

Practice Assessment : The PARSEC Model

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Abstract

Background: Practice assessment (PA) is proposed to be a necessary aspect of clinical governance and quality improvement. However, lacks in causal understanding of its mechanisms is causing unexplained variations in its effect. Informatics has been seen to be invaluable in similar fields although its effect on PA is largely unknown. Future implementation efforts will need guidance on how to develop PA systems and how to operationalize best practices, and current evidence.

My objectives are to: (1) identify the barriers to effective audit and feedback interventions in health-care and to suggest how informatics methods implemented in the context of theories of behaviour change can help to overcome these barriers; (2) develop a model capable of supporting the development and administration of electronic PA interventions using findings from barriers to A&F, approaches to behaviour change, and product engineering.

Methods: We used a qualitative, explanatory case-study to identify the barriers to effective A&F intervention and to frame these barriers within the context of informatics methods and behaviour change theories using instances of deployed interventions as cases. Qualitative data was collected from the cases, and these data were subjected to a deductive thematic content analysis. These findings then informed the creation of a generic model of electronic PA. The model was described using a standard of software specification.

Results: The thematic analysis resulted in the identification of six overarching themes regarding barriers to effective PA implementation. These were: resource constraint, adoption, clinical governance, cognitive biases, control theory, and learning culture. A presentation of the models' requirements was then used to describe how instances should be developed, what they must contain, how they should be administered, and what are the activities needed to their deployment.

Conclusion: Although A&F causal mechanisms are still unknown, the use of multiple theoretical perspectives allowed us to identify qualitatively potential barriers influencing its effect on improving quality and health outcomes. These findings suggest that the use of informatics methods an impact large enough to warrant separate evaluation. This shift in paradigm offers hope as to the possibility of achieving greater sustainability, lowering net costs, creating a beneficial culture of quality, and putting in place the foundation of an evidence-based, quality-focused, and accountable primary health care system.

Résumé

Introduction: L'évaluation de la pratique (PA) est recommandée comme un élément essentiel de la gouvernance clinique et de l'amélioration de la qualité. Cependant, une mécompréhension de ses mécanismes d'action entraîne d'inexplicables variations dans ses effets. L'informatique fut reconnue comme inestimable dans des domaines similaires, néanmoins son effet sur le PA est largement inconnu. De futurs efforts d'implémentation auront besoin de guidance pour développer des systèmes de PA et opérationnaliser le savoir sur les meilleures pratiques et la recherche actuelle.

Mes objectifs sont : (1) d'identifier les barrières à une intervention efficace d'audit et de rétroaction (A&F) en santé et de suggérer comment l'informatique, dans le contexte des théories des modifications comportementales peuvent aider à surmonter ces obstacles; (2) de concevoir un modèle capable de supporter le développement et l'administration d'interventions de PA électronique utilisant les barrières au A&F, des approches au changement comportemental, et de l'ingénierie du produit.

Méthodes: Nous avons utilisé une étude de cas qualitative, à fin explicative, pour identifier les barrières à l'A&F efficace et pour placer ces barrières dans le contexte de l'informatisation et du changement comportemental, utilisant des instances d'interventions déployées comme cas à l'étude. Des données qualitatives ont été collectées à partir des cas, et ces données furent soumises à une analyse déductive thématique de contenu. Les résultats de cette étape ont ensuite informé la création d'un modèle générique de PA électronique. Ce modèle a ensuite été décrit utilisant un standard de spécification logicielle.

Résultats: L'analyse thématique a permis l'identification de six thèmes globaux concernant les barrières à l'implémentation efficace de PA. Ces derniers étaient : ressources limitées, l'adoption, la gouvernance clinique, les biais cognitifs, la théorie du contrôle, et la culture de l'amélioration. Une présentation des requis du modèle a ensuite été utilisée pour décrire comment les instances devraient être développées, ce qu'elles devraient contenir, comment elles devraient être administrées, et quelles activités seraient nécessaires à son déploiement.

Conclusion: Bien que les mécanismes d'action de l'A&F sont encore inconnus, l'usage d'une approche plurithéorique nous a permis d'identifier qualitativement les barrières potentielles à son effet sur l'amélioration de la qualité et la santé. Nos résultats suggèrent que l'usage de l'informatique influence

suffisamment les interventions d'A&F pour justifier leur évaluation séparée. Ce changement de paradigme ouvre la porte à des interventions plus durables, moins chères, à la création d'une culture bénéfique de qualité, et la mise en place des fondations pour un système de santé primaire basé sur les données probantes, orienté vers la qualité, et responsable.

Preface and Contribution of Authors

The end of the industrial revolution marked the beginning of a new one, the information revolution. This new age was characterised not by the machine or people that drove it, but by an intangible thread of scientific and technical advancements. The defining factor of this new era is its dependency on the production and consumption of information. Information, in this time, is sought not for its intrinsic value, but for the influence it has on the people and powers that are shaping our world. The advent of the digital computer marked a sharp increase in the breadth of information that is available and the rate at which it is collected. Innovative software solutions eventually revolutionised most domain of human activities from models in physics, to engineering simulations, to business intelligence. Through all of these changes, one field lagging behind, medicine. A number of reasons have been advanced to explain this, but the facts are that medicine is not introducing and making use of information technology at the same rate as other domains. By looking at the great advances that were caused in other fields, this suggests that great potential is still to be seen in medicine. One of the major use of health data is to provide meaningful and actionable feedback to physicians in order to allow them to adapt their practice patterns improving their performance and promoting better health outcomes. Few have tried, much is still unknown, but this idea is, in my opinion, a necessary component of future health systems. It is this consideration that led to the research presented in this document.

This document is formatted according to the requirements for “manuscript thesis”. This publication, which can be found in section 3, was added to this document along with linking sections for fluidity and readability. This format has for side-effect the separation of some of the background and discussion section. The content of the manuscript was not repeated to prevent duplication. This will need to be taken into consideration when reading the background or discussion section of the overall document.

The first chapter introduced the concept of practice assessment and discussed its relation with major paradigms of quality in health care. It also presented the need for electronic practice assessment and what would be the next step in its development. In the second chapter, I will present the foundational knowledge on which this research is based. It will discuss current knowledge, prior findings, best evidence regarding audit and feedback and the various techniques of behaviour change that it uses. Chapter three will present

a manuscript which was prepared for journal publication and aims at answering the first objective of this research. It will present a qualitative case study design of 4 electronic audit and feedback interventions. Chapter four will introduce the Practice Appropriateness Research System for Evidence-based Care (PARSEC) model and discuss its development. This framework of barriers and facilitators was developed using the findings presented in chapter three along with other concerns relating to its objective of supporting future implementations. Chapter five will complete this thesis with a self-reflective examination of the strengths and weakness of my approach, along with a discussion of the significance of its findings for future research and practice.

The main author of this document, Maxime Lavigne, was the sole author of all content except the manuscript. This manuscript was a collaboration of the main authors and its thesis committee but relied on work done by the main author.

Abbreviations

A&F	Audit and Feedback
ACGME	Accreditation Council for Graduate Medical Education
AE	Adverse Events
EMR	Electronic Medical Record
FI	Feedback Intervention
NHS	National Health Service
PA	Practice Assessment
PM	Performance Measurement
PBLI	Practice-Based Learning and Improvement
QA	Quality Assurance
QI	Quality Improvement
SCOT	Social Construction of Technology
SD	Standard Deviation
SRS	Software Requirements Specification

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My first acknowledgement is to Dr Tamblin, who, three years ago, supported my initial admission to the Department of epi and gave me the opportunity to enter the MCHI. At the MCHI, I was offered challenging projects and given carte blanche as to their development. Along with Dr Buckeridge and his team, I worked on projects on the limit of current knowledge and was able to practice my trade on innovative ideas and with amazing technologies. From this point, Dr Buckeridge was already helping me to sharpen my skills and improve my analytical and critical reasoning. He then moved on to supervise my master and helped me find this topic. I wish to recognise the time and efforts that he put in helping me achieve my goals.

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Clarity of thought and motivation was often driven by friendly conversations with fellow students, and, in this regard, no one was more helpful than Mr Gagnon, and Mr Powell.

I wish to thank my family for their continuing support and encouragements. Times were not always sunny, and quitting would often have felt like the easiest choice, but they allowed me to move onward. There are no words that can carry my level of gratitude.

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1 Introduction

"Begin at the beginning," the King said, very gravely, "and go on till you come to the end: then stop." — Lewis Carroll, Alice in Wonderland

Practice assessment (PA) is an evidence-based evaluation process which systematically assess a physician's medical practice with the aim of generating insights able to support continuous improvement. Also known as practice report or physician profiles, it is a particular kind of audit and feedback intervention. Audit and feedback (A&F) being defined as "Any summary (written or verbal) of clinical performance of health care over a specified period of time." (Ivers et al., 2012) In selecting the term practice assessment, I am placing emphasis on strategies that use a holistic assessment of medical practices to provide personalised support of physicians natural tendency of seeking to improve their professional competency. Audit and feedback techniques can be viewed as closed loop dynamical systems in which the output of a system is measured and compared against standards in order to create a feedback signal that will be used to adjust how new inputs are processed. (Gardner et al., 2010) The term audit and feedback is by definition contextual to health care, but similar strategies are common practice in other fields such as business, education, and engineering. In aiming to impact physician practice patterns using clinical data, it draws on principles from the areas of performance measurements, knowledge translation, and behaviour change.

Feedback in Medicine

Feedback is an integral part of the modern medical profession it is seen from residents getting recommendations from supervisors to practising physicians asking for consultations. The modern medical professional will have to deal with feedback of varying content and from multiple sources throughout its day-to-day practice. Apart from external feedback, medical doctors also have the opportunity to see the results of their decision in the health of their patients.

One of the first formal feedback processes that are still in use today is the Mortality and Morbidity (M&M) Conference. Although it has been criticised for not being comprehensive enough in its presentation or focusing mostly on “interesting” cases, it nonetheless offers an opportunity for peer review and is believed to be driving change. M&M were the first feedback effort used as a mean of ensuring quality and appropriateness of patient care.(Hopkins, 1989)

Quality Assurance

System-wide patient safety measures were a product of the 1980s. Serious failings from health care organisation, together with high profile cases of medical error, along with documented differences in services and standards of care increased public awareness and led to a lack of confidence or trust(Kennedy et al., 2001; Portillo, 1998). Although the existence of variation in practice is now common knowledge, it was controversial in the mid 1980(GMS, 1986). This led to some of the first major adverse events review studies(Brennan et al., 1991) and an increased use of audits(DOH, 1999). Audits were taking place as part of a new field of quality assurance, that aimed at continuously monitoring patient care in order to identify ”problems” that required attention. It is this new strategy which was considered a new but highly desirable concept in European member states of World Health Organization in 1989.(Group et al., 1989) Quality assurance initiatives had to, in part, help soothe the public anxiety and bring back confidence through better monitoring and greater transparency.(Group et al., 1989) It needed to break a cycle of inaction from multiple actors of the system; ”At a very minimum, the health system needs to offer that assurance and security to the public”(Kohn et al., 2000) Clinical audits were performed as a way to verify and control the appropriateness of medical care. Quality assurance strategy established power dynamics between health system managers and medical professionals, challenging professional competency and making use of coercive corrective measures. Its strategy was ”reactive, retrospective, policing, and in many ways punitive; often involved in determining who was at fault after something went wrong”(USMLE, 2016).

Moving to Quality Improvement

Although proponents of quality assurance are still found in the public discourse, most national strategies evolved to a broader perspective of improving all aspects of quality; not only on patient safety and medical accountabil-

ity(Gauthier et al., 2003). This paradigm shift was led by an influential report which emphasised that the divide between what we know is good care and the care that is provided, is not a gap but a chasm. Patient safety was still an issue, but we now know that the overall system was failing at providing high-quality care. The report recommended that health care should be safe, effective, patient-centred, timely, efficient, and equitable(America and Medicine, 2001). Along with its British equivalent (DOH, 1998), it set an agenda for a new field of quality improvement (QI) and clinical governance. In this new paradigm, organisations were accountable for continuously improving the quality fo their service and safeguarding high standards of care. It recognised the lack of national standards, the lack of shared best practices, and the presence of inequities in clinical practice and clinical outcomes(DOH, 1998). In this new view, physicians were expected to be lifelong learners and to be participants in this new culture of quality improvement. Efforts were consequently made to establish and monitor new standards of care and to put in place a performance framework which supported learning by sharing successes and failures (DOH, 1998). Essential to this objective was the ability of health professionals to assess the care they gave compared to established standards of care. This aim recommended the expansion of the use of clinical audits and underlined the importance of local ownership to support new and innovative clinical practice. As part of this requirements, they laid out the need for a range of audit methodologies adapted for local use and using best evidence. Therefore, QI changed how and for what reason clinical audits were performed. It no longer aimed at detecting harm but rather areas of improvement. The relation between health systems and physicians was no longer one of confrontation but rather one of mutual aid in which both sides contributed to the betterment of clinical practices and patient care. Donald Berwick summarised this new understanding of clinical audits with the statement ”we cannot possibly inspect our way to excellence.”

Practice Assessment and its Modern Role

Clinical audits were postulated as an integral part of clinical governance (DOH, 1998). Conjointly, it was seen necessary to develop a support infrastructure for physicians to drive excellence at a practice and local level. Audit and feedback is an increasingly used QI technique which supports core QI processes such as knowledge transfer, monitoring of practice, changing behaviours, and

driving continuous improvements. By allowing local stakeholders to monitor and assess the performance and quality of patient care and to compare their process against standards or peers, A&F, and its more holistic version practice assessment is able to affect positively how health care is provided. By favouring evidence based and cost effective solution such as the use of preventative care, PA also contributes to improving the health of populations and lowering the per capita costs of health care. These three goals have been proposed as necessary in order to achieve high-value health care and constitutes the triple aim initiative (Berwick et al., 2008). Chronic diseases are another context where evidence-based clinical interventions exist for treatment and prevention, but in many settings, clinicians do not apply these interventions in an optimal manner to all patients who might benefit. They are the largest cause of mortality, potential of life lost (PYLL), and disability-adjusted life year (DALY) in the world (Media Centre WHO, 2013). They inflict a substantial economic burden on the economies of nations, and their toll is predicted to increase in the coming decades (Bloom et al., 2012).

Breaking with the idea that "more care is better care" are new initiatives looking at preventing wasteful or unnecessary medical tests, treatments, and procedures (Grady and Redberg, 2010). At the base of "Choosing Wisely" is the recognition that most health systems are wasteful, and that measures should be taken to ensure physicians make decisions which are supported by evidence, works for patients similar to theirs, is not duplicative, is free from harm, and is truly necessary (ABIM Foundation, 2016). PA allows to both monitor the state and impacts of over-treatment, and to help to change the patterns of practice that are causing it.

Practice Assessment in Primary Care

Primary care constitutes the backbone of modern health care system (MSSS, 2003). It is the first, and sometimes only door in, and for this reason, primary care physicians covers the most patients and are consulted for the largest variety of issues (DOH, 1997). They are the closest lever to individual behaviours and are known to impact the health of their communities. This suggests that the quality and performance of patient care delivered in primary care will have the most impact on the health of a population. However, the generality of primary care also implies that its practitioners will need to be proficient and make use of the broadest set of practice guidelines and evidence-based recommen-

dations. This places primary practice in a precarious position since the body of knowledge on recommended practices is growing at an increasing rate and it has been estimated, in 2003, that it would take a physician 8 hours a day to provide all recommended interventions (Yarnall et al., 2003). Consequently, the specific characteristics of primary care make it an ideal candidate for PA. This is why audits and peer reviews were included in the mandate of Primary Practice Groups in the UK since their creation (DOH, 1997).

Looking at the Future

Since practice assessment is a discipline of information management, its understanding necessitates an overview of how healthcare is predicted to evolve in the next decade. A first prediction is that more organisation will use clinical information system and that these systems will collect more clinical data and offer greater integration that is currently seen. It is also likely that future electronic medical records (EMR), will make available to the physician a greater set of indicators and metrics about the how social determinants of health impact a patient. Similarly, a more comprehensive set of information is expected to be available for each patient. Finally, we predict that more evidence-based guidelines and recommendation will be created and that this new generation of protocols will consider patient preferences, will include patient-specific recommendations made using personalised medicine, will account for multi-morbidity, and will be better known by patients because of improved communication tool.

The Dilemma

The notion of what is appropriate and quality care has changed drastically over the last 30 years. Growing expectations from the public, health organisations, and governmental agencies are putting pressure on physicians to deliver care which is more effective, of higher quality, and at a lower cost. At the same time, physicians are experiencing a constant modification of both the knowledge they rely on and the criteria used to assess quality care. In addition to the challenges of being up-to-date with the latest evidence-based care, medical decisions need to be contextual and take into consideration personal characteristics and patient preferences.

An ethical dilemma emerged from this situation since it seems that medical professional are now facing unrealistic expectations that greatly surpasses the

help and support which is offered to them and that is likely to worsen with time if no action is taken. The situation is complex, and it is expected that coercive measures and sanctions would not be helpful as even perfect compliance with practice guidelines is shown to be dangerous in certain common clinical scenarios (Boyd et al., 2005).

A potentially more effective strategy would be to work alongside physicians and other medical professionals to co-develop the organisational and technological infrastructures that are required to support their processes adequately and facilitate continuous improvement. A central element of this strategy could be practice assessment systems. This technique is recommended as part of an effective clinical governance strategy, is already used in medical education, and leverage the notion of physician feedback which is at the core of the modern medical profession. Beneficial side-effects would be expected such as the improvement of clinical data quality through meaningful use and the establishment of a platform that supports integration with external decision support mechanisms. Finally, as we consider this issue in the context of developments in clinical care, it becomes clear that we need a strategy that is sustainable, scalable, and can integrate with new large and heterogeneous sources of clinical care data.

1.1 Objectives

Practice assessment is a quality improvement technique which could help us solve the current dilemma of health care. However, for effective PA to be developed more information is needed on its causal mechanisms and on the barriers and facilitators that impact its effects. These findings need to be operationalizable and created in a way that can make it suitable to drive system development. My aim is therefore to :

1. identify the barriers to effective audit and feedback interventions in health-care and to suggest how informatics methods implemented in the context of theories of behaviour change can help to overcome these barriers
2. develop a model capable of supporting the development and administration of electronic PA interventions using findings from barriers to A&F, approaches to behaviour change, and product engineering.

2 Background

"We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology."
— Carl Sagan

Throughout this research, I aimed at laying down the necessary foundation for the future development of practice assessment. The findings presented in this document constitutes an incremental improvement over the current body of knowledge of the audit and feedback field. In this section, I will seek to present the current state of the field, along with the wide range of previous work this research leveraged from the fields of psychology, economics, engineering, and medicine.

Electronic practice assessment is a solution to a problem. It is not only technical but also political and social in its action. It is a technological system achieving its effect through the influence it has on human behaviour and on their social dynamics. It is part of a political environment and needs to coexist and conform to existing norms, values, and the culture of that organisation.

The background section will be divided in the following way. First, the problems PA try to solve will be presented along with their impact on society. The larger field of audit and feedback will then be presented, along with how they are thought to work, and what is known about their effects. The different components of PA will then be divided and presented independently. Starting with performance measurement, going into behaviour change, and finally moving to clinical information systems. Acknowledging a problem and identifying a possible solution is not enough, this is why I will then discuss product development; or how the process and activities leading to the creation of an electronic PA might affect its success. The final section will contextualise the contribution of this research by presenting what are the current gaps and next steps in the field of A&F.

2.1 The Problem and its Impact

Practice assessment systems cannot be used to cure patients. They achieve their effect indirectly through prompting a modification of undesirable practice patterns in health professionals(Ivers et al., 2012). This improvement in clinical decisions should lead to fewer adverse effects, a reduction in unnecessary health care, and an increase in the use of preventative care.

Patient Safety The provision of healthcare occasionally results in unintended injuries or complications. Called adverse events (AE), they led to death, disability, or prolonged hospital stay. Other countries have observed that 2.9%-16.6% of patients in acute care hospitals experience 1 or more AEs. In Canada, the number of admissions that results in an AE is estimated at 185 000 per year. With 37%-51% of AE being retrospectively considered preventable, this results in 70 000 unwanted cases annually(Baker et al., 2004). In addition to being a threat to patient safety, AE is known to have large economic consequences. In Australia, they were considered to account for 8% of hospital bed days and cost the system \$4.7bn a year(Vincent et al., 2001).

Unnecessary Health Care In order to ensure that no patient goes undertreated, current medical practices often err on the side of overtreatment.(Kerr and Hayward, 2013) Some estimate that 30% of the care delivered in the US is duplicative or unnecessary. This is both wasteful and may not lead to improved outcomes(ABIM Foundation, 2016). As an example of the consequences of unnecessary health care, a recent study of senior physicians leaving hospitals for conferences analysed 66041 hospitalisations and showed significantly lower 30-day mortality from acute cardiovascular conditions. This effect as been attributed to younger staff being more risk averse and choosing more conservative treatment options.(Jena et al., 2014). A collaboration between Choosing Wisely®, the Physicians Alliance, and Consumer Report already aims at creating resources allowing physicians to have a conversation with their patients about making better choices using appropriate evidence-based care that is based on the individual situation and which promote the effective use of healthcare resources(ABIM Foundation, 2016).

Preventative Care In 2013, the total cost of six chronic diseases was \$8.1 billion in Quebec(Corporate Communications, 2014) and three out of five peo-

ple over the age of twenty in Canada had a chronic disease(Chronic Disease Strategic Plan, 2013). A few lifestyle choices are known to impact the onset of chronic diseases profoundly : eating habits, physical activity, tobacco use, and high alcohol consumption. Through their practice, physicians have the power to make recommendations to patients that can affect these behaviours. Furthermore, environmental and social determinants of health are known to be strongly associated with chronic conditions and should be taken into consideration. In Québec, in 2010, 5% fo the population accounted for 50% of acute care services and these high users were mostly the results of chronic conditions(CSBE, 2010). Nevertheless, when a study looked how care is provided to adults in metropolitan areas of the United States, they found that patients only received 54.9% of recommended care. In at least one lifestyle habit, alcohol dependence, care was significantly worse with 10.5% of recommended care(McGlynn et al., 2003).

2.2 Audit and Feedback

The two most widely accepted definition of audit and feedback are shown in table 2.1.

Cochrane (Ivers et al., 2012)

any summary of clinical performance of health care over a specified period of time

National Institute for Clinical Excellence (NICE, 2002)

A quality improvement process that seeks to improve patient care and outcomes through systematic review of care against explicit criteria and the implementation of change. Aspects of the structure, processes, and outcomes of care are selected and systematically evaluated against explicit criteria. Where indicated, changes are implemented at an individual, team, or service level and further monitoring is used to confirm improvement in healthcare delivery.

Table 2.1: Definitions of Audit and Feedback

The difference between these two definitions comes from the purpose it

serves. Cochrane needed a definition they could use to identify whether a reported intervention was using audit and feedback for the purpose of their systematic review. NICE, on the other hand, proposed a definition which can be used to inform its development or describe its implications. The second definition emphasises the area of care it assesses, the level of changes it proposes, the use of explicit criteria, its presence within a larger quality improvement process, and its need for continuous monitoring. By opposition, the relative simplicity of the first definition meant that it needed to rely on external definitions for exclusion criteria. Therefore, interventions will be classified as A&F if, in addition to fulfilling the aforementioned definition, they cannot be considered as ‘facilitated relay’, ‘reminder’, or any other unique category in the Cochrane Effective Practice and Organisation of Care. The definition practice assessment used is similar to NICE in its holistic view of the medical practice, but also highlights physicians as the primary target and nexus of change. Other A&F interventions include ‘practice reports’, ‘physician (or practitioner) profiles’, and ‘health care report cards’. A definition is provided for them in table 2.2. Practice assessment, in comparison to A&F, emphasises the recognised need to local performance improvement and reflexive practice (Teasdale, 2002; Department of Health (DoH), 1998; Tousignant, 2015; Collin, 2011)

Core Mechanisms

Feedback, as Latham and Locke (1991) pointed out, is nothing more than information and as per itself has no consequence. For this reason, the study of audit and feedback must be grounded in theory to be able to predict and assess its effects. Another difficulty lies in the necessity of considering A&F system as a whole since its components are mutually affecting one another (Aström and Murray, 2010). No theoretical model of A&F has yet gained consensus. However, a few existing model and framework can inform its study. I will present the background of A&F in three steps. The first step will look at feedback in dynamic systems. The second step will present a more complete model of feedback interventions. The final step will present a multi-theory approach suggested by the Cochrane review to be specifically relevant to audit and feedback interventions.

Practice assessment

An evidence-based evaluation process which systematically assess a physician's medical practice with the aim of generating insights able to support continuous improvement.

Health Care Report Cards (Dranove et al., 2002)

Public disclosure of patient health outcomes at the level of the individual physician or hospital.

Practice reports (Glazier et al., 2014)

The generation of a descriptive overview of a practice based on clinical data.

Physician Profiling (Congress of Delegates, 2012)

An analytic tool that uses epidemiological methods to compare physician practice patterns across various quality of care dimensions (process and clinical outcomes). Cost, service and resource utilisation data are dimensions of measuring quality, but should not be used as independent measures of quality care. The ultimate goal is to deliver high-quality, evidence-based care to improve clinical outcomes.

Table 2.2: Definitions of Similar A&F Techniques

Control Theory

One of the simplest frameworks of audit and feedback is its consideration as a closed loop dynamic system. This method describes a regulation cycle in which the action of a first system produces an output in a second system that will then be used to regulate the first. Examples of these systems can be easily found in biology, engineering, climatology, and many other fields. One example could be the homeostatic regulation of blood glucose through insulin and glucagon (Aström and Murray, 2010)

When applied to our context, the cycle would start with a physician (controller) using knowledge, patient data, contextual information, and preferences (system inputs) to make a decision about patient care (system output). A monitoring system would then measure the decision taking along with relevant information such as patient outcomes and costs and would feed this measured output into an evaluation system that would compare the practice patterns against explicit criteria and standards (reference). This measured difference

would then be fed back to the physician, in order to support the correction of future decisions.

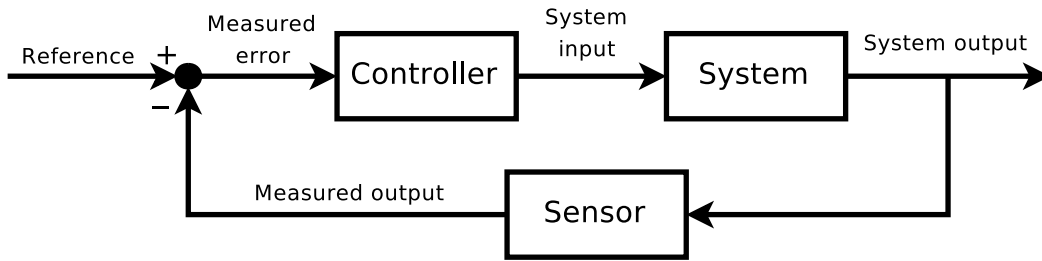


Figure 2.1: Illustration of the Feedback Loop of a Control System - Orzetto GFDL

The model proposed by control theory is simple, but powerful. It has been used to study a wide variety of systems and remains an active field of research in engineering. One of its main advantage is that they compensate for systematic biases and allows to perform well in an environment with many unknowns. The cruise control on a car, for example, do not know about hills, wind, or rain, but automatically compensate using the error signal. It can however be difficult to operationalize the concepts proposed in this model due to its high level(Aström and Murray, 2010). Furthermore, when applied to human decision, it assumes a ration agent model and ignores the impact of a wide range of effects. Important efforts have been made in the adaptation of this model by the fields of psychology and sociology with the production of the “Attention and Self-Regulation” adaptation by Carver and Scheier (2012) but its use in the evaluation of audit in feedback still required adjustments(Gardner et al., 2010).

Feedback Intervention Theory

Feedback intervention (FI) theory provides a model for FIs defined as *actions taken by (an) external agent (s) to provide information regarding some aspect(s) of one’s performance*. Even though it touches on more than clinical feedback, it excludes types of feedback common to physicians in its analysis. For example, it excludes task-generated feedback that is obtained without and intervention, such as a physician seeing a patient health improving. It also excludes personal feedback that relates to the characteristics of the person and not its performance and excludes self-initiated feedback-seeking behaviour.

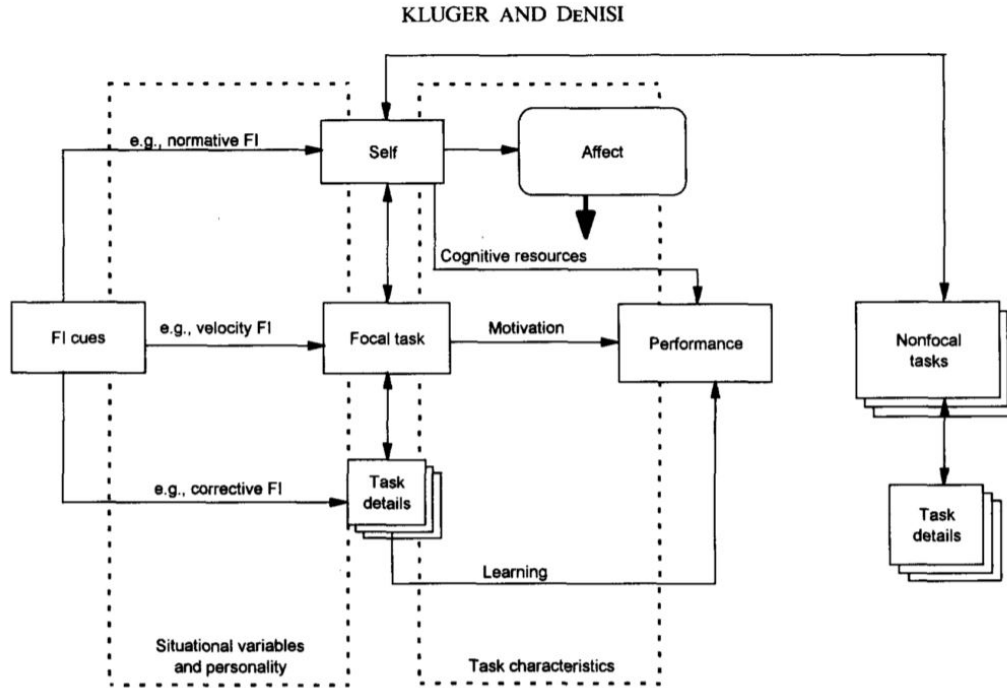


Figure 2.2: A schematic overview of feedback intervention (FI) theory from Kluger and DeNisi (1996)

This model of FIs was designed to take into consideration the outcomes of certain tasks such as learning and motivation, as well as its effect on meta-task processes and how feedback is resolved. It integrates the notion of attention to self, of depletion of cognitive tasks, and the impact of affective processes. Feedback intervention theory also points to the importance of considering goal setting, threats to self-esteem (intelligence, professional competency, ...), and the presence of external rewards or punishments. This theory suggests that feedback interventions will have a greater effect if provided for familiar tasks, if they contain cues that support learning, if they attract attention to discrepancies at the tasks level, and if they focus on tasks level goals instead of attention to the self. Finally, FI theory suggests that the large gap between the effect and perceived effects of FI might be due to participants achieving personal goals which are not linked to desired outcomes.

Theoretical Perspectives to Change Interventions

This approach of using multiple theoretical perspectives to change was recommended by the latest Cochrane review on the evidence of A&F to compensate for the current lack of a formal and comprehensive model of its effect. On

of the main argument of this approach is that different theoretical model can be used together in the evaluation or the planning of quality-improvement strategies. It suggests that interactions of factors at different levels influence the effectiveness of QI intervention and that an understanding of the obstacles and incentives for change is crucial (Grol et al., 2007). It discusses multiple approaches but three types of relevant theories: impact theories, which describes how an intervention facilitate change; process theories, which refer to how they should be planned; and state-of-change theories, which proposes that professional and team differ by their state and require different factors and strategies for change.

An advantage of this approach is that it considers both the implementers and the target group. It makes the recommendation that the target group should be part of the planning and development of new interventions. It further suggests to make sure that the interventions suit the complexity of practices, and that the measures and solution need to be, driven by and close to, results of the problem analysis. It suggests that implementation needs to be step-by-step, that intervention should consider and integrate with established structure of professional development and quality management, and that implementers need to take into account the properties of the innovation such as its scientific basis, and the groups that developed it. The theories proposed in this approach can be found in table 1.

Results

A review of 140 A&F interventions found evidence of moderate quality that they cause an increase in compliance with desired practice. When dichotomous outcomes were used an effect of 4.3% (IQR 0.5% to 16.0%) was seen as opposed to 1.3% (IQR 1.5% to 17%) using continuous outcomes. Similarly, this study observed effect size of 0.4% (IQR -1.3% to 1.6%) for dichotomous and 17% (IQR 1.5% to 17%) for continuously measured patient outcomes levels. The quality of this evidence was however considered low due to the limited number of trials targeting patient outcomes (Ivers et al., 2012).

The same study concluded that, under the right circumstance, A&F can play an important role in improving professional practice. A model of effects was derived from their meta-analysis and revealed five significant factors. A&F interventions were more effective when their **source** was a supervisor or senior colleague, their **frequency** was at least monthly, their **format** was both verbal

and written, their **instruction for improvement** offered both explicit goals and a specific action plan, and their **direction of change** what aiming for a decrease rather than an increase in provider behaviour. A&F interventions were additionally shown to be substantially more effective when the **baseline** was low(Ivers et al., 2012). As shown, the effect of A&F interventions on compliance with desired practice and patient outcomes have been low to moderate(Foy et al., 2005). This is consistent with previous knowledge of FI which was showing improvement around .4 of a SD(Kluger and DeNisi, 1996).

As early as 1987 however, feedback interventions were shown to be unreliable and uncertain to the point of even being detrimental to performance in certain conditions(Congress, 1987). A history of feedback interventions underlined that the low performance and high variability of A&F are most often ignored(Kluger and DeNisi, 1996). The effectiveness of A&F was shown to varies substantially among studies not to be fully explained by currently known factors(Foy et al., 2005; Ivers et al., 2012; Balas et al., 1996).

Design Recommendations

How to design audit interventions is still an unsolved problem. However, the NHS produced two documents presenting current best practices and guiding local implementers through the necessary tasks and activities. Each of the five stages they proposed (figure 2.3) is presented along examples, reasoning, current evidence, and a summary of key points to remember (NICE, 2002). In 2010, a guide for clinical audits was created that aimed at explaining their importance and relevance to clinicians and managers. They produced a set of recommendations about its content, its delivery, and its integration into existing systems. These considerations nevertheless will require adjustments before they could be used in electronic PA since their focus on clinical audits means they are usually made to be done at specific points in time and on specific audit topic (Bullivant and Corbett-Nolan, 2010).

2.3 Performance Measurement

The most often quoted definition of performance measurement (PM) presents it as “the process of quantifying the efficiency and effectiveness of past actions”(Neely et al., 2002). Implied with this definition is that this information is then used to drive future action. PM is not only about measurements, but

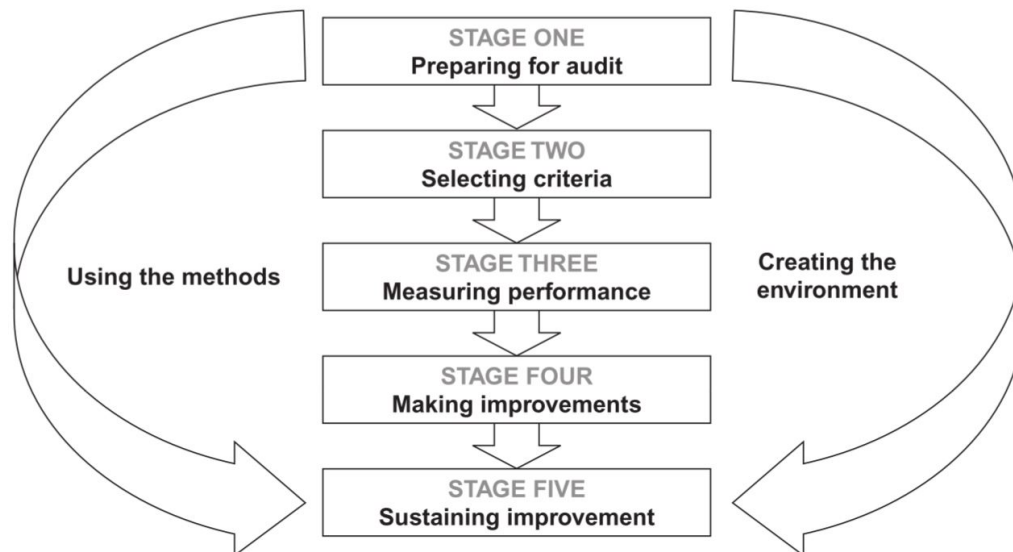


Figure 2.3: The stages of clinical audit as proposed by (NICE, 2002)

also about analysis and reporting. Even if PM and PA are different in both their purpose and process, there are overlap between them.

The effect of PM in healthcare is usually modest with little to no intermediate or end-stage improvement in outcomes. Central to understanding PM is that it lead to an improvement in what was measured, but too often these measures were chosen for their simplicity or availability rather than their link to desired outcomes (Hayward, 2007). Rodney Hayward, a major author in the field, suggests that it might be the single most important health policy tool for improving health care and that correctly assessing what is good, poor, or wasteful is impossible without clinically detailed information(Hayward, 2007). The Institute of Medicine in a report on measurement and accountability in health care identified a set of recommendations that underlined the need for local performance reports about overuse, underuse, and misuse of healthcare(Institute of Medicine, 2011).

Four insights for PM are informative in the development of PA. A first recommendation is a need for detailed and meaningful metrics. Too often they are made to fit what data is available, and this is both inefficient and sometimes counter-productive(Kerr and Hayward, 2013). Improvement in these simplistic targets is often mistaken for better care(Hayward, 2007). They could also lead to practitioners blindly following them to the point of being harmful and to some patient failing to receive the care they need while other get unnecessary care(Kerr and Hayward, 2013). Furthermore, metrics development should

focus on more detailed full spectrum targets instead of binary threshold that usually qualifies extremes. All-or-Nothing PM has also been predicted to lead to the prioritisation of low-value care and to providing incentives to get rid of “bad” patients. Getting the targets right is of particular importance in a context where many health systems are setting pay-for-performance schemes with incentives to higher achievers(Hayward, 2007).

A second insight is that performance measures are too often designed to measure physician practices instead of health outcomes(Garg et al., 2005). There are many potential causes for this, one being that the metrics used were often taken directly out of practice guidelines. The field of PM warns against the direct use of recommendation designed to inform medical decisions as metrics of performance. As these guidelines are usually made for a specific condition and sometimes by interest groups, they tend to minimise under-treatment occasionally leading to increased over-treatment and diminished patient autonomy(Kerr and Hayward, 2013).

The third insights highlight the importance of designing metrics with the patient in mind. PM systems are often structured around physician practice patterns but fail to integrate other aspects of quality such as the burden imposed on patients, patients’ preferences, and costs. PM systems are also reported to have increased effects when working, collecting and analysing data at the level of the individual patient(Hayward, 2007). Designing PM systems with patients in mind also require making sure that at no point improving performance on a target is prioritised over adequately informing patients(Kerr and Hayward, 2013). The final recommendation to implementers is to develop mechanisms able to determine the relevancy and priority of the goals they measure. In doing so, a PM system would be able to comparatively weight actions and base its recommendation on the likelihood of benefit or harm for individual patients. Such a system would need to commit on computing the net-benefit of care for individual patients considering their situation and preferences(Hayward, 2007; Kerr and Hayward, 2013).

2.4 Behaviour Change

Behavioural Economics

Behavioural economics is the discipline that applies behavioural science principles to the study of economic reasoning. It postulates that people’s judgments

and choices are formed by two cognitive systems similar to intuition and reasoning called respectively system 1 and system 2. System 1 is a fast emotional and associative cognitive process while system 2 is more controlled and rule-based. Research has found that most everyday decisions are performed using system 1 and that they are associated with systematic biases in decisions that would be considered sub-optimal under the rational agent model. Reasoning is deliberate and requires efforts while intuition is spontaneous and most commonly used. Behavioural economics proposes a formal model of choice under risk and a study of heuristics used when predicting or evaluating evidence (Kahneman, 2003). The predictions of this theory were considered important enough that, in 2010, the United Kingdom created behavioural insight teams to inform governmental decision makers on social and public policies. When applied to the context of A&F in health care, behavioural economics approaches recommended the use of feedback which is personalised, close to the behaviour, and shows the evolution of performance (Voyer, 2015).

Behavioural Economics proposes that an option which comes more quickly to mind is more likely to be chosen; calling this effect the accessibility heuristic. This heuristic might be seen in physicians overestimating the likelihood of a patient characteristic due to its presence in recent patients. This theory also states that perceptions are reference dependent and that utility is perceived with relation to a reference point. A result that can be observed in patients assigning different values to treatment options based on their current health status. Behavioural economics also showed the existence of a framing effect in which a judgement could be altered by equivalent descriptions of its choices. An example of this effect might be that a physician could be more likely to follow the recommendation of a PA system if it chooses to emphasise the benefits for its patient instead of the harm. Finally, this approach demonstrates the presence of an attribute substitution effect in which a difficult question can be answered by using a more accessible attribute. This effect is linked with the affect heuristic and might be shown by users choosing to use the system not based on its usefulness but on its appeal or how they like its creators (Kahneman, 2003).

Incentives

In order for a physician to change its behaviour, the proper incentives must be present. However, it is unclear which incentive(s) works best for this purpose.

Four perspectives will be presented in this section. The educational argument proposes that, as professionals, physicians are intrinsically motivated to improve their knowledge and competency. This learning could, therefore, be facilitated by providing them with the tools and technology to encourage and support this natural tendency(Grol, 997c).

The economic argument suggests that by associating better outcomes with financial rewards or undesired behaviour with penalties, physicians will seek to maximise their profits by improving patient health outcomes. This view is often criticised as opening doors to “playing the system”, a situation where financially profitable behaviour would be prioritised over patient care. This type of incentive is available in the UK since 2004 as part of the Quality and Outcomes Framework, yet it is still unclear whether this framework led to significant improvement(Campbell et al., 2007).

Another argument is the coercive action, or legislative incentives, in which a governing body decides to make certain behaviours mandatory and non-compliance punishable by legal or professional consequences. When family physicians enter practice, they are obliged to participate in activities for continuing professional development (CPD) to maintain their right to practice. One of the provided ways to collect CPD credits is through activities related to practice assessment and self learning(CPD Staff, 2015)

The last argument proposed that the literature on optimal experiences, intrinsically motivating environments, sense of accomplishment, satisfaction, and choice can be leveraged to design a game reward system which provides social meaning through motivation, an enhanced status, and the use of rewards as social tool(Wang and Sun, 2011). This kind of incentive is common in the field of video games but rarely used in health care.

2.5 Clinical Information System

Clinical Information Systems (CIS) are computer programs which are used to collect, store, process, and communicate data generated by the delivery of health care. The advantages of using information technology to manage clinical data were clear enough that the earliest CIS were created at a time when computer science was still in its early days (McDonald, 1976). The main types of CIS are electronic health record (EHR), patient health record (PHR), clinical reminder system (CRS), and computerised physician order entry (CPOE).

EHR, are now ubiquitous to most practice, and its presence paved the way for more advanced clinical decision support system (CDSS) which make use of the standardised and machine-readable clinical data it contains (Garg et al., 2005). In addition to supporting and improving decision during patient care, past data could also serve to facilitate quality improvement. One type of CIS using this technique is computerised audit and feedback.

The use of CIS is however not without risk as they were shown to facilitate some errors, a problem that their evaluation rarely tested for (Koppel et al., 2005). Furthermore, some authors highlighted that although advanced CIS had been heralded as revolutionary for some time now, they were, in practice, still few and far apart (Wears and Berg, 2005).

2.6 Product Development

Electronic practice assessment systems are technological products part of a socio-political culture. This section presents approaches to address these considerations.

Participatory approaches, for example, have been shown to ensure cultural and logistical appropriateness, to increase the quality or outputs and outcomes over time, and to improve the sustainability of project goals beyond funded time frames. It was also seen to increase ownership of the product, promote system change, and generate professional capacity and competence in stakeholders (Jagosh et al., 2012).

Co-construction approaches discuss the ways a product user-base and community affect its development and use. This process has been described as creating products crystallising a culture and that can no longer be understood apart from its end-user and cultural ambience. The social construction of technology (SCOT) breaks apart from traditional technological determinism in suggesting that technological revolutions are the results of co-construction between a product creator and its users working together towards a common goal. As opposed to being imposed on users by a technologically superior product replacing its predecessor (Bijker et al., 2012). The creation of PA needs to consider that organisation are simultaneously social (people, values, norms, culture) and technical (tools, equipment, procedures). This social and technical aspect are interdependent and interrelated (Wears and Berg, 2005).

2.7 Knowledge Gap

This chapter laid down the background on which this research is based. In it, I have underlined the opportunity for practice assessment to drive down unnecessary care, to ensure patient safety, and to promote the use of preventative interventions. There is, however, a large gap between the need for PA and what is known about how to develop and implement it. This section will present where the knowledge gaps are and how they led to the objectives.

A first and key piece of information missing is the need for an agreed upon model of audit and feedback. Even though this need keeps getting pointed out by evaluators and implementers, none of the currently proposed models achieve consensus (Ivers et al., 2012). This lack of a theoretical foundation is being exacerbated by how little we understand how and when A&F works best. This resulted in systematic evaluation observing that A&F continues to be an unreliable approach to quality improvement (Foy et al., 2005). It has been shown to cause substantial and positive effects on performance, but the factors that contributed to this success are still poorly understood. Not knowing this information is not only limiting the potential effect of PA but might also lead to undesirable or detrimental effects (Congress, 1987) This lack of theoretical model is not new as we have been working on this problem, as one author estimates, for the last 120 years old (Kluger and DeNisi, 1996). The use of information technology is another mostly unexplored area of research for A&F that could lead to improvements. From the study of feedback, we know that it was advantageous on its own and resulted in improved outcomes compared with non-computerized intervention (Kluger and DeNisi, 1996). Its reported benefits on other types of clinical information systems reverberate the recommendation that the effect of informatics on A&F should be given more attention (Garg et al., 2005). This promising potential is however given little attention and has led to few publications.

This lack of theoretical foundation to the barriers and facilitators of PA, coupled with limited evidence as to the impact of informatics, led us to propose that more reflection is warranted. This led to our first objective, *to identify the barriers to effective audit and feedback interventions in health-care and to suggest how informatics methods implemented in the context of theories of behaviour change can help to overcome these barriers*. However, it is unclear what methodology should be used to answer this question. It has been pointed out that traditional meta-analysis approaches are inadequate at both exploring the

heterogeneity and complexity of A&F interventions. A multi-theory approach was recommended to mitigate this issue, but it is still an open problem(Ivers et al., 2012, 2014). Even though the need for qualitative and mixed-method methods was highlighted, few publications could be found that made use of that recommendation. One of the reasons why methodologies able to collect richer information were suggested, is that published evaluations of A&F are notorious for poorly reporting what are the behaviours they target, in which context is it used, what are the characteristics of the participants, and what is the theoretical basis for their intervention(Ivers et al., 2012). This effect can be seen in one study that looked at previously known effects of feedback using A&F interventions and could not find anything due to poor reporting(Gardner et al., 2010). Additionally, no studies were found exploring the impact of informatics on A&F, and no clear consensus is present as to what perspective should be used in the multi-theory approach.

The use of evidence on the barriers to effective A&F to *develop a model capable of supporting the development and administration of electronic PA interventions using findings from barriers to A&F, approaches to behaviour change, and product engineering* identifies a new set of knowledge gaps. First, little is known about the content and delivery of A&F interventions. Past publications have recommended that publications include a clear and thorough description of the intervention, additional details about how the feedback was provided, and ideally present illustrative examples(Ivers et al., 2012; Health Quality Ontario, 2016a). A second gap is in the lack of guidance as to the generation of patient centred metrics and targets which are weighted according to their priority and integrate patient preferences. Another missing link is in the identification of which techniques should be used to design and implement PA. Although it is recognised that the consideration of cognitive biases in the design of health intervention can be beneficial, little evidence exists in the field of A&F. Furthermore, software engineering principles inform us that the development process of the software system would also have a large impact on the suitability and effectiveness of the final system, yet no information could be found as to how it should be led. Best practices exist that can inform the high-level phases of clinical audits, however, these recommendations still need to be supplemented with guidances on the tasks and activities needed to develop and implement PA intervention(Ivers et al., 2010; Bullivant and Corbett-Nolan, 2010). Finally, it is still unclear which type of incentive(s) would best support PA interventions in affecting sustainable change in behaviour.

Preface to manuscript

This article, not yet submitted to the Journal of the American Medical Informatics Association, addresses the absence of a consistent theory of audit and feedback by exploring the role of informatics and multiple behaviour change theory in computerised A&F interventions. The objective of this study was to identify barriers to effective A&F interventions in healthcare.

A qualitative, explanatory case-study design was used as the approach to identify the barriers to effective A&F intervention and to frame these barriers within the context of informatics methods and behaviour change theories. To achieve this, we: (1) identified all available publication on computerised A&F interventions, (2) selected cases which fitted our criteria, (3) collected qualitative data from the cases, (4) subjected this data to deductive thematic content analysis, (5) summarised the codes into representative themes.

**Manuscript: Audit and Feedback in Primary Care; Theory-based
Approach to Effectiveness, Reliability, and the Benefits of
Informatics**

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Manuscript Abstract

Objective: Audit and feedback (A&F) promotes the adoption by clinicians of evidence-based findings and aims to improve healthcare quality. It tries to influence their behaviour in order for them to establish practice patterns leading to improves performance and better health outcomes. A&F is a good candidate for computerization due to its reliance on information processing. Although feedback interventions are effective in other fields, in healthcare they produce moderate effects with variable results. Lack of knowledge on the cause of this limited effectiveness is due, in part, to poor reporting of the theoretical basis of interventions. This study aims to identify the barriers to effective computer-assisted A&F interventions in healthcare and to suggest how informatics methods implemented in the context of theories of behaviour change (BC) can help to overcome these barriers.

Materials and Methods: This study used a qualitative, explanatory case-study design applying deductive thematic content analysis to computer-assisted A&F interventions identified through a review of the literature. Qualitative data were collected using a coding scheme developed by combining multiple theoretical perspectives and adjusted to allow the extraction of resource utilization content. The codes were synthesized into representative themes which identified possible determinants of effectiveness and framed them in the context of their deployment as integrated informatics system.

Results: The thematic analysis led to the identification of six overarching barriers to effective A&F implementation: “Resource Constraints” includes limitations related to the additional costs and labour required; “Diffusion of Information” refers to issues related to the adoption and use of new technologies; “Clinical Governance” or the expectation of A&F systems to integrate within existing organizational planning and quality improvement efforts; “Dynamic System and Control Theory” addresses how the causal mechanisms of A&F can be used to drive design choices; “Cognitive Biases and Behavioural Economics” relates to how real users differ from theoretical rational agents, and how this can be affect A&F interventions; and “Learning Culture” underlines the importance of fostering the right culture in order to drive sustainable change.

Conclusion: Using qualitative content analysis and a multi-theory approach, we identified a set of principles for effective A&F design. We found that informatics facilitated the development of A&F and improved compliance

with the proposed principles. This finding suggests that the effectiveness of computer-assisted A&F could be improved through careful application of the identified principles and also that computer-assisted A&F is different enough from other types of A&F to warrant separate evaluation. More evaluation is needed as to the effects of the principles.

3 Audit and Feedback in Primary Care; Theory-based Approach to Effectiveness, Reliability, and the Benefits of Informatics

3.1 Background and Significance

Noncommunicable diseases (NCD) are now the largest cause of mortality, potential of life lost (PYLL), and disability-adjusted life year (DALY) in the world (Media Centre WHO, 2013). They inflict a substantial economic burden on the economies of nations and their toll is predicted to increase in the coming decades. The dissemination and use of evidence-based practice guidelines is essential to the management of NCDs, however in the United States, patients receive only about half of the recommended clinical manoeuvres (McGlynn et al., 2003). Given that “we can only improve what we can measure” (Hanold et al., 2000), closing this gap between ideal and actual care requires measurement of quality and performance in health care (Institute of Medicine, 2011). Assessment of the performance and quality of physician practice routinely identifies unwanted variations in practice patterns and patient outcomes that cannot be explained by lack of resources or patient characteristics (Flottorp et al., 2010). Furthermore, health information systems are now a ubiquitous source of clinical data which is increasingly made available for quality improvement and research purposes.

Audit and feedback is a systematic evaluation of a clinician’s practice patterns and outcomes against patterns of peers, standards of care, and past

performance with the aim of improving clinical practice and patient outcomes. It combines aspects of performance measurement and feedback, two central components of quality improvements models. Audit and feedback, medical audit, physician profiling, and peer comparison interventions all assess, at a population or practice scale, the level to which the care provided matches best practices and evidence-based guidelines, and then feed this information back with the aim of modifying physician practice patterns. This process is used to both monitor and improve quality of care, and is generally time and resource intensive (Lough et al., 1999). In addition to being an essential component of clinical governance, audit and feedback can also be used to address all three aims of the IHI Triple Aim framework; patient experience, health of population, and per capita cost of health care (Berwick et al., 2008).

Health system managers and governmental agencies have highlighted the urgent need for effective A&F and some have suggested informatics as a way to counteract the prohibitive levels of resource utilisation which are sometimes associated with these interventions. (CSBE, 2010). Concurrently, A&F is increasingly being used to modify physician behaviours. However, evidence shows a lack of understanding of the causal mechanisms (Balatsoukas et al., 2015)(Foy et al., 2005), which techniques should be favoured (Gardner et al., 2010), and how such interventions should be designed or implemented (Ivers et al., 2010). A&F interventions in healthcare tend to produce low to moderate effects and with considerable variability, which is not fully explained by currently known factors (Ivers et al., 2012). This current state of evidence has led some to suggest that further reflection is warranted before investing time and resources into wider scale implementation of A&F systems in clinical practice.

So despite the assertion that audit and feedback systems may be “the single most important health policy tool for improving health care Hayward (2007),” the current evidence for their effectiveness is weak and there is an urgent need to learn how to best develop, implement, and evaluate these systems (Balas et al., 1996). Given that informatics has been shown to increase the effectiveness and promote the adoption of A&F systems (Guldberg et al., 2009)(Sequist et al., 2005), it is also important to understand the role that informatics can play in A&F systems. Any effort to improve A&F should orient it within a theoretical framework (Foy et al., 2005) and base improvements on an understanding of the causal pathway through which A&F systems realize their effect (Craig et al., 2008). Efforts to synthesize the current evidence on

A&F have been limited by the lack of detail in published studies, which tend to not identify the theoretical foundations and omit important aspects of the interventions (Foy et al., 2005). Behavioural theory and control theory have both been identified as foundations for A&F interventions, however no single theory appears to be sufficiently expressive alone (Foy et al., 2005)(Gardner et al., 2010)(Grol, 1997c). It may also be useful to consider different theoretical frameworks for content and delivery with A&F systems (Gould et al., 2014).

The evolution of clinical practice guidelines provides an analogy to the evolving understanding of A&F systems. The initial adoption of guidelines was quite variable and insights into their mechanisms of action contributed to the design of better guidelines. Analogously, for A&F research, this is an opportune time to take a step back and assess the current evidence and knowledge from a broader theoretical perspective in order to align it with known models of behaviour change.

The design of a practice assessment intervention is often seen to be driven by real-world constraints. Both the performance measurement and feedback components are time- and resource-intensive tasks, which in many cases must be done continuously. A&F systems also require the integration of multiple heterogeneous sources of data and the ongoing analysis of variations in practice and against targets. Given these fundamental elements of A&F systems, we hypothesize that not only could informatics facilitate, make more effective, and reduce the cost of audit and feedback, but that it could meaningfully change how the interventions are designed and implemented to the point of significantly changing the effects of A&F systems on practice patterns and patient outcomes. For example, information technologies can help to increase the frequency of assessment, personalize feedback, and automatically draw on multiple sources of data and knowledge.

Objective

This study aims to identify the barriers to effective A&F interventions in healthcare and to suggest how informatics methods implemented in the context of theories of behaviour change can help to overcome these barriers.

3.2 Materials and Methods

We used a qualitative, explanatory case-study design to identify the barriers to effective A&F intervention and to frame these barriers within the context of informatics methods and behaviour change theories. We performed a review of the literature on electronic A&F and selected as cases instances of deployed interventions. Qualitative data was collected from the cases, and these data were subjected to a deductive thematic content analysis. A thematic analysis was performed with the pragmatic purpose of producing findings, which can be easily operationalized to drive future intervention development. Thematic content analysis is well suited to summarizing variations and regularities within a dataset in addition to providing an outline of its content and topics (Green and Thorogood, 2013). It is used extensively to develop explanations of phenomena, typologies, and classifications (Green and Thorogood, 2013). Case-study designs are well suited to our investigation since they are known to allow looking at a “phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used” (Yin, 2013).

Electronic audit and feedback studies

Given our focus on understanding the barriers to A&F and the potential effect of informatics on them, the review was limited to electronic A&F interventions. We queried the Medline system through using the Ovid interface in January 2016, for French and English language publication published between 1996 and 2016.

This search strategy included empirical studies focusing on A&F as defined by “any summary of clinical performance of health care over a specified period of time” (Ivers et al., 2012). Included studies had to have an electronic A&F system as a core component and had to provide feedback to a physician in the context of patient care. Posters, abstracts, and preliminary results were excluded along with studies of interventions aimed at modifying health system or hospital level processes.

Our search strategy was based on the Cochrane systematic review on audit and feedback. (Ivers et al., 2012) Pilot testing of the strategy revealed difficulties related to poor reporting of the informatics component of A&F interventions. Adjustments were made to improve sensitivity along with iter-

ative refinements using snowball sampling of citations from included studies. The final search strategy focused on three theme: Audit and Feedback, Quality Improvement, and Informatics and can be found in appendix A. Articles were assessed for relevance based on title and abstract before the full text was retrieved. No formal appraisal of quality was performed.

The initial 456 entries were retrieved in JabRef and 433 did not meet our inclusion criteria. After removing duplicates and assessing full text papers, 4 articles were left. Summary characteristics of these studies can be found in Table 3.1(Kable et al., 2012).

Theoretical Perspective

In order to mitigate the difficulties encountered in previous theory-based evaluation of A&F(Gardner et al., 2010), we used a combination of theoretical perspectives. This approach ensured that the analysis was less dependent on a single theory of human behaviour and provided sufficient expressivity to develop findings from a range of perspectives (Grol, 1997c). It also allowed us to compare competing theoretical accounts and to achieve the expressivity required by A&F interventions (Gardner et al., 2010). The frameworks we used were identified from current best evidence for A&F(Foy et al., 2005)(Grol and Wensing, 2005)(Ivers et al., 2012), from past frameworks used in theory-based evaluation (Gardner et al., 2010)(Aström and Murray, 2010), and other influential approaches to behaviour change in health(Grol et al., 2007)(Kahneman, 2003).

Data Collection

Using the identified set of theoretical perspectives and models, we deductively derived a coding scheme that was used to perform data collection. Consistent with standard practice for thematic analysis, a first read was performed to become familiar with the dataset, to derive descriptive summaries, and to verify the coding scheme. The coding scheme was then adjusted iteratively to include codes related to resource utilization and to promote extraction consistency. We then organized the codes into representative themes, which were described and compared with possible impacts of HIT, and predicted causal mechanisms of behaviour change. Special attention was taken to ensure that

Authors (Country), Study aims	Context	Participants	Comments & Key Findings	Limitation discussed by Authors
Ehrenfeld, et al. 2014 (US) to describe the development and use of a performance feedback system and inform future standard setting.	Anaesthesiology resident training in a University Medical Centre. To conform with new accreditation system (ACGME).	All 60 students of the anaesthesiology resident training program.	<ul style="list-style-type: none"> Residents were dissatisfied with previous levels of feedback and its timeliness. Resident wanted frequent update of their performance including comparison. A&F had little to no effect on the resident performance. 	<ul style="list-style-type: none"> Users lacked familiarity with the quality metrics. High baseline performance. Some users took part in a related intervention. Performance measures are not independent because of common supervisor and system level functions
Kordy, H. Hannöver, W, and Richard, M. 2001 (GE) to describe the Stuttgart-Heidelberg model for driving quality improvement through computer-assisted feedback.	Practising therapist in a clinic which use the Stuttgart-Heidelberg model.	Therapists of 635 randomly sampled patients from a 4 year time period.	<ul style="list-style-type: none"> Low predictive ability of the model to identify ("signal cases") or patients for which the therapeutic intervention did not lead to the target outcome. The model promotes problem orientation, facilitates the transparency of the therapeutic work as well as positive exchanges between staff members. 	<ul style="list-style-type: none"> The generality of the approach could hide group specific findings. Signal cases could have condition specific interpretations. Some data needed to be manually entered in the system Does not provide guidance on detected issues.
Lobach, F. D. 1996 (UK) to test whether computer-generated individualized feedback could improve compliance with guidelines recommendations.	Practicing physicians at a primary care clinic inside a university medical centre. On improving adherence to care guidelines	All 45 physicians randomized to either control or intervention, stratified by training level.	<ul style="list-style-type: none"> Intervention Group had significantly higher compliance. Clinicians have favourable attitudes toward emailed feedback. EMR data can be reliably audited to provide feedback on practice patterns. 	<ul style="list-style-type: none"> Necessary data could not always be electronically integrated. Compliance to care guidelines is not always associated with better patient outcomes. Patient preferences influenced compliance. Clinicians could not countercheck recommendations.
Lyman, et al. 2008 (US) to describe the development and use of an audit and feedback system aimed, and to evaluate its usefulness and short term impacts.	Ambulatory curriculum of internal medicine resident training, in the context of PBLI training.	51 internal medicine residents in their 2nd and 3rd year of training.	<ul style="list-style-type: none"> 94% of respondent were confident the system was useful. Only 46% of residents believed the system accurately represented their practice. Significant increase in all items of the instrument. 	<ul style="list-style-type: none"> Data gathered for administrative purpose is limited in its accuracy. Results are limited by the lack of long-term outcome data. The study lacked a control group. Small resident panel sizes and the influence on time-to-effect.

Table 3.1: Characteristics of the Selected Case Studies

the categorization process followed our objective of generating operationalizable findings.

3.3 Results

Cases Description

Our case-studies included data from 3 different countries (US, GE, UK), spanned 4 different fields of medicine (anaesthesiology, psychotherapy, primary care, internal medicine), and were published as early as 18 years ago (1996). All cases included description of the development of their system. Interventions were split in half between educational and quality improvement objectives.

Only three of the case-studies discussed the effect of the intervention on clinical performance, two found significant changes(Lyman et al., 2008)(Lobach, 1996) and one observed little to no improvement(Ehrenfeld et al., 2014). The three cases that surveyed users about their experience with electronic A&F system reported favourable attitudes.

The thematic analysis identified 6 overarching themes, which provide insight into the barriers to effective A&F interventions: resource constraints; dynamic system and control theory; cognitive biases and behavioural economics; clinical governance; adoption; and learning culture. We will refer to cases by the first two letter of their first author surname in upper case; LO (Lobach, F. D. 1996)(Lobach, 1996), EH (Ehrenfeld, et al. 2014)(Ehrenfeld et al., 2014), KO (Kordy, H. Hannover, W., and Richard, M. 2001)(Kordy et al., 2001), LY (Lyman, et al. 2008)(Lyman et al., 2008).

Resource Constraints

Audit and feedback is a time-consuming, laborious, and costly process. This need for resources affect the development of A&F systems, and all of the studies mentioned limited resources as one of the driving factors of their system. Half of the studies further suggested implementation of a scalable system using routine data would only be achievable using informatics methods.

All interventions were able to integrate with a clinical information system to automate the extraction process which mitigated one of the main burden of manual audits. Only LO faced the need to complement existing data entry processes, in all other cases existing processes captured sufficient data rou-

tinely. With comparison to manual audits studies reported reported to be less labour intensive, to make the extraction quicker, to have greater reliability, to enable data extraction at any time, and to have a lower overall cost. LO and KO noted that after investing in this initial cost, the system was able to automatically and periodically update the clinical data used for auditing. The automatic computation of metrics also implies that continuous improvement of criteria and targets can be done with minimal effort as opposed to a manual system. As EH pointed out, having a system in place facilitated the use of dynamic thresholds that were based on individual physician or patient characteristics. Finally, the use of electronic diffusion technologies improved the accessibility and availability of the feedback provided by the systems. Half of the cases saw this as an essential feature of their success. The informatics methods used by the systems affected the extraction of data, the generation of results, and the dissemination of results.

The studies used A&F as a teaching tool, as part of the continuous improvement process, as a comparative tool, and in order to show progress. These additional aims were made possible because they could all be implemented as features of the A&F system. KO and EH showed that they could easily reuse the same core functionalities but implement different views or reports which were more suited to these other aims.

LO pointed out the need to both consider the initial costs of developing A&F systems and the resources that are required to maintain it. Finally, the systems designed by LY, LO, and EH all made use of pre-existing solutions. This observation suggests that the costs of A&F development could be minimized by leveraging interconnections with existing systems and the use of open-source software.

Dynamic System and Control Theory

Audit and feedback can be seen, from a control theory perspective, as supporting physicians with corrective feedback generated from a systematic comparison of their practice patterns to explicit criteria. This perspective suggests that the performance of this closed loop dynamic system is impacted by: how clinical data are extracted; which criteria and metrics are chosen; the frequency and precision of the feedback; and the way in which the system supports corrective action. Although none of the case studies mention control theory explicitly, both KO and EH state objectives that indicate similar intentions. The first

step in creating a feedback loop is having a reliable and representative way of measuring existing clinical performance. All cases followed the recommended practice of leveraging routine data (NICE, 2002), and 3 out of 4 also encoded formal procedures into their system to automatically perform data collection therefore ensuring consistency of extraction.

Once the performance has been measured, the establishment of a corrective feedback requires the ability to detect deviation from targeted standards. All studies used group consensus when identifying relevant metrics and criteria, and two mentioned the objectivity of a computer system to be advantageous. The four studies used different strategies when identifying performance targets. KO emphasized patient outcomes, LO and EH, focussed on evidence-based practice, and Lyman on resident learning outcomes. However, all studies assessed explicitly which metrics to use as part of their automated evaluation. Control theory suggests that feedback which is more actionable and closer to the physician's decision will be most effective in changing behaviour. This suggests that A&F could be improved by the inclusion of corrective actions however, only Lyman included the use of improvement plans, and they were user generated. An integration with external decision support system (DSS) is expected to improve the effect of the intervention and was present in half of the cases. Control theory also indicates that continuous monitoring and adjustment of the system should be performed in order preserve targets accuracy; however, none of the cases mentioned this concept.

A control theory approach predicts that control loops with a lower latency, higher frequency, and more precise view of the system will lead to better performance. Two studies accounted for the possibility of differences due to patient preference, and three included patient-level information. The system in EH was always available for consultation, and contained updated data from the day before. LY's system was used during the second year of resident training and used clinical data from 2-3 months in the past. LO provided its feedback every two weeks, and the frequency of KO was unclear but feedback was given pre-and-post treatment.

Cognitive Biases and Behavioral Economics

Behavioural economics explores “the systematic biases that separate the beliefs that people have and the choices they make from the optimal beliefs and choices assumed in rational-agent model” (Kahneman, 2003). Studying judg-

ment under uncertainty from this perspective suggests that A&F systems will be more effective in changing behaviour if they take into account cognitive biases such as framing, accessibility, and affect.

The first insight provided by this approach is that rapid associative thinking can be powerful and accurate, given enough practice and rapid feedback. As presented in two previous themes, all of the cases put in place a system which, theoretically, could provide arbitrarily frequent feedback. A second insight is that when intuitively assessing their performance, physicians may tend to overemphasize recent or typical behaviour and underestimate deviations. Possible solutions include individualized feedback, which all cases did, and the inclusion of peer comparison, as in LY and EH. Interestingly, few respondents in LY found that the feedback they received accurately reflected their practice.

Framing refers to the ability to influence the outcomes of a choice by inconsequentially varying its description (Kahneman, 2003). The technique of varying the attractiveness of an option by highlighting its positive rather than negative aspect is also known as positive framing, but none of the cases under study mentioned using this approach.

The affect heuristic is the tendency for good or bad feelings about the options or context of a decision to influence the judgement made. In all reviewed cases, users participated in the development of the system which could contribute to a positive view. This heuristic also indicates that adoption of electronic A&F system could be influenced by how technological proficiency of the user. Approaches to address this cognitive bias include marketing of a system, for which no mention was found, or designing an attractive user experience, which would be facilitated by an interactive medium, such as in LY and EH.

Clinical Governance

Some authors have suggested that integration of an A&F intervention within a broader plan of organizational change is critical in order to achieve sustained improvements (NICE, 2002). This approach was reported in three out of the four cases. A related strategy, identified by consideration of best practices, is that "... clinical audit must be monitored, evaluated, sustained, and reinforced within a supportive environment." (NICE, 2002) This need for ongoing monitoring and evaluation could be mitigated by using the A&F system to

evaluate themselves. Two of the cases discussed how the use of computer-assisted A&F allowed them to achieve long lasting benefits.

Although the effect of a multifaceted A&F intervention is debated, this strategy was made possible in two studies by the presence of external decision support system. Two studies mentioned that users were worried of A&F systems facilitating the introduction of coercive or punitive incentives. Nevertheless, users in LY, which required its use as part of a learning exercise, reported that they thought the system was responsible for improving their practices.

Adoption

By assessing a professional's practice, audit and feedback can be viewed as challenging professional competency and discretion. Consistently, both LO and KO mentioned that some stakeholders viewed the external evaluation of practice as an issue. However, some cases also discussed the benefits of having the evaluation performed by an impartial and objective "system".

Standardization and the loss of professional discretion is a common concern with DSS and A&F interventions Timmermans and Mauck (2005). No cases mentioned how this concern was impacted by the use of an electronic system, however, each report in LO indicated that "the provider always has the final say".

When implanting new technologies, resistance to change is to be expected and should be planned for. Often used techniques to limit this include the use of opinion leadership, leveraging influence in social networks, or training champion users. This was mitigated in all cases of our case study by including staff members and potential users in the development process. Additionally, only half of the case mentioned providing some sort of user training or documentation.

Learning Culture

"A learning culture is a set of organizational values, conventions, processes, and practices that encourage individuals—and the organization as a whole—to increase knowledge, competence, and performance." (Human Capital Management, 2013) Creating such a culture is an important factor of quality improvement and KO mentioned it to be one of the essential elements of their intervention. Multiple levels of participation were seen in the studies, but all

of them involved staff and users in the development process. A participatory approach is known to promote ownership, help sustain changes, develop internal capacity, and promote a learning culture. (Parry et al., 2009) A learning culture can also be promoted by making use of the natural tendency of professionals to look at each other for support, information, and feedback. One of the studies suggested that electronic A&F had distinctive qualities that facilitated this communication. KO noted that computer-assisted A&F allows for all of the clinical team to contribute data to a case, facilitates exchanges between staff members, and that it serves as common platform to discuss continuous improvement. Another aspect that might contribute to the establishment of the desired culture is for the system to be clear about its limitation and about the role users could have in improving it. It was unclear if any cases had formal mechanisms to collect ongoing comments and feedback but at least one case mentioned the possible limitations of the systems in its reports.

3.4 Discussion

Audit and feedback is an increasingly used quality improvement technique which government agencies and health system planners recommend as an essential component of continuous improvement strategies. Although there is a growing need for its development, there is little evidence to guide the design of effective A&F. The existing evidence reveals that A&F interventions in clinical settings are highly variable and tend to have low to moderate effects. To help close this gap between evidence and practical we analysed the literature and synthesized the results of studies on computer-assisted A&F to help guide research and practice on this topic.

Previous attempts to comprehensively assess the factors that influence A&F have used quantitative methods or attempted to use a single theory, and have faced challenges due to reporting issues and the complexity of A&F implementations. We used qualitative content analysis and a multi-theory approach to mitigate this limitation and to identify a set of potential principles for effective A&F design. Content analysis also mitigated the effect of heterogeneous reporting on data extraction and instead leveraged their differences to produce a richer account of the cases. The use of a case-study design allowed us to stay closer to the situations in which A&F was taking place. It also produced detailed descriptions of systems and context which allowed us to obtain

Sub-Themes	Themes
Continuous monitoring Part of a multifaceted QI plan Integration in System planning Coercive Support	Clinical Governance
Individualized and Rapid Feedback Accessibility Framing Heuristic Affect Heuristic	Cognitive Biases
Action-Feedback Period and Latency Criteria are measurable, explicit, consensual, and objective Making good use of routine data Consistent and Reproducible extraction Includes Recommendation for Correction Integrates with DSS Performance Targets are correlated with desired outcomes Feedback Precision (Individualized) Accounting for patient preferences	Control Theory
Labour and Cost Intensive Lacks sustainability Leveraging existing tools	Resource Constraints
Participatory Approaches Supporting Communication Social Constructivism	Learning Culture
User management and Training Resistance to Change	Adoption

Table 3.2: Sub-Themes categorization

a more holistic view than what could be captured through experimental or survey research (Zainal, 2007).

Using this approach, we found that the manner in which informatics was used deeply impacted how each system was designed and how they considered each of the resulting theme. For example, informatics methods supported the use of the interventions' results in organizational planning, simplified the generation of individualized feedback, minimized the labour and cost of interventions, promoted the exchange of findings between stakeholders, and improve the frequency at which feedback could be provided. This observation suggests that computerization of A&F could lead to more efficient and more effective interventions, which supports the assumption that electronic A&F is different enough to warrant its evaluation independently from A&F performed without the aid of computers.

Our objective was to produce actionable evidence about the barriers to A&F and the six themes that have been identified can be used to drive the inception phase of intervention design. For example, when choosing amongst possible design alternatives, multiple stakeholders could use the elicited themes to perform multiple-criteria decision analysis to optimize the solution which would have the best predicted impact and which would suit the priorities of the stakeholders involved.

Furthermore, evaluators of A&F interventions can use our findings in addition to existing known factors in order to integrate different perspective which could have been otherwise overlooked. More research is needed to study quantitatively, how each of these principles affect A&F interventions and how their effects compare to one-another. This type of research will have to account for the likely interactions between the themes. Future investigators might make use of the centralization of core functionalities in computer-assisted A&F in order to facilitate and lower the cost of evaluating multiple alternatives concurrently.

The use of qualitative content analysis methods meant that our results were dependent on what the authors chose to include in their publications. Since scientific publications are often limited in space and requires concision, this could have affected our results. However, we made the assumption that if some information was considered by the authors to have significantly affected their intervention, they would have included it. Transferability of the results is often questioned with this methodology, however by synthesizing the collected codes in representative themes, we aim to have produced findings which are

more generalizable than the context from which they were taken.

An interesting side-effect of putting in place electronic A&F systems is that they will accumulate large amounts of routine practice data which will then be available for research. This data could be used to derive the next generation of high priority targets for quality improvements. It could also be useful in identifying how practice guidelines could be adjusted to better inform practices.

Finally, most cases presented how they were able to create their system by using the least amount of resources they could. However, integrated, customizable, and adaptive electronic A&F systems are likely to be complex engineering projects requiring adequate founding to be effective. Even if they require a greater initial investment, electronic system are likely to be less costly than manual A&F and could, through increasing compliance with evidence-based recommendations, lower the overall cost of healthcare in some settings.

3.5 Conclusion

We applied a quantitative case-study design with thematic content analysis to the analysis of barriers to effective A&F interventions. Additionally, we performed the analysis using the knowledge and viewpoints of multiple theoretical perspective including control and behaviour change theories. We identified six overarching themes and provided examples using our cases as to how these principles could be important, how they can affect the design of the intervention, and what effect would informatics have on their consideration.

This approach enabled us to improve upon past evaluations of A&F in bridging the evidence gap between the perceived importance of A&F and what is known on how to implement effective interventions. We suggest these findings be used in driving the inception phase of future A&F projects, as they will help system developers to compare possible alternatives and facilitate the identification of missing links.

4 The PARSEC model

"In theory, there is no difference between theory and practice. But, in practice, there is." — Jan L. A. van de Snepscheut

This chapter presents a model of electronic practice assessment which was developed in order to fulfil the second objective of this research : *to develop a model capable of supporting the development and administration of electronic PA interventions using findings from barriers to A&F, approaches to behaviour change, and product engineering*(IEEE, 1998). In order to produce more actionable results, and since practice assessment systems are software products, the model will be presented using a modified version of the IEEE standard for software requirement specification (SRS). The document was modified to remove the "specific requirements" section, as this level of detail is would only be needed by the individual instances of this model.

4.1 Introduction

Purpose

This document aims at presenting a generic specification of the PARSEC model. It describes how its core software product should behave, what are the operations it offers, the constraints it needs to respect, the assumptions and dependencies on which it relies, and what ongoing activities are needed to administer it. The target audience of this document are health organizations or system implementers which seek to create and deploy a practice assessment intervention.

Scope

The product being specified is the Practice Assessment Research System for Evidence-based Care or PARSEC model. As a practice assessment initiative, it aims at facilitating physicians self-learning through an external evaluation of

their practice patterns against evidence based standards and their peers. This particular model was developed for the context of primary care physicians in outpatient clinics, in the province of Quebec, Canada. For use in any other setting, this model may require adaptations. As this model was developed for the purpose of supporting physician, it is not meant to provide a larger health system level view although some of the techniques could be reused for this purpose. Besides, this tool is not intended to replace existing process of strategic planning or continuous improvement. By its application, this tool can, however, support such process in providing ground for discussion or facilitating individual goal setting. Finally, it is not meant as a continuous medical education intervention. Once an area of improvement is identified this model would rely on connecting the individual to predefined external resources.

Definitions, Acronyms, and Abbreviations See Preface and Contribution of Authors.

References See Bibliography.

Overview

The rest of this document presents an overall description of the model from different perspectives. It offers a high-level view of its deployment, describes how instances of this model would be deployed in practice, identifies the functions that they are expected to provide, and the characteristics of its intended users. The specification will end on a presentation of the model's constraints, assumptions, and dependencies.

4.2 Overall Description

Product Perspective

The PARSEC model is based around a strategy of continuous iterative development requiring the creation of a governance committee inside the institution. This committee should be composed of representatives from the physicians, patients, health organisation, and system maintainers. Through each iteration, the committee will use the latest evidence-based guidance, feedback from its community, and existing targets and priorities to plan for improvement of

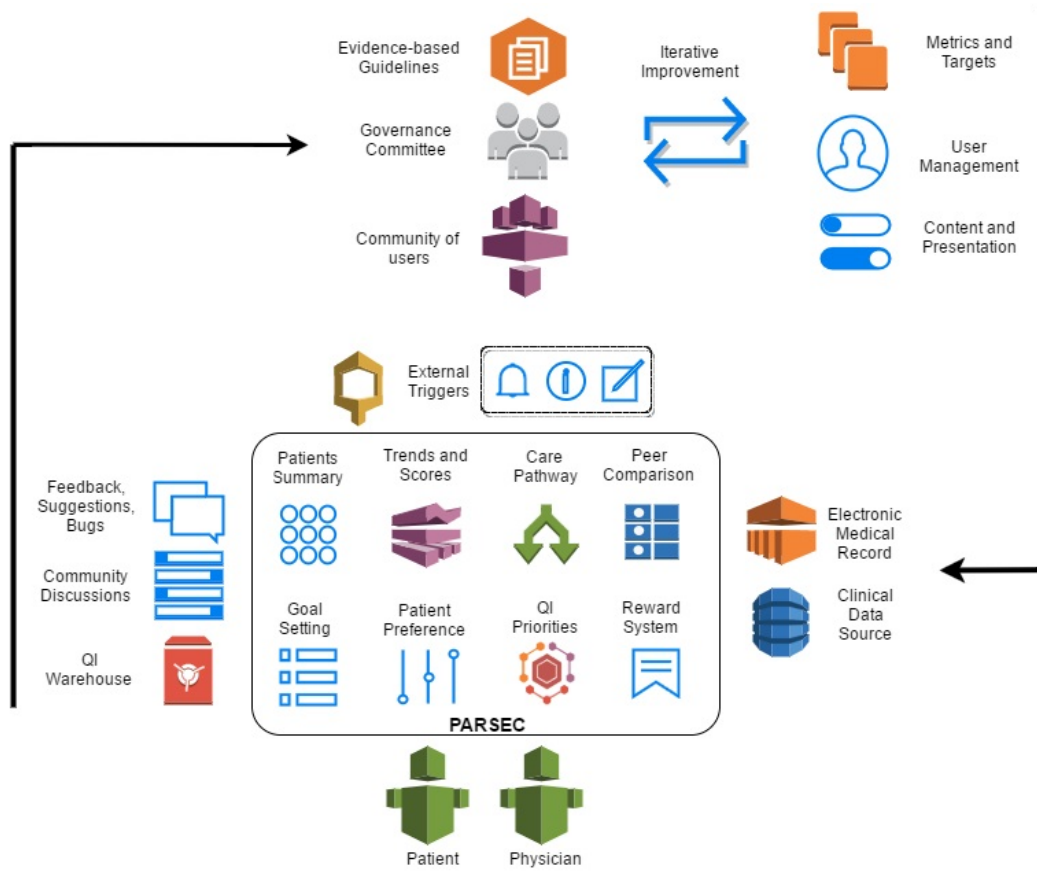


Figure 4.1: Overview of the PARSEC model

the system’s metrics, targets, user management strategy, content, and presentation. This planning should promote the creation of short and long terms goals and establishes a shared vision among the stakeholders.

The core software product is required to connect with existing clinical data sources and to provide a view, within the electronic medical record (EMR), that allows physicians to both obtain a quick summary of its practice and to allow for deeper exploration. In order to offer these functionalities, individual systems will need to make use of patient summaries, trends and scores visualisation, care pathways, the use of peer comparisons, to support physician goal setting, to adjust for patient preferences, to integrate in an organisation quality improvement priorities, and to provide an internal reward system. These functionalities are described in greater details in the section Product Functions. As the scope is limited to physician feedback, any additional recommendation or educational material will need to be driven by external systems. Thus, instances of this model need to accounts for the creation of external triggers enabling the use of multi-faceted approaches.

Finally, it is necessary that instances of this model provide ways through which their users can propose feedback, suggestions, and corrections. This component needs to be part of the system, and should be different from the forum. The forum is an online community discussion board in which users of the PA system can go to interact and discuss with other users and with the governance committee. This community group should provide sections which allow for communications specific to an organisation, but should mainly be a public place for all users of PARSEC related instances to share their experiences, and learn from each others. The last function defined by this PA model is to feed the information it generates into a data warehouse intended at driving future quality improvement efforts. An overview of the complete system can be found in fig 4.1.

System Interfaces

User Interfaces This section lists use cases of the PARSEC model. Use cases are a de facto standard for the description of interactions between users and a system. Use cases present these interactions along with additional information as to the goal of the user, and the contexts in which they take place.

This model emphasises the need for to limit the disruptiveness of PA system. Users should be allowed to ignore the system completely. Required inputs from physicians should be exceptional rather than the norm. Although systems are expected to recommend the correction of incomplete or malformed clinical data, its presence should affect the system's overall usability.

Throughout the systems, views that are shown to physicians should prioritise patient health outcomes over process measures. Similarly, the system should only ask for the attention of users when it made the determination that the resulting actions would be of high priority for a patient. All of the interfaces are meant to provide information personalised to a particular physician.

Continuous attention should be placed on the user experience provided by instances of this model. User interfaces should be assessed in an ongoing fashion for their performance, usability, and correctness. Specific attention should be placed on creating designs that have a low cognitive loads and which transfer knowledge efficiently. Framing heuristics should also be considered when presenting information that is expected to result in a decision.

Use Case 1: As a physician, I want a way to quickly get a sense of the state of my practice without leaving my current environment

This use case is intended as a way to provide an update to physicians which can be processed “at a glance”. This model takes into account that users will only request an advanced exploration of their performance occasionally. It is nonetheless important, for this model, that the user can access a quick summary of their practice in the form of their score on a few compound measures. Additional trend signalling symbols and potential signs warning the user that attention is required could also be used. Additionally, this use case facilitates the acclimatisation of new users and provide existing users with little interest in performing PA a minimum set of meaningful information.

Use Case 2: In-Depth exploration of a practice with measures of performance and quality

This scenario takes place outside patient consultation. It will usually be done at a time the physician dedicated to practice assessment, although this time could be short. In this mode, the user will have full access to all the functionalities offered by the system. Physicians should be allowed to link patient level assessment of performance to the individuals which they were generated from. Additionally, every score and metrics should be provided along with information about the methodology that was use to create it. Use case 1, and 2 recognizes the importance of taking into account the different context of utilisation and foreseen differences in adoption.

Use Case 3: Allows a physician to easily compare its practice against that of its peers, and colleagues

In this use case, a user sees where his practice patterns stands with respect to colleagues or comparable professionals and allows physicians to identify areas of expertise which would benefit from being shared or that could be improved. Additionally, it promotes the creation of a shared understanding of how users can work together to improve their practice group. Furthermore, it could drive behavioural changes by leveraging an individual competitiveness or the tendency to conform to societal norms. Comparison of practice patterns will need to account for differences in the case mix and adjust for patient preference and the severity of cases.

Use Case 4: Engaging the physician into a motivating long term interaction with continuous improvement through the use of rewards and incentives

Environments of self-motivation are contexts in which par-

ticipants are inspired and motivated to improve. By providing rapid feedback with clear goals, and rewards for obtaining them, a user can stay engaged and motivated in returning to the system and improving its performance. This use case includes the creation and management of objectives for the users. It also implies informing the users of ongoing progress and achievements. In addition to the information presented to individual physicians, this can lead to the promotion of the performance of some user in their respective organisation; not necessarily in terms of absolute performance, but in terms of improvement and achievements.

Use Case 5: Facilitating communication and sharing of ideas In this use case, a user wishes to share some results of the practice assessment to members of his social network for further discussion. This acknowledges the social nature of physicians and the importance of recognising and leveraging influential members of the community.

Use Case 6: Allow physician to claim CPD credits As part of the incentive scheme offered by the College of Family Physicians of Canada, the time physicians spend assessing their practice and engaging in self-learning activities can be claimed as credit towards their Continuing Professional Development (CPD) quotas. The system should, therefore, at regular intervals, provide the users with explicit recognition of the time spent doing PA.

Use Case 7: Provide mechanisms to report an information, target, or metric as being inaccurate, or misleading The iterative nature of the model already recognises the importance of continuous improvement. However, errors in decision support systems have been observed to cause detrimental and dangerous consequences Koppel et al. (2005). The systems must, therefore, provide mechanisms allowing users to report items they consider to be inaccurate or misleading. The governance committee should prioritise the acknowledgement and processing of these reports over any other actions.

Use Case 8: Allow adjustments to patient's preferences This model takes into account that patient preferences will not always match the expectations of the metrics and targets. In order to lower the frequency of false positives in the identification of cases requiring attention and to provide a more truthful representation of a physician's practice, instances of this

model should provide physicians with ways to tailor a patient's evaluation to the patient preferences and need. In the case where the adjustments render a metric uncomputable, the priority should be placed on removing it from the assessment. Since this action is likely to be frequently done during patient consultation, the selection of user preferences should aim to be effortless and efficient.

Use Case 9: Personal Goals In recognition of the view that physicians will intrinsically seek to improve their professional competency, users need to be able to identify targets and metrics as being of high priority to them. Additionally, systems should allow the identification of personal goals, monitor their progress, and inform users of their completion.

Hardware Interface The software products should reside at a location which allows it to have access to its required clinical data sources. Efforts should be made to integrate it into the user interface of the organization's EMR and adequate latency should be ensured.

Software Interface The PARSEC model necessitates the choice of a data management and business logic encoding system. Additionally, implementers will need to put in place mechanisms for user and role management, internal user feedback, and the complete journalisation of user actions and system events.

Operations Core system operations are centred around three steps. In a first step, the system will load all new data and events that happened since its last update. It will recompute its metrics and update its recommendations. A second operation is a mandatory journalisation along with timestamps into persistent write-only storage. A final step is to push the results of newly computed metrics into an external quality improvement data warehouse.

Site Adaptation Requirements PARSEC is a generic model for PA interventions. It is expected that most sites will require different instances and that site-specific adaptation will be of great importance. For this reason, this document does not list specific targets, indicators, or data collection strategy as these would depend on a site's vision, on its priorities, on its available data, and on its defining characteristics and context.

The primary drivers of this adaptation will be an instance’s governance committee. This multi-disciplinary team of physicians, patients, managers, and software engineers will have to identify which targets, threshold, and metrics makes the most sense in their context and how should they prioritise their implementation. They will be responsible for filling the blanks in this model and through the establishment of a vision and long-term planning strategy, the governance committee will be able to ensure that PA is aligned with their organisation’s continuous improvement strategy. Additionally, they are responsible for defining the metrics used to evaluate the effect of the system and to monitor it for possible adverse effects. It is necessary for the governance committee to take into considerations the views and suggestions of the users, and of the community. Community management is one of the pillars of a product success. It acknowledges that ”humans have a fundamental need to be consulted, engaged, to exercise their knowledge (and thus power) [...]” (Plott, 2011)

Another site-specific consideration is the management of users and roles. The development of valid and verified clinical systems requires considering carefully never having more users then you can manage well. Consequently, early development will require exclusivity and participants in these stages need to be chosen cautiously. Users with low baseline performance might not be suitable for early access versions since they might be a harder to convince or motivate. Some opinion leaders need to be in the early group, however including too many leads to a risk of not being able to tend to them appropriately and could negatively impact the intervention. Waiting lists can provide greater visibility and serve as a conduit to train future users before they use the system. Finally, health organisations, which decide to implement PA systems, have to make sure that physicians have dedicated time allowed for its use.

Product Functions

Patients summaries

Patient summaries are a functionality of the system that allowing users to get an overview of the patient population. Compound scores are computed per patient for categories such as data quality, preventative care, and evidence-based care, and are presented in a way that allows physicians to quickly identifies areas of improvements or patients requiring attention.

Trends and scores

Cross-sectional practice level metrics are computed at regular intervals and their results are presented in a way which enables physicians to detect potential trends. A useful metric is a representative composite overall score indicative of the current state of their practice. Cross-sectional metrics need to take into consideration the relative priority of each measure and be adjusted to represent its propensity to affect patient health outcomes.

Care pathway

Care pathways are longitudinal indicators computed at the level of an individual patient. They can be used to calculate and present the difference between an observed and predicted treatment plan. By their longitudinal perspective, care pathways have the advantage of adjusting their assessment to account for the state of the patients.

Peer comparison

Peers comparison affects how the systems show scores and metrics to the user. By presenting them along that of colleagues or comparable practices, it lets physician put their current performance into perspective.

Goal setting

Governing committees should consider the ability to set personal goals from the inception of the system. They should be easy to create and simple to assess and, as previously mentioned, progress and completion should be trackable by the physicians.

Patient preferences

The potential impacts of patient preferences on measures should be mitigated prior to their inclusion in PA. Possible mitigation strategies are to adjust the original metric to be more inclusive, to switch the patient to an alternative context-aware metric, or to exclude the patient from this measure altogether.

QI integration

Along with physician goals, the governance committee should also be able to encode quality improvement goals which match the current learning objectives

of the organisation, or the community. Systems should handle these like user entered objectives.

Reward system

PARSEC proposes that specific milestone or achievement trigger “rewards”. These rewards are meant to be integrated into the deployment of the system. Examples of rewards that could improve self-motivation include mentions in an organisational bulletin board, the publication of the user’s name in a “leader board” inside the application, or simply the establishment of a “level” system placing physicians in a categorical ordinal scale of “proficiency in the system”.

User Characteristics

Users in this model are family physicians. They are therefore either adults or older, have high literacy, and various levels of proficiency with information technology. They will all have university level education and high degrees of medical expertise.

Constraints

Instances of the PARSEC model will be limited by the availability and quality of the clinical data sources they are linked with. Additionally, it is expected that the implementation and administration activities of the systems will be restrained by the limited amount of resources dedicated to it. All instances of this model will have to value patient safety over everything else, and this implies constraints on the appropriateness and correctness of the information it contains. PA systems need to be auditable and to be reliable enough to be used in day-to-day practice.

Assumptions and Dependencies

As electronic medical records differ in how they collect, provide, and represent the health care information, an organisation’s decision to change its EMR could have drastic repercussions on PA system. Any system implemented in the province of Québec would also benefit from the agreement of the Collège des médecins du Québec.

5 Discussions & Conclusion

”The first principle is that you must not fool yourself — and you are the easiest person to fool.” — Richard Feynman

Although little yet known about how and when audit and feedback works, it is an increasingly used quality improvement technique. Health organisation and developers of intervention have to resign on using best practices and evidence that are currently unable to explain the variability which is seen in the effect of A&F. Furthermore, traditional A&F lead to interventions that are time-consuming, laborious, and expensive while mostly ignoring the potential benefits of informatics.

The aim of this research was to bridge the gap between how PA is needed and what is known about how to develop it. For this purpose, we established two objectives. The first was to identify the barriers to effective audit and feedback interventions in health-care and to suggest how informatics methods implemented in the context of theories of behaviour change can help to overcome these barriers. The second was to develop a model capable of supporting the development and administration of electronic PA interventions using findings from barriers to A&F, approaches to behaviour change, and product engineering.

In the manuscript of section 3, we used a qualitative, explanatory case-study design to identify the barriers to effective A&F intervention and to frame these barriers within the context of informatics methods and behaviour change theories. This case-study included a deductive thematic content analysis of the collected qualitative data, and its selected cases were individual computerized A&F systems identified using a review of the literature. A thematic analysis followed that had the pragmatic purpose of producing operationalizable findings. The analysis resulted in six overarching themes:

- Clinical Governance
- Cognitive Biases
- Control Theory
- Resource Constraints
- Learning Culture
- Adoption

In addition to the identification of barriers to effective A&F interventions, the manuscript discussed how informatics methods supported its use in organizational planning, simplified the generation of individualized feedback, minimized the labour and cost of interventions, promoted the exchange of findings between stakeholders, and improved the frequency at which feedback could be provided. These results suggest that the use of information technology in PA increases its effectiveness.

Following the completion of the first objectives, the results were then used to inform the creation of the PARSEC model. In recognition of the fact that electronic PA is, at its core, a software product, and in order to produce more actionable findings, the model was presented using an engineering standard for the elicitation of software requirements specification (IEEE, 1998).

Using this method, the model's scope and purpose was introduced. An overall description was then given describing the product perspective, the product functions, the characteristics of users, the constraint it faces, and the assumptions and dependencies on which it relies. The product perspective section specified the foundational use cases of the model, the required hardware for its deployment, the necessary software tools, and the system operations. A final section described the process through which this generic model of PA could be instantiated into a site-specific system.

At this point, I would like to remind the reader that due to the constraint of the manuscript format, part of the discussion has already been presented in section 3.

5.1 Contribution and Significance

By aiming to bridge the gap between what is needed and what is known, we favoured tools and techniques which supported the generation of findings capable of informing the development and administration of electronic PA. Primary users of this research are implementers seeking to develop more effective PA interventions. Better PA would lead to less unnecessary care, safer practices, and increased used of preventative measures. Therefore, this research could have an indirect effect on the daily practice of primary care physician in helping them improve the performance and quality of care they provide, and consequently achieving better patient health outcomes.

The methodology used by this research enabled the identification of prin-

ciples of A&F, which would have been difficult to obtain from existing evaluations. These principles allow for a better understanding of the barriers and facilitators associated with these interventions. Furthermore, this research leads the way to a greater comprehension of how information technologies can impact A&F. It ultimately contributes to future efforts to build a more comprehensive theory of A&F which, if successful, might allow us to resolve the variability that has been omnipresent for so long.

5.2 Novelty of the Approach

One of the characterising difference of this approach is its focus on practice assessment instead of audit and feedback. This use of a more precise concept allowed us to propose a model which had a single unifying vision. Additionally, it is doubtful that a model capable of supporting the development of A&F could be generated without specifying in greater details its context, intended users, and primary purpose.

Furthermore, the current evidence supporting the implementation of A&F is a set of disparate suggestions each informing distinct components of the system. In integrating the factors influencing A&F together with techniques of behaviour change and product engineering, I hope to achieve a more holistic approach. For example, considering all components together and adopting a pragmatic approach linking the theory to its practical application allowed the consideration of emergent properties. This strategy is useful in cases where barriers or facilitators to PA only appear as a property of the overall system, and could not be easily identified from its atomic components.

5.3 Limitations

The discussion section of the manuscript presented a major limitation which I will discuss here in greater details. This limitation refers to the discrepancies between the interventions identified by our review of the literature and the systems known to be in use. Known examples include the physician review module of the quality and outcome framework (UK) and closer to home the “Primary Care Practice Report” from Health Quality Ontario (Health Quality Ontario, 2016b). An indicator of the magnitude of the problem is that knowing the existence of these systems, no publication was found on either. As

we developed the manuscript's search strategy, there seemed to be little consistency or standards in the Mesh terms used by librarians to represent the computerised aspect of A&F. Additional exploration revealed that, for some studies, both title and Mesh terms were uninformative as to the use of informatics. This exploration was undertaken after finding suspicious the fact that the initial search strategy only resulted in 60 publications. Although nothing could be done for unpublished work, we adjusted the search strategy to take into account potential misclassifications of the use of informatics. This more sensitive approach, however, led to additional noise and a greater burden to the manual filtering. The most common cause of rejection were studies reporting the use of software tools, such as Microsoft Excel®, while performing a manual audit. Another common reason was the use of computerised A&F in the context of nursing or dentistry while the criteria were for interventions used by physicians as part of medical care.

A second limitation relates to one of the assumptions of this work. This assumption was that part of the variability seen in the effect of A&F emerged from technical aspects of their developments. Thus, the choices of process, technologies, and activities made during the creation of interventions would modulate the magnitude of its final effects. Consequently, better guidance on the specifics of implementation would lead developers to produce systems with less variable results. However, the model I propose is still, to a large extent, site-dependant. The technical aspects of how implementers will choose to instantiate and adapt this specification will have an impact towards the success or failure of the resulting system. To counteract this effect, the PARSEC model includes best practices and recommendations on the architecture and the marketing of the product.

A third limitation relates to the size of the engineering project proposed by the PARSEC model. Even though it was shown in the manuscript that, for some usage scenario, the use of traditional method would just be unfeasible; the resource requirement suggested in PARSEC might be prohibitively high. The amount of time and resources needed might exceed what is available for PA or eventually exhaust the motivation of its creators. The use of an agile development philosophy could remedy this limitation by focusing on early and continuous delivery of valuable software Alliance (2016). Furthermore, as we shown, it is likely that electronic PA will lead to a favourable net cost-benefit.

For the sake of clarity and conciseness, I assumed, in this text, external clinical information systems to be ideal. For computerised patient record (CPR)

to be usable to PA, they need to be more than just electronically accessible version of their pen and paper equivalents. The ideal CPRs have two characteristics which improve their effectiveness for PA; they collect broader and more comprehensive data, and they make this data available to external systems using common standards and vocabulary. Although it is doubtful that one can successfully implement an electronic PA intervention in a context where these assumptions do not hold; the number of infringing EMR is expected to diminish due to the formalisation of requirements, such as *Meaningful Use*, and national recommendations (Dick et al., 1997).

5.4 Future Research

This document proposed that the computerization of A&F interventions lead to effects and processes which are different enough to warrant separate evaluations. However, a lack of publication associated with the presence of misclassification resulted in the identification of too few interventions to power a quantitative analysis of their effect. Future research could be done on the creation of a scoping review that explores in more detail these limitations. Such research could investigate improving the search strategy used in this document by making better use of gray literature and by contacting authors of known unpublished systems. Furthermore, a comprehensive identification of interventions would allow the creation of a meta-analysis focusing specifically on the differential effects between traditional and computerized A&F. The results could then be used to highlight the advantages and drawbacks associated with the use of informatics and, at the same time, inform the future implementations.

Finally, as part of one of the objectives, this document lays the ground for the creation of electronic PA by proposing a generic model capable of supporting its development and administration. As implementers instantiate the PARSEC model, it is expected to improve and adapt. Until this model is used, its feasibility and effectiveness will, however, remain speculative. As Ivers et al. (2012) pointed out, "the field would likely benefit if investigators explicitly built upon knowledge generated from prior trials, systematic reviews, and relevant theory to design audit and feedback interventions". I am confident that as this model informs new interventions, it is likely that the PA will get closer to bridging the gap between what is needed and what is known.

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Appendix A : Theories on Change in Health Care

Individual professionals

Cognitive theories	Implementation of change needs to take into account professionals' decision processes, and they need good information and methods to support their decisions in practice.
Educational theories	Implementation of change should be linked to professionals' needs and motivation; intrinsic motivation is crucial; people change on basis of experienced problems in practice.
Motivational theories	Implementation of change needs to focus on attitudes, perceived social norms, and experienced control related to desired performance.

Social context

Theories of communication	Importance of the source of innovation (credibility), the framing and rehearsal of messages, and the characteristics of the messages' recipient.
Social learning theory	Changing performance takes place through demonstration and modeling and through reinforcement by others.
Social network and influence theories	Change demands local adaptation of innovations and use of local networks and opinion leaders in dissemination, including identifying innovators and key persons in the social network.
Theories related to teamwork	More effective teams are better able to make necessary changes to improve care because they share goals and are able to share knowledge.
Theories of professional development	Professional loyalty, pride and consensus, and "reinvention" of change proposal by professional body are important.
Theories of leadership	Involvement and commitment of leaders and (top) management in change process are important.

Table 1: Overview of Theories on Change in Health Care from Grol et al. (2007)

Organizational context	
Theory of innovative organizations	Implementation should take into account the type of organization; decentralized decision making (teams) about innovation is important.
Theory of quality management	Improvement is a continuous cyclic process, with plans for change continually adapted on the basis of previous experience; organization-wide measures are aimed at improving culture, collaboration, customer focus, and processes.
Theories of integrated care	Change multidisciplinary care processes and collaboration instead of individual decision making.
Complexity theory	Focus on system as a whole, find patterns in behavior (attractors) and link change plan to these, and test and improve the plan.
Organizational learning theory	The creation or availability of conditions in the organization for continuous learning at all levels can lead to successful changes.
Theories of organizational culture	Changes in the culture can stimulate changes in performance, particularly a culture of teamwork, flexibility, and external orientation.
Political and economic context	
Reimbursement theories	Attractive rewards and (financial) incentives can influence the volume of specific activities.
Theory of contracting	Contractual arrangements can guide professional and organizational performance.

Table 2: Table 1 - Continued

Appendix B : Search Strategy

Source Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and
Ovid MEDLINE (R) 1996 to January 13, 2016

Query

```
(  
  (audit adj3 feedback).tw. or  
  exp Feedback/ or  
  exp Medical Audit/ or  
  exp Peer Review, Health Care/  
) and (  
  exp Delivery of Health Care/  
  exp Practice Patterns, Physicians’/  
  exp Quality Assurance, Health Care/  
  exp Quality Improvement/  
) and (  
  Automatic Data Processing/  
  Cloud Computing/  
  Computer Systems/  
  Decision Making, Computer-Assisted/  
  Decision Support Systems, Clinical/  
  Decision Support Systems, Management/  
  exp Decision Support Techniques/  
  Health Information Systems/  
  Medical Informatics Applications/  
  Medical Informatics/  
  Reminder Systems/  
  Software/  
)
```

Results

id	Number of Results	Topic
1	41355	Practice Assessment
2	810111	Healthcare Delivery
3	149976	Clinical Information System
4	456	1 AND 2 AND 3

Table 3: Summary of Intermediary Results