Understanding and optimising electronic audit and feedback to improve quality of care

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Chapter 1

General introduction
Rapid advances and innovations in the medical field have led to extraordinary amounts of new literature being produced on a daily basis [1, 2]. However, a consistent finding is that new research often fails to translate into real-world clinical practice [3–6]. For instance, in the United States it has been observed that patients received 55% of recommended care [7]. Furthermore, 20% to 30% of patients may receive care that is not needed or care that is potentially harmful [8]. Due to these evidence-practice gaps, patients may fail to benefit from the advances in medicine and can be exposed to unnecessary health risks, and healthcare systems may be exposed to unnecessary expenditure. Quality improvement strategies are widely applied in an effort to close these evidence-practice gaps through systematically changing health professional behaviour and organisation of care [9], and can save both lives and money [10]. This thesis addresses audit and feedback: one of the most commonly used quality improvement strategies in healthcare.

Audit and feedback: over half a century of research and practice

Audit and feedback (A&F) builds on providing summaries of clinical performance, over specified periods of time, to individual health professionals and care teams [11]. Clinical performance is typically measured by a set of quality indicators derived from clinical guidelines or expert opinion – each indicator representing a quality aspect of care (e.g. proportion of patients receiving a treatment according to the guideline recommendations, or mortality rates) [12]. A&F seeks to direct health professionals' attention to discrepancies between desired and actual practice by making any evidence-practice gaps explicit, and thus motivate professionals to change their behaviour [13–15]. From a health informatics perspective, health professionals who receive feedback about their clinical performance can make better decisions about whether and how to change practice than professionals who do not [16, 17].

Interventions that use A&F techniques to improve the quality of care have been practised and studied for many years. A&F can be the core of the intervention or part a larger multifaceted intervention, e.g. when combined with educational meetings or reminders [18–20]. A Cochrane review of 140 randomised controlled trials (RCTs) of A&F reported a median absolute increase in professional performance of 4.3%, with an interquartile range of 0.5% to 16% [21]. Hence, although A&F is generally effective at improving quality of care, there is substantial variation in the observed effects. A&F appeared to be most effective if provided by a supervisor or colleague, more than once, both verbally and in writing, if baseline performance is low, and if it includes explicit targets and an action plan [21]. However, these effect modifiers only partially explained the observed variation in A&F effects.

The uptake of electronic health records in recent years has significantly impacted the ease with which A&F can be executed [22,23]. Its consequences particularly relate to the increased amount of routinely collected clinical data available for A&F, the reduced time and resources required to analyse those data, provision of timely feedback through electronic A&F systems such as dashboards, and the ability to compare achieved performance levels across different care providers [24,25]. In response, hospitals and other healthcare organisations have increasingly adopted A&F techniques as a strategy to systematically improve their quality of care. The research in this thesis capitalises on these novel opportunities provided by electronic health records and electronic A&F (e-A&F) interventions.
Advancing stagnant science

In spite of the widespread application of A&F, effect sizes of A&F interventions have increased very little over time [26]. This suggests that researchers and providers of A&F have not been able to cumulatively learn from previous studies to develop consistently effective interventions [27]. Given the importance of A&F as a key component in many healthcare improvement interventions, there is an urgent need to identify opportunities to advance the stagnant science of A&F [26, 28].

Using theory and evidence to guide the design and evaluation of audit and feedback

Theory and evidence should inform the design and evaluation of A&F interventions. They can help clarify behavioural causal pathways and underlying mechanisms, thereby contributing knowledge about how to optimise A&F effectiveness [29, 30]. However, previous A&F studies have scarcely made explicit use of theory or built on extant knowledge from past interventions [31, 32]. For example, although some best practices for A&F designs have been identified from various theories and empirical studies in the literature, few interventions have actually featured those practices [21, 26]. These suboptimal designs of A&F interventions have led to unnecessarily missed opportunities to achieve larger effects, and have limited our ability to learn from and across studies. The latter is further diminished by the often poor reporting of intervention design [33]. Therefore, it is imperative that A&F interventions are explicitly based on theory and evidence. In this thesis we describe Control Theory and how it can be used to guide the design and evaluation of A&F interventions (Chapter 2). We also reviewed the current theory and evidence to inform the choice of clinical performance comparator; a key component in the feedback message in A&F that aims to draw attention to a discrepancy between actual and desired practice (Chapter 3).

Furthermore, pragmatic RCTs that evaluate whether an A&F intervention is effective by comparing against “usual care” [34] have increasingly failed to contribute new knowledge, yet are still being conducted [26]. Since we already know A&F is an effective quality improvement strategy, those traditional RCTs that explore whether A&F is effective are no longer meaningful and merely add to research waste [35, 36]. While we have the results of over 140 RCTs of A&F at our disposal, we still know awfully little about how A&F works and how we can increase its effectiveness [27]. Meta-regressions of those RCTs have also been unable to offer a solution: they struggled to identify key ingredients for successful A&F due to the often poorly defined “usual care”, and substantial variation in factors relating to the context, feedback recipients, and clinical topic [21, 37–39]. Evaluation of A&F therefore needs to move away from traditional RCTs that compare to usual care and adopt a new approach that involves sequential and systematic testing of different variations of A&F designs [28, 40]. Testing these variants in direct “head-to-head” comparisons allows for a more controlled environment to achieve greater confidence in causal inference regarding effective A&F intervention designs [28, 41]. For example, one can use this approach to build knowledge about how best to operationalise particular design elements, such as the performance comparator [42], written behaviour change message [43], feedback timeliness and frequency [44], and many others [45]. In this thesis, we report on a head-to-head RCT that evaluated whether the effectiveness of an e-A&F intervention with an empty structured action plan can be increased when extended with an integrated “action implementation toolbox” containing suggested actions for improvement (Chapter 6 and 8).
Understanding the mechanisms through which audit and feedback improves care quality

The underlying mechanisms through which A&F may lead to effective quality improvement are poorly understood. Researchers have often treated A&F as a “black box” and focused solely on the box’s output, that is, impact on quality of care, while ignoring the mechanisms inside [46]. Insufficient theory-driven, empirical studies have been conducted that aim to unravel these mechanisms to build further knowledge about how A&F works, to enhance A&F designs, and increase their effectiveness.

Process evaluations are typically conducted alongside or after A&F trials and aim to assess fidelity and quality of implementation, clarify causal mechanisms, and identify contextual factors associated with variation in outcomes [47]. Most process evaluations analyse unstructured data collected through interviews, focus groups, or observations using qualitative research methods which are often laborious and time-consuming [48]. The electronic nature of modern A&F provides us with novel possibilities to study the intervention process, because these systems can record many events that are relevant to the A&F process. More specifically, they can automatically capture interactions (e.g. logins, key strokes, page views) which refer to whether, which, and how users interacted with the system’s components; which and under what circumstances information was displayed (e.g. the contents of the feedback message); and record clinical decisions (e.g. which quality indicators were targeted for improvement) [49]. These electronic data, which are a by-product of using the intervention in real-life, have thus far been underutilised in research that tries to understand how A&F interventions lead to changes in processes and outcomes [50]. Unobtrusive, quantitative process evaluations that harness these data may provide a more comprehensive picture of the intervention process to explain observed variability in effectiveness, discover where the process may fail, and reveal determinants for success [49, 51]. In this thesis we report about process evaluations of e-A&F interventions that used quantitative data to uncover health professionals’ interactions with the intervention, their improvement intentions, and which actions they actually took to change practice (Chapter 4, 9, and 10).

Many of the mechanisms remain implicit when an A&F intervention is released in clinical practice. This includes, for instance, to what extent and how the feedback influences recipients’ perceptions about their own clinical performance and intentions to improve practice. Such mechanisms may be impossible to study by quantitative process evaluations of A&F interventions in real-world settings, e.g. when contaminated by organisational or managerial constraints, or by social influences when feedback is delivered to teams [52, 53]. Laboratory experiments provide an opportunity to investigate these specific A&F mechanisms by mimicking those real-world settings under controlled conditions [54, 55]. For example, experiments may utilise (an adapted version of) existent A&F systems to explore feedback recipients’ responses under various simulated or real circumstances such as high or low performance, or different feedback formats. Such experiments in the field of A&F are scarce at best, but yield new insights into recipients’ decision processes in addition to studies in clinical practice alone [54]. In this thesis we describe laboratory experiments to understand to which extent and through what mechanisms A&F influences health professionals’ perceptions about their own clinical performance and their intentions to improve practice (Chapter 4 and 7).

Clinical settings

The chapters in this thesis report about studies of e-A&F interventions across three different clinical settings, which we now briefly introduce.
Cardiac rehabilitation

Cardiac rehabilitation (CR) is a multidisciplinary, outpatient therapy to support patients with coronary heart disease recovering from a cardiac incident to regain physical capacity, improve psychosocial condition, and achieve lifestyle changes [56]. CR reduces mortality, future cardiovascular risk, and symptoms of depression and anxiety; it can improve quality of life, and it can facilitate work resumption [57–62]. CR teams typically include cardiologists, nurses, physical therapists, psychologists, dieticians, social workers, and rehabilitation physicians. CR has been shown to be cost-effective in economic evaluations in North America and Europe [63]. It has been associated with a 35% reduction in mortality over a follow-up of four years in the Netherlands [62], with similar findings in the United States [64] and Canada [65]. However, despite the known benefits, widespread endorsement of its use [56,61,66], and international and national guidelines [67–71], CR is often underutilised, poorly standardised, and does not follow the available scientific evidence [60,72,73]. Only a minority of patients in the Netherlands eligible for CR actually receive it (28.5% among patients with an acute coronary syndrome or coronary intervention) [74]. Other studies showed that the content of exercise training programs varies widely between CR centres [75], and substantial differences in how Dutch CR centres organised their services [76].

Intensive care pain management

Intensive care units (ICUs) are complex organisational units within hospitals providing multidisciplinary and expensive care to a heterogeneous population. In the Netherlands, all ICUs voluntarily participate in the National Intensive Care Evaluation (NICE) registry, which was established in 1996 to systematically and continuously monitor and improve quality of ICU care [77]. Patients admitted to the ICU are usually in need of intensive monitoring and some form of mechanical or pharmacological support, have a relatively high mortality and morbidity risk [78,79]. During their time in the ICU many patients are exposed to adverse experiences; acute pain being one of the leading stressors [80]. More than 30% of patients experience moderate to severe pain at rest, and about 50% of patients experience pain during common care procedures [81–84]. The physical and psychological stresses caused by pain have been associated with increased length of stay, morbidity, and poor mental health outcomes [85–87], and affect quality of life even after ICU discharge [88,89]. However, studies have shown large gaps between ideal and actual care with respect to intensive care pain management [90–93]. The severity of pain is often underestimated by ICU professionals, and as a consequence pain is treated inadequately [94,95].

Primary care medication safety

Safe medication practice is a core objective for health care systems worldwide, and was recently identified by World Health Organization (WHO) as the theme for the third Global Patient Safety Challenge [96]. It has been estimated that the cost associated with medication errors equals $42 billion USD annually across the globe [97]. An estimated 237 million medication errors occur at some point in the medication process in England per year, causing avoidable adverse drug reactions with a total estimated cost of £98.5 million per year and 712 deaths [98]. While most items prescribed in primary care carry very low risk for harm, the sheer volume of primary care prescribing (more than 2,000 items each minute) means that medication errors in primary care contribute to more than seven times the number of avoidable deaths than
secondary care (627 versus 85) [98]. About 5% of patients who are managed in English general practices and at risk of medication errors received a potentially hazardous prescription, and about 12% had no record of adequate blood-test monitoring [99]. The prevalence varied strongly between practices [99].

**Aims and outline of this thesis**

The aim of this thesis is to advance the science of A&F through better understanding and optimising its ability to improve quality of care. To achieve this aim we have formulated the following research questions:

1. What is the theory and evidence underpinning A&F and the use of clinical performance comparators in A&F interventions?

2. What is the impact of three state-of-the-art, theory and evidence-based electronic A&F interventions across different clinical settings on the quality of care?

3. What are the mechanisms through which A&F affects health professionals’ clinical performance perceptions, improvement intentions, behaviour, and, ultimately, quality of care?

Part I of this thesis explores the answer to research question 1. Chapter 2 explains Control Theory and how it can be used to guide the design and evaluation of A&F interventions. Chapter 3 reviews the theory and evidence to inform the choice of clinical performance comparator; a key component in the feedback message that aims to draw attention to a discrepancy between actual and desired practice. The other three parts of this thesis seek to answer research question 2 and 3, with each part describing multiple studies in the context of a specific electronic A&F intervention and clinical setting.

Part II reports about an A&F intervention with outreach visits to improve cardiac rehabilitation in the Netherlands. Chapter 4 describes a laboratory experiment and quantitative process evaluation in the context of this intervention to explore the factors that influence how multidisciplinary teams select indicators as targets for improvement; the first, but essential, step in A&F interventions to achieve effects. Chapter 5 reports the results of a cluster randomised controlled trial (cRCT) evaluating the intervention’s effects on guideline concordance and professional practice in 18 cardiac rehabilitation centres.

Part III concerns an A&F intervention with action implementation toolbox to improve intensive care pain management in the Netherlands. Chapter 6 provides the study protocol; Chapter 7 reports a laboratory experiment to explore ICU professionals’ clinical performance perceptions and improvement intentions before and after receiving feedback; Chapter 8 presents a head-to-head cRCT evaluating the impact of the intervention with versus without toolbox in 21 ICUs; and Chapter 9 describes a mixed-methods process evaluation exploring the mechanisms through which the toolbox facilitated ICUs’ action planning.

Part IV involves a pharmacist-led A&F intervention to improve medication safety in primary care in Salford (Greater Manchester), UK, which included an online dashboard listing patients exposed to potentially hazardous prescribing or inadequate blood-test monitoring. Chapter 10 studies how the dashboard was utilised by pharmacists and general practice staff to resolve medication safety risks. Chapter 11 reports the results of a prospective, interrupted time series study to evaluate the impact of the intervention in 43 general practices.

Finally, the general discussion in Chapter 12 synthesises and discusses the main findings presented in this thesis.