

Using *Process-Mapping* to Design Integrated Health Information Management Systems

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Abstract

There is growing interest internationally in the development and effective integration of efficient and useable electronic health information management systems. However, it is essential that researchers, designers and implementers have a clear understanding of the current care processes in place before they start to develop or implement new electronic systems within health care settings. A critical first step to designing such systems is the development of accurate models depicting existing care pathways and clinical processes. Here, we introduce the concepts of process-mapping, and discuss how these tools are currently being applied to a comprehensive process mapping project of pre-operative assessment services across Scotland.

1 Introduction

In order to improve the safety and quality of care within health services, it is important for policymakers and clinical managers to understand precisely how services function in practice, that is: *who does what, why and when?*. This can be a difficult task when services are complex, geographically distributed, operating on a large scale, functioning autonomously with widely varying practices and contexts. In other words, getting a reliable and comprehensive picture of a complex system is often a challenge. Existing clinical practices need to be recorded, described, measured and analysed using transparent and systematic methodologies which can be reliably replicated across services and disciplines.

Here, we describe our ongoing work on process-mapping of clinical practices. We are using these techniques to systematically describe the clinical processes of preoperative assessment across hospitals in Scotland. Pro-

cess mapping is helpful if one is trying to analyse and understand service processes and in particular to evaluate the effects of service changes. By comparing the service processes and care pathways before and after specific clinical interventions, it is possible to reliably compare services and assess whether the intervention had the desired or expected effect and if it was successful in improving services processes or pathways for patients or on the contrary led to a deterioration of services or performance.

The remainder of this article is organised as follows: we begin with motivation and background information on the domain of application in section 2. This is followed by a description of the process-mapping methodology in section 3. We describe, as a case-study in section 4, the application of these techniques to an on-going project of preoperative assessment processes analysis in Scotland. We conclude with a discussion and future work in section 5.

2 Background & Concepts Definition

2.1 Motivation

Millions of people are scheduled for elective surgery every year and therefore need to undergo preoperative assessment and screening prior to surgery [1, 2]. Currently, health resources worldwide are undergoing substantial rationalisation due to the twin effect of increasing costs due to changing demographics and a tighter overall economic environment, precipitated by the banking and financial crisis since 2008. At the same time, policymakers have put an increased emphasis worldwide on providing greater access to telehealth services, due to the increasing challenges posed by ageing populations and chronic illness. Thus, the agents and recipients of health services need to anticipate future shifts in the location of clinical processes - many currently performed in secondary care settings - will need to be shared

with or relocated the community

Indeed, many health trusts in the U.K. and elsewhere already provide some form of tele-medicine or tele-healthcare services, such as telephone-based screening services, such as NHS direct and NHS 24 which are now tele-health services routinely used in the U.K.¹ For preoperative assessment, one possible option would be to replace or shift some of the physical appointments currently undertaken in outpatient clinics to collect the patient past medical history to telephone screening interviews or internet-based systems. Indeed, this is already the case in some health trusts [3].

But in order for tele-health solutions to be successful beyond limited trials and be effectively integrated within nationwide health delivery systems, it is an essential precondition that those who plan clinical interventions understand precisely how existing preoperative processes of care operate and are provided within existing health delivery systems settings. Developing accurate models of existing services is therefore a critical step to inform the design of future service transformation models.

2.2 Evaluation of Complex Interventions within Clinical Processes

The NHS Modernisation agency defined a clinical process as “a series of connected steps or actions to achieve an outcome” with the following characteristics: a purpose, start and end points (scope), defined groups of agents and users, rules and links to other processes [4]. In 2000, the Medical Research Council (MRC) issued a discussion framework document² for the evaluation of “complex interventions” in the health services [5]. Many interventions within the health services - such as the introduction of new technologies and the associated requirements for changes in the organisation of services - are indeed *complex*: they are hard to identify or specify in isolation as they take place within an intricate set of interconnected interactions of therapeutic treatments, roles, processes and services, all of which are themselves complex.

The MRC Framework was certainly successful in its original intent of generating a *debate* on the issue of evaluating complex interventions within the health services. It also attracted some criticism for being too vague - especially as it was used by many researchers as a protocol document - or too closely resembling a drug development trial, lacking of evidence, with an over-emphasis on evaluation at the expense of the development and implementation of the intervention itself, and for the fact that it did not specifically consider the local *context* in which interventions took place

¹Online and telephone services used by member of the public to describe their symptoms before being instructed whether or not to present themselves at general practice or emergency.

²<http://www.mrc.ac.uk/Utilities/Documentrecord/index.htm?d=MRC003372>

[6, 8]. Others argued that intervention theory or complex systems theory - which view complexity as a feature of the system rather than the intervention - were more appropriate for the evaluation of interventions than the traditional methods of clinical trials [9, 10]. Some researchers emphasised the importance of *process evaluations* within trials in order to permit the interpretation of results, in particular whether the failure of an intervention could be attributed to an inherently flawed design or rather inadequate service delivery [11]. Following consultation, the MRC evaluation guidance framework was revised and expanded in 2008 [8]. The new guidance acknowledged that too narrow a focus on the evaluation of an intervention may result in other key aspects - development, pilot and feasibility studies - and reporting and long term implementation - of the intervention being overlooked and thus reducing the overall quality of the intervention and the significance of the evaluation itself. A new complex intervention “lifecycle” was proposed, consisting of development, evaluation and implementation phases as seen in Figure 1. The revised MRC document emphasised that useful insight was gained when *interventions’ processes* were also evaluated, in order to identify factors which may promote or prevent the success of the intervention.

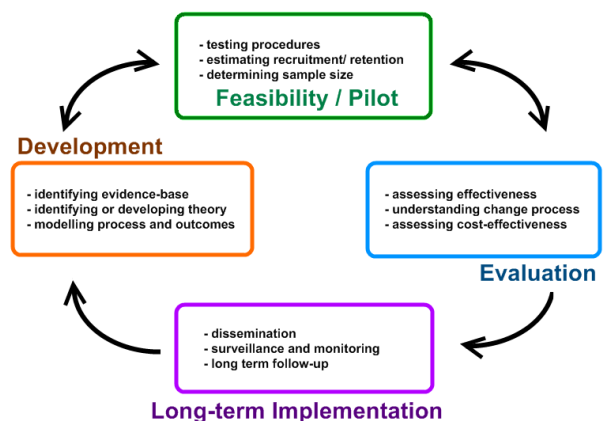


Figure 1. The Complex Intervention “lifecycle”, adapted from the MRC Guidance, 2008

3 Process-Mapping Methodology

3.1 Goals of Process-Mapping

A process map is a visual representation model of a set of clinical services. It needs to include all relevant clinical procedures and associated administrative steps. The aim of a process map is to provide the agents involved in the ser-

vices, or those analysing or planning an intervention within these services, with a detailed overall picture of how the services are currently provided and how well they are performing.

Process-mapping can help to identify:

- important or unexplained variations in clinical practices
- unnecessary steps and multiple patients handovers
- batching of works and bottlenecks
- unnecessary delays and queues
- processes or information duplication
- inefficient or illogical processes, waste of resources
- recurrent sources of clinical errors

A process map can be helpful to enable agents tightly involved within the processes themselves to “take a step back”. This in turn may facilitate the identification of critical steps which could be improved. Process-mapping may diagnose structural problem in the running of services or highlight aspects of the services which are performing well. It can help a multi-disciplinary team making sense of clinical practices and develop a shared understanding of existing needs, requirements and issues. It can be a tool to help health professionals understand how services are perceived by outside agents, particularly: service users. Patient’s perspectives will be essential to identify issues with the quality of care provided. Process mapping can be very useful for members of the multi-disciplinary team who rarely have an opportunity to contribute to service improvement, although they have an in-depth understanding of how services are run and existing short-comings. It can be an opportunity to capture patients’ experiences. It can be useful in identifying well known work-flows issues, such as process *processes and functional bottlenecks*. Processes bottlenecks cause delays due to the intrinsic duration of the process itself (i.e. a clinical procedure which is time-consuming). On the other hand, a functional bottleneck, occurs when a specific service deals with many multiple and competing demands for limited resources (i.e. need for laboratory testing results, or radiology which are necessary across all services within a hospital).

3.2 Methodology

Process-mapping can feel daunting at first, so the key to breaking complex clinical processes into more manageable “chunks” is always to start with a high-level map of main activities (see Figure 2 as an example). First: key steps are defined then, secondary, sub and parallel processes are identified. All these activities can then progressively be refined in order to incrementally include the necessary levels of details. The appropriate granularity will always be context-specific and is typically dictated by the end-goals of the task at hand.

Information which routinely needs to be recorded include:

- all individual steps within the process
- duration of these steps
- all the agents involved
- all the documents and artefacts used throughout the process

Some common process-mapping techniques are familiar and similar to many used within Human-Computer Interaction (HCI) while others are typically within the remit of health services research, including:

- care pathway analysis tools
- multi-disciplinary team panel
- patient walkthrough
- workflows through clinical & administrative steps
- patient shadowing / prospective follow-up
- patient retrospective analysis (access to medical records)

Table 1. Elements of Processes Analysis

Task & Time	define tasks and the time required to complete these
Responsibility	define who has responsibility for completing a task and for the overall task
Skill Set	identify whether staff are suitably qualified to perform a task
Variation in Tasks	identify nature, sources and impact of variations in tasks’ completions
Duplicated or corrective Tasks	identify tasks which are carried out multiple times or performed in order to correct an earlier problem
Waiting Time	define waiting times between tasks
Delays	identify and define delays within processes
Queues	identify and define batching & queues within processes
Bottlenecks	identify and define process & functional bottlenecks
Handovers	define and describe the nature of patient handovers
Whole Process Duration	define the total time to complete the process including waiting times, delays, queues & bottlenecks

3.3 Processes & Outcomes Analysis

Without clearly defined and specified outcomes, it is often difficult to objectively assess or identify issues with *and within* existing processes. Equally, it is difficult to evaluate changes and assess whether services transformations

have led to actual improvement in processes or instead in a loss of effectiveness. On the other hand, using quantitative measures of clinical processes can seem counter-intuitive or arbitrary at times. Thus, a useful measure of outcomes are one which directly impact on the quality of service delivery (e.g. numbers in waiting lists, time to wait, number of cancelled appointments, number of patients who do not attend (D-N-A) appointments etc.) Ideally, measures will capture data which is of direct relevance to local services, patients and services managers alike although it may be impractical to collect data which will be useful to all stakeholders. Again, pragmatic choices may have to be made based on the resources available and the specific goals of mapping. Data capture will be more efficient if it can be integrated within work practices without adding significant over-heads (e.g. through the services patient management systems). It is important that the data collected is accurate and consistent across the various agents who will collect it. Once a comprehensive process map has been drawn, health professionals can proceed to the next stage of the methodology which consists in the actual processes analysis itself. The goal here is to objectively assess the level of effectiveness of existing processes, identify issues and understand how practices can be further optimised. Identified issues can be iteratively mapped and defined in more details until structural problems are clearly specified and remedial action can be taken. Health services and sociology practitioners and researchers, have also recently developed more sophisticated theories and analysis tools, including the *Normalization Process Theory* (NPT), a theoretical model of *processes of intervention* within health services [12, 13].

3.4 Care & Patient Pathways

Health services can be modelled as complex queuing systems [9, 10]. How care, patients' pathways and queues are practically managed within the system will significantly impact on patients' satisfaction and perception of the quality of care delivered throughout the system. Patients being asked to repeatedly attend inefficient clinical processes may lead to frustration with services which may in turn result in poor compliance with treatments, leading to worse outcomes for the patient and an increased burden to the health services and the patients themselves. Patients cancelling or not attending medical appointments will in turn waste important resources as well as seriously disrupting clinical workflows. Designing patient pathways is a mean of developing more systematic and coherent pictures and flows of patients throughout the health services. They are designed to ensure that the provision and quality of care is consistent and coherent across services and that services providers are accountable to both patients and services managers. In order to provide the highest quality of care, it is essential that

not only clinical managers understand processes from the health services' point of view but also from the perspective of the patients'. Patients experiences of services can be very different from that of health professionals providing these services.

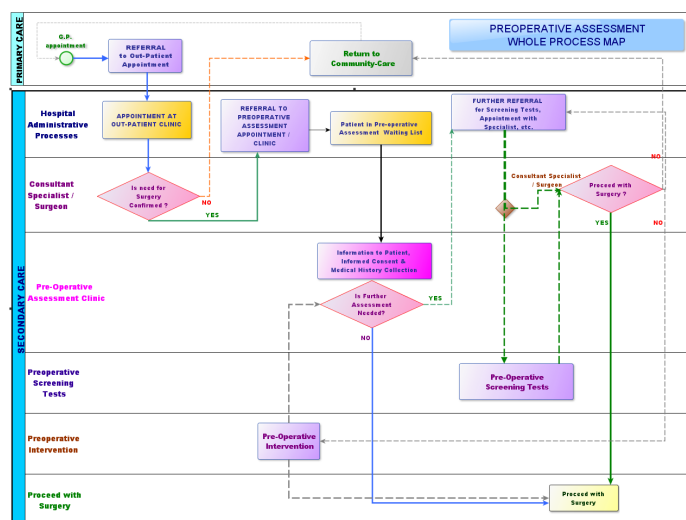


Figure 2. A High-Level Preoperative Assessment Process Map

4 Case Study: Process-Mapping of Pre-operative Assessment Services

4.1 Motivation

According to the most recent available figures on U.S. National Health Statistics Reports, an estimated 53.3 million procedures (surgical and nonsurgical) were performed during 34.7 million ambulatory surgery visits in 2006 and 45 million procedures were performed on hospital inpatients in 2007 [14, 15]. The World Health Organisation (WHO) estimated the worldwide figure to be in excess of 230 millions procedures in a 2008 report [16]. In the U.K. it is estimated that there is in excess of 8 million surgical procedures each year. The NHS Modernisation Agency's Pre-operative Assessment Project (Aug. 2001 - Nov. 2002), estimated that up to two thirds of day cases cancellations and 50% of inpatients cancellations were directly due to patients related factors and that more efficient preoperative processes could have prevented a significant number of these cancellations [1, 2]. Pearse et al. found that, while 12.5% of surgical operations were performed on a high risk surgical populations (defined as mortality rates of 5% or over for a specific procedure), this population accounted for more than 80% of post-operative deaths [17]. One of the

greatest challenges currently facing health systems globally is the increasing burden of chronic diseases, which have now become the leading causes of mortality worldwide, in what the WHO has described as a “major shifts in death patterns” [18, 19]. With an estimated two-thirds of those who have reached pensionable age having multiple morbidities [20, 21], a major challenge for preoperative assessment is to quickly distinguish those patients who require minimum assessment and those who will require more extensive management. As potential complications from multiple morbidities can be extremely complex, effective evaluation will depend upon the efficient collection of all appropriate medical information, good data management and effective communication and information exchange between the members of the multi-disciplinary team. Good quality information technology systems may help promote data collection and information sharing as part of preoperative assessment [22]. However, in order to develop high quality systems, it is essential to identify the key steps in an optimal patient pathway for preoperative assessment.

4.2 Process-Mapping of Pre-operative Assessment Services

Between March 2010 and March 2011, we performed a systematic review of the medical literature in search of the available levels of evidence underpinning the effectiveness of existing practices of preoperative assessment [7]. We used the results of the review to develop a map of the evidence underpinning key decision points within preoperative processes. As a mapping tool, we used the java-based yEd Graph Editor³, which is freely available for download³. The editor is a very versatile tool which permits to rapidly create a wide range of process maps. The high-level process map, identifying the main key steps of a generic preoperative assessment is illustrated in Figure 2. We added hyperlinks to individual process nodes in order to relate key steps of the process to the identified evidence. As an example, clicking on the “Preoperative Tests” node of Figure 2 prompts a page of hyperlinks to all the evidence-based guidelines on preoperative assessment identified during our systematic review. This is illustrated in Figure 3.

Our current project involves processes mapping of preoperative assessment services in Scotland. We are mapping existing practices within preoperative services across a range of major and intermediate hospitals in 14 healthboards of Scotland. Based on detailed process-mapping of services, we anticipate to make a number of service recommendations, towards increasingly standardised and evidence-based processes, whenever variations in practices are not justified by important local clinical factors (i.e. such

as specific features within a population treated in a health-board which could explain local variations in practices). Certain elements of existing services may be suitable for transformation and redesign, such as a shift from paper-based systems to electronic systems. This may enable the introduction of electronic decision support systems at key decisions points. Other aspects of the services may be suitable for a transfer to community-base care and / or telehealth (e.g. phone or web based preoperative screening at the general practice or from home, if suitable, which may save the patients a lengthy or repeat journeys to hospital). Any substantial transformation however will inevitably need to be based on solid evidence of effectiveness. In addition, if a technological intervention is to be successful, it will also inevitably require broad support from key stakeholders, including: health professionals involved in the running of existing services, clinical managers, policymakers and of course patients.

SCREENING TESTS - GUIDELINES

For Cross References, see:

Screening Tests - (Expert Reviews)

Guideline	Date	STUDY	Author
Network for Advancement of Transfusion Alternatives	2010	Detection, evaluation, and management of preoperative anaemia in the elective orthopaedic surgical patient: NATA guidelines	Goodrough, L. T. and Maralis, A. and Earnshaw, P. and Benson, G. and Blets, P. and Blain, E. and Ferguson, D.A. and Corbett, H. and Hubler, O. and Morik, T. G. and Coar, Y. and Stappesdel, R. and BrSpapaki, M.
British Committee for Standards in Haematology	2000	Guidelines on the assessment of bleeding risk prior to surgery or invasive procedures.	Chew H.L., Crawford J.C., Watson H.G. and Greaves M.
Guidelines Advisory Committee (Canada)	2005	The value of screening preoperative chest x-rays: a systematic review	H. S. Joo, J. Wong, V. N. Nair, and G. L. Sawchuk
NICE Preoperative Tests Guidelines	2003	The use of routine preoperative tests for elective surgery	NHS-NICE

Comments to: TherapEconomy@gmail.com

DISCLAIMER: This taxonomy of the preoperative assessment literature was designed as part of a Scotland Chief Scientist Office Fellowship in Health Services Research 2010/2013 and is not exhaustive

Figure 3. Hyperlinks to Evidence-Base Guidelines

5 Discussion and Future Work

The first step in enabling transformation processes within health delivery systems is to understand precisely how services function in practice. Important variations in the provision of care can be analysed by using comparable measures of performances and outcomes. Indeed, health systems are often modelled as *complex systems*. An intervention within the workflow of a complex process chain will generally affect services as a whole, often in unpredictable ways. Ripple effects are not necessarily confined to neighbouring processes, but can also affect diverse and remote components of the delivery system. Process-mapping is a useful tool to understand existing care pathways and clinical processes. In turn, this can be used in an attempt to anticipate the potential effects of complex technological interventions on work processes.

³http://www.yworks.com/en/products_yed_about.html

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