.8) |
| ***Resource Use*** | | | |
| **Total** | **40 (22.1)** | **3 (5.9)** | **37 (20.4)** |
| Hospital | 19 (10.5) | 2 (3.9) | 17 (13.1) |
| Need for Further Intervention | 12 (6.6) | 0 (0.0) | 12 (9.2) |
| Economic | 4 (2.2) | 0 (0.0) | 4 (3.1) |
| Adverse Events (attributed to HIT intervention) | 3 (1.7) | 0 (0.0) | 3 (2.3) |
| Adverse Events (not attributed to HIT intervention) | 1 (0.6) | 1 (2.0) | 0 (0.0) |
| Carer Burden | 1 (0.6) | 0 (0.0) | 1 (0.8) |
| ***Physiological/Clinical*** | | | |
| **Total** | **18 (9.9)** | **5 (9.8)** | **13 (10.0)** |
| Endocrine | 7 (3.9) | 2 (3.9) | 5 (3.8) |
| Metabolic | 5 (2.8) | 3 (5.9) | 2 (1.5) |
| Psychiatric | 2 (1.1) | 0 (0.0) | 2 (1.6) |
| Blood/Lymphatic | 1 (0.6) | 0 (0.0) | 1 (0.8) |
| Infection/Infestation | 1 (0.6) | 0 (0.0) | 1 (0.8) |
| Nervous System | 1 (0.6) | 0 (0.0) | 1 (0.8) |
| Respiratory | 1 (0.6) | 0 (0.0) | 1 (0.8) |
| ***Mortality/Survival*** | | | |
| **Total:** | **1 (0.6)** | **1 (2.0)** | **0 (0.0)** |
| ***All Outcomes*** | | | |
| **Total** | **181 (100.0)** | **51 (100.0)** | **130 (100.0)** |

**Table 3. Categorisation of Outcome Measures Reported in Included Studies**

## Adverse Events

Only 3/45 (6.7%) RCTs reported an assessment of whether the introduction of the HIT intervention had been associated with adverse events; in one study no adverse events were identified but the authors provided a clear description of a methodology for identifying unanticipated effects of introducing the intervention43; in another study the authors reported that clinicians experienced “frustration” associated with using the HIT intervention44; and in one study the investigators described a method for identifying “harms” associated with the introduction of the intervention which included negative patient perceptions (reported to affect fewer than 10% of participating parents) 45. One RCT reported the effect of the HIT intervention on Adverse Events related to other aspects of treatment, specifically those caused by the insertion of peripheral venous catheters 46.

## Risk of Outcome Reporting Bias

Studies were assessed for the risk of outcome reporting bias using the Selective Outcome Reporting domain of the Cochrane Risk of Bias Tool42. The risk of outcome reporting bias was assessed to be low in 14/45 (31.1%) studies, unclear in 28/45 (62.2%) studies and high in 3/45 (6.7%) studies (see Study Characteristics Table in Supplementary File).

## Changes in Outcome Reporting Over Time

The most recently published trials were more likely to report Patient/Carer Functioning outcomes (Mann-Whitney U = 120.0, p = 0.046) and were less likely to report Healthcare Provider Functioning (Delivery of Care) outcomes (Mann-Whitney U = 44.5, p = 0.042). There was no significant association between the year of publication and the frequency with which physiological/clinical, mortality and resource use outcomes were reported.

# DISCUSSION

We have systematically evaluated the categories of outcomes reported in randomised trials of HIT interventions conducted in paediatric healthcare settings. Most studies report outcomes relevant to healthcare providers, but not those of direct relevance to patients. In most studies it was unclear whether all the outcomes that were measured were subsequently reported. Most studies did not report whether the HIT intervention was associated with any adverse events.

Outcomes that are relevant to healthcare providers, such as documentation quality, adherence to guideline recommendations, and time taken to complete recommended clinical assessments 47-49 are important and may act as useful surrogates for more patient focussed outcomes. However, there are well documented examples which demonstrate the risks of relying upon surrogate outcomes in clinical trials50. We would therefore suggest that trials that rely on these outcomes should always be appraised with caution, as they do not provide direct information about whether the interventions actually benefit children and young people with healthcare needs.

When studies rely on surrogate outcomes, we would suggest that it is particularly important to consider whether there were any unintended consequences associated with the introduction of the intervention. There is recognition that the use of HITs has the potential cause harm to patients51-53 and to result in reduced productivity within healthcare systems54. However, our findings demonstrate that most studies did not report an assessment of whether the intervention under review was associated with any adverse events (n = 3/45 (6.7%) studies included this assessment). This is a significant finding because it has been demonstrated that the failure to actively identify and report adverse events within studies may significantly affect their conclusions 55-57.

The purpose of an RCT is to evaluate whether the intervention does more good than harm. Therefore, until measurement and reporting of patient-focussed outcomes becomes more commonplace, and the reporting of adverse events becomes routine, it will be difficult to fully evaluate whether HIT interventions are effective, or cost-effective with regards clinical care in pediatrics.

Our finding that the risk of outcome reporting bias was high or unclear in the majority of studies (n = 31/45 (68.9%)) is concerning. As noted above, outcome reporting bias in RCTs is commonplace 58 and can affect the conclusions of individual trials and meta-analyses26,27. We would therefore suggest that it is important that investigators attempt to ensure that all study outcomes are reported, regardless of the result, to ensure that these risks are minimised.

Although COS are most frequently developed for use in trials involving participants with particular health conditions, they have also been developed for use in appraisals of specified interventions 32-34. When COS have been developed for use in other research settings, 92% have included physiological/clinical measures of health, 40% included Quality of Life measures and 33% included measures of morbidity or survival 40. Given the infrequency with which these outcomes were measured and reported in the RCTs included in our review, we would strongly suggest that a diverse group of stakeholders, including children and families, as well as other key stakeholders, are consulted on their views about how to evaluate the effects of implementing HITs in pediatrics.

Combining these views within an agreed framework for evaluating outcomes in pediatric studies of HITs, such as a standardised COS, could be very beneficial. This type of initiative could increase the likelihood that important outcome categories are measured, and that all measured outcomes are subsequently reported in published investigations.

Other ways of improving the selection, measurement and reporting of outcomes might include the development and the routine publication of study protocols, and the utilisation of methodologies designed to identify and clearly report the presence or absence of adverse events associated with the introduction of HIT interventions.

One potential limitation of our review is that we have attempted to compare the outcomes that were reported in studies that were conducted across a heterogenous range of healthcare settings. For this reason, we used methods that enabled the categories of outcomes (rather than specific measurement tools) to be compared between studies. We also used accepted methods for completing the systematic review and used a validated tool for assessing the risk of outcome reporting bias in the included studies.

As technology progresses, it seems inevitable that further, prospective studies of HIT interventions will be undertaken. Our findings highlight the need for careful outcome selection and reporting practices within these studies. Despite high levels of centralised funding for HITs, and clear indications from policy makers that they are perceived to be beneficial, only minimal attention seems to have been given to developing formal recommendations or regulations relating to the outcome reporting practices that should be used in assessments of their effects. We would, therefore, recommend the development and routine adoption of a framework for identifying and reporting outcomes (such as a COS) for use in evaluations of HIT interventions conducted in pediatric healthcare settings.

# CONCLUSIONS

RCTs of HIT interventions conducted in paediatric settings frequently report outcome measures related to the process of delivering care, rather than physiological, quality of life or survival outcomes. Assessments of whether the interventions have unintended consequences, or result in adverse events are infrequently reported. It is therefore difficult to evaluate the benefits and risks of these interventions, and to appraise which interventions are most worthy of financial investment and adoption into clinical practice. Measures to improve the quality of trials of HIT interventions may include the routine publication of study protocols and the development of an outcome reporting framework.

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# COMPETING INTEREST STATEMENT

The authors have no competing interests to declare

# CONTRIBUTORSHIP STATEMENT

Dr Neame conceptualized and designed the study, collected data, drafted the initial manuscript, and reviewed and revised the manuscript.

Mr Chacko contributed to the design of the data collection instruments, collected data for the study and reviewed and revised the manuscript.

Dr Kirkham helped to design the study and the data collection instruments, and critically reviewed the manuscript for important intellectual content.

Drs Sinha and Hawcutt conceptualized and designed the study, coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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