A framework for evaluating the economic impact of EHR-based interventions
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1. Foreword

The NHS Five Year Forward View addressed the ever increasing need for the improvement of NHS digital technologies, with the aim of establishing fully interoperable electronic medical records (EMRs). The establishment of such systems leads to the question of patients’ access to their health records via these EHR-based interventions. By being at the centre of their own care, through access to these records patients will develop more self-awareness of their health issues and better understanding of their care management plans. Ensuring that patients are at the centre of their care is a core concept, and one that I have always strongly advocated. By putting the patient in the driving seat with respect to their own data it is going to be transformative for patient care and patient safety.

As the demand for health services in England increases, commissioners and providers should be focusing on the economic impact of such EHR-based interventions and how to evaluate their impact on patient care. This report jointly funded by the Imperial College Healthcare Charity and the Peter Sowerby Foundation provides a practicable framework for prospective and retrospective evaluations of the effectiveness of EHR-based interventions.

The report comes with thanks to the Peter Sowerby Foundation for their continued support in providing us with the opportunity to lead a major programme of research in the area of e-health and to develop this report.

I hope this publication will give readers a better understanding of the need to evaluate these EHR-based interventions and provide them with a framework to do so.

Professor the Lord Ara Darzi
Director, Institute of Global Health Innovation
Patient empowerment and engagement are core concepts for health systems aiming to deliver high quality patient centric care. The theoretical underpinnings of these concepts reside in various strands of literature that include health literacy; patient activation; shared decision making; and health information exchanges (HIE). The digitisation of the health and social care record is known as an Electronic Health Record (EHR). Patient held records (EHR-based interventions) are a form of HIE whereby patients have access to their own medical records. There are several types of EHR-based interventions available to health systems. The improvement in information exchange between clinicians and patients has the potential to deliver numerous benefits to patients, care providers and health systems. To this end, various EHR-based interventions have been implemented across the UK, US, and Europe. These play a key role in enabling patients to become more engaged in their own care by providing patients’ access to their medical records.

Conceptually, there are two main motivations for implementing EHR-based interventions: 1) EHR-based interventions empower patients and / or 2) they enable care integration between multiple providers. However, the evidence on the effectiveness of EHR-based interventions is mixed, which presents a challenge to policy makers deciding how best to invest in digital operations when their budgets are constrained. To understand how to procure the most effective EHR-based interventions, an approach that considers EHR-based interventions as ‘complex interventions’ is needed. This ensures that the potential (theoretical) benefits from EHR-based interventions – such as reductions in GP consultations – are well defined before in-depth research is conducted. This level of understanding should support the NHS and other health systems in their pursuit of implementing the most appropriate EHR-based interventions for various local and national settings.

The methodological approach to this research requires a sound evaluation design, data that is collected accurately and then analysed appropriately. These methods may not be readily available to local commissioners of care so this report aims to provide guidance for commissioners who need better information on the effectiveness and potential savings that EHR-based interventions may provide. This should support procurement decisions in this area.

The guidance provided in this report is derived from a working group of commissioners, providers and academics. A systematic search of the literature and narrative review that synthesises current evidence is provided. A practicable framework for prospective and retrospective evaluations of the effectiveness of EHR-based interventions is described for commissioners, healthcare providers and policymakers.
3. Introduction

The NHS faces fiscal pressures stemming from the rising demand for health services in England, with a projected deficit of £22 billion by 2021 (NHS England, 2014). This leaves providers little option but to find savings - typically called efficiency savings - by thinking creatively about service delivery. New models of integrated care involve reducing the demands on primary and secondary care providers by reforming community and social care, or policy innovations such as adopting new processes and / or products that integrate health and social care (King’s Fund, 2017).

At this time of increased pressure, the government aims to raise its effort to digitise the NHS to modernise the health system to ensure it can meet current and future challenges. The National Information Board (NIB) is a collaboration of key health stakeholders, including NHS England. The NIB published the Personalised Health and Care 2020 report, which is a proposal of clear policies to encourage interoperability and integration by harnessing the full potential of accurate information and its exchange between clinicians and patients. For example, the NIB is pursuing methods for patients to have full access to their medical records to “enable [them] to make the right health and care choices”, whilst also giving real time digital information on a person’s health and care to professionals and carers (National Information Board, 2014). The Wachter Review supports this approach and calls health systems to improve ICT system interoperability and functionality of medical records (Wachter, 2016).

Health Information Exchanges (HIE) are a means of improving the flow of appropriate health information to patients and between providers. They aim to address individuals’ needs more precisely to raise the quality and safety of the care they receive. There are several types of HIE, which we summarise in the next section. On the provider side, HIE provide the technological infrastructure to link up information between health and social care organisations by enhancing their access to individual patient records. Similarly, HIE provide patients with a consolidated record of all their health and social care information, creating the opportunity to easily improve, or integrated care. Integrated care is defined by Kodner and Spreeuwenberg (2002) as “a coherent set of methods and models on the funding, administrative, organisational, service delivery and clinical levels designed to create connectivity, alignment and collaboration within and between the cure and care sectors.”

Patients’ access to their health records via HIE has the potential to support individuals’ self-awareness of their health issues and their care management plans. This understanding is integral to ‘health literacy’, which refers to “people’s knowledge, motivation and competence to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life concerning healthcare, disease prevention and health promotion to maintain or improve quality of life” (Sørensen et al, 2012). Similarly, by providing patients with a consolidated record of all their health care information and consequently promoting health literacy, HIE have the potential to vastly improve patient activation, i.e. “the knowledge, skills and confidence a person has in managing their own healthcare” (Hibbard & Gilburt, 2014). Taken together, for health systems transitioning towards integrated care models, the benefits from HIE are a promising solution that may resolve pressures on the system.

The focus of this report is the alignment of information at the patient-provider interface for service delivery. Clinical connectivity and alignment between patients and providers is essential to alleviate information problems between stakeholders. Integration is particularly important for the ageing (over 60s) segment of the population. Population ageing is a major concern because, increasingly, this patient demographic presents with growing disease complexity; patients are presenting with multiple conditions and in multiple provider settings. This elderly patient group is often referred to as high-need, high-cost (Commonwealth Fund, 2016), which is why they are an important target group for HIE adoption.
Health Information Exchanges

HIE are technology platforms that enable patients to access their health and social care records, whilst providing potential for them to coordinate various elements of their own care. HIE can provide better information and data flows between care provider organisations and patients, empowering patients to take greater ownership of their care. As such, HIE aim to share the responsibility for health between patients and providers, which is why they are patient-centric interventions. Coulter & Ellins (2007) suggest that sharing information with patients by simply allowing them to review their medical records – an initiative called patient held records – “can enhance patients’ knowledge and sense of control”, whilst acting as a decision aid to support shared decision making. Patient held records are one type of HIE, which relies on the digitisation of health records for access, hence these are known as EHR-based interventions.

In general, HIE have the potential to reduce care costs and improve population health, but how, where and why they may achieve this is unclear. This limits our ability to implement them effectively. Better evidence will provide this clarity and it is needed to ensure that spending is high-value i.e. health gains are maximised for every pound spent, given all alternatives that commissioners of healthcare could exercise. Making the case for system-wide HIE requires robust policy evaluations of existing local HIE that have been evaluated with respect to their constituent parts. Such evaluations require appropriate study designs and accurate data, which are not always feasible. This report aims to make a first step towards understanding the costs and benefits of HIE, focussing on a new HIE known as the Care Information Exchange (CIE), which was recently introduced in North West London.

Electronic Health Records

Several forms of electronic health record have been evaluated in recent years. Studies have consistently focused on the ability of EHR-based interventions to reduce patient visits to provider organisations; however the strength of study designs is less consistent as many are non-experimental designs, which are less robust. Table 1 provides a full summary of existing evidence.

In an inconclusive systematic review on the effectiveness of EHR, Mold et al. (2015) identified one experimental study from Norway by Kummervold et al. (2004), which found a reduction in GP visits due to the introduction of an internet-based platform for patient-physician interaction. Similarly, in a UK-based experimental study, Ross (2014) found a significant increase in emergency room visits and no change in office visit attendance for heart failure patients associated with the introduction of a web-based EHR. A United States-based non-experimental, observational study by Chen (2009) found a reduction in office visits due to the introduction of EHR and another UK study by Fitton et al (2014) reported a reduction in GP consultations associated with the implementation of patient-held records and a telephone consultation initiative. The quality of physician interactions in light of these interventions has also been studied; in Norway, Andreassen (2006) found that patients who use email communication are better-able to articulate their issues than they would in a face to face consultation. Additionally, evidence exists to show that GP workloads have not been worsened by these forms of patient communication (Liederman et al., 2005). An impact assessment by the Department of Health reported the potential for one saved consultation per patient, per year if they are enrolled on an EHR-based intervention (Department of Health, 2012). Each GP consultation has an estimated cost of £34 (Curtis and Burns, 2015), therefore fewer GP consultations could reduce direct medical costs in the NHS (Bergmo et al., 2005; Andreassen, 2006; Mold et al., 2015).

In light of this evidence, the mechanism by which office visit reductions are achieved has been explored. A Health Foundation report reinforced the importance of self-care, which has the “potential to alleviate the pressure on health and social services caused by workforce shortages, and rising demand for services” (de Silva, 2011) by improving a patients’ ability “to lead a healthy lifestyle; to meet their social, emotional and psychological needs; to care for their long-term condition; and to prevent further illness or accidents” (Barlow et al., 2002; Kennedy, Rogers and Bower, 2007). Again, these mechanisms require further investigation given the limited insight on this.
Taken together, this seemingly promising evidence makes a straightforward case for investing in EHR-based interventions, however this is an overly simplistic assumption because the evidence is overwhelmingly incomplete and uninformative for a few main reasons. As already stated, the quality of the evidence is mixed and, moreover, it is highly context specific. Simply put, the types of intervention and their impact in various care settings is so variable that coherent, justifiable spending decisions using current evidence are difficult to make. The same Health Foundation report (de Silva, 2011) highlights the challenges associated with EHR-based interventions, which have limited (measurable) impact on patient outcomes. Therefore, a degree of standardisation in studying and reporting on EHR-based interventions is needed to improve evidence for policy making, and more rigorous evaluations of EHR-based interventions are needed.

Figure 1. A conceptualisation of EHR-based interventions. Information asymmetries are a market failure in healthcare that technological infrastructure can alleviate. Overall, technologies should improve information exchange between patients and care providers. Whilst perfect information between parties is rarely achievable, HIE (depicted by the blue line) should promote system-wide linkages to this information.
Methodological concepts for evaluating complex interventions

EHR-based interventions must be treated as complex interventions, which means that potential effects are broad in terms of whom, where and when the intervention effects will occur. A sound understanding of the theoretical effects of the intervention in various settings is required to understand the causal effects of an intervention. These links can be articulated as effects on patients, care providers and national health systems, which can then be empirically tested by comparing measurements made before and after introduction (Moore et al., 2014). This is one methodological approach to ensuring associations between the introduction of interventions and subsequent effects are causal i.e. improvements in patient health and care are due to the intervention. According to recent guidance, a process evaluation of complex interventions should use systematic approaches to the evaluation design, drawing on descriptions of intervention theory and identifying key process questions (Moore et al., 2014). These principles should be adopted to accurately measure health and economic outcomes.

Economic evaluation is a general term for studies that compare the economic impact of two or more available interventions. Two main types of economic evaluation are cost-effectiveness analysis and cost-benefit analysis (CBA) – the former compares economic outcomes in terms of a monetary cost for health and / or quality of life gains, the latter expresses outcomes in terms of the monetary benefits attributable to interventions. Both forms of economic evaluation require estimates of the effectiveness of interventions and the costs produced by each.

In summary, to limit bias in the study of HIE and EHR-based interventions, a powerful study design treats these as complex interventions with several theoretical benefits that should be measured empirically using economic evaluation methods. This study design should be used by policy makers and care providers, in collaboration with product developers, to develop solutions that achieve health system savings and improve the quality of care patients receive in the near and long-term. As we show in the following sections of this report, the literature on the effectiveness of EHR-based interventions is relatively immature because associations between the introduction of interventions and subsequent effects are, overall, limited. This suggests that more methodological guidance is needed.

4. Research aim and objectives

Complex interventions have a variety of potential effects. This adds difficulty to the exercise of finding reliable associations between the introduction of an intervention and attributing changes in care (effectiveness) to it.

Research Aim

To develop an evidence-based framework to estimate the economic impact of CIE.

Objective 1

Characterise the scope and quality of existing cost-effectiveness analysis literature relating to EHR-based interventions.

Objective 2

Develop a practicable framework to support cost-effectiveness analyses of EHR-based interventions. This should indicate the potential return on investment to local health economies.
5. Building an Evaluation Framework

This section is split into two sections to describe how the cost-effectiveness framework was developed:

1. Literature Review
2. Developing the framework

Literature Review

The aim of this review was to 1) identify the theorised impacts associated with EHR-based interventions, 2) determine what measures of effectiveness and cost are commonly used and 3) appraise the current quality of evaluation research performed.

Methods

Search strategy
A systematic search of the literature published between 2007-2016 was performed on Google Scholar’s, and the Health Management Information Consortium (HMIC) databases. Search terms used were “Health Information Exchange”, “HIE”, “Patient held records system”; “Personal Health Record”; “EHR-based interventions”; “patient portal”; “electronic health records”; “cost effectiveness”; “economic evaluation”; “cost-benefit analysis”; “CBA”.

Study selection criteria and risk of bias assessment

Studies were included if they: a) involved interventions using EHR, b) had an outcome related to associated benefits or costs; c) considered United Kingdom-, United States- or Europe-based studies. All eligible studies were reviewed to appraise their risk of bias according to the Cochrane Collaboration’s risk of bias tool.

Data extraction strategy and synthesis

The information from included studies was abstracted into a standardised computed-based form. Collected information included: first author, date, type of participants, study type, intervention and outcomes assessed.

Results

The database search retrieved 1277 citations. Their titles and abstracts were screened according to a) intervention type, b) economic evaluation design and c) presence of an objective measure of impact or effectiveness. After screening, 10 papers were included. For meta-analysis, individual studies were separately analysed for data extraction and synthesis purposes, resulting in a total number of 15 papers (Figure 2).
Description of included studies

The 15 studies included involved participants from diverse health care settings, including primary care (n=9), hospitals and community-based practices (n=3), outpatient services (n=1), internal medicine patients (n=1) and chronic heart failure patients (n=1) (Table 1). All studies were experimental in nature: five randomised controlled trials, five retrospective cohort studies, two quasi-experimental, two cluster randomised trials and one case control study.

EHR-based interventions

EHR-based interventions were diverse and often included multiple approaches. Online access to medical records (n=8) and online patient-provider communication systems (n=8) were the most utilised interventions, either isolated or as part of a more complex intervention with other components. Health maintenance reminders were used in two studies. Table 1 presents a detailed characterisation of the various interventions.

Measures and comparisons

The measures assessed included: a) number of consultations, b) safety aspects (identification of medication discrepancies) and c) self-efficacy. A detailed overview of the measures evaluated is presented in Table 1.
**Number of consultations**

The impact of EHR-based interventions on the number of face-to-face consultations has inconsistent results amongst studies. While five authors report an overall reduction on the total number of face-to-face consultations (Nagykaldi, 2012; Bergmo, 2005; Zhou, 2007; Chen, 2009; Fitton, 2014), one study failed to detect any differences (North, 2014) and two others detected an actual increase (Delbanco, 2012; Palen, 2012). Similarly, the effect of EHR-based interventions on the number of telephone consultations also varied between studies: while three reported an increase of the total number (Palen, 2012; Zhou, 2007; Chen, 2009), others reported either a decrease (Fitton, 2014) or absence of effect (Katz, 2004; Fairhurst, 2008; Lin, 2009). The three studies evaluating the impact of EHR-based interventions on the number of A&E admissions consistently reported an increase on the total number of encounters (Palen, 2012; Chen, 2009; Ross, 2004).

**Safety**

In the only study assessing the impact of EHR-based interventions on safety aspects (Schnipper, 2012), an increase on the identification of medication discrepancies was observed.

**Self-efficacy**

In included studies, EHR-based interventions consistently improved medication adherence or perceived adherence (Delbanco, 2012; Jackson, 2014; Ross, 2004). Amongst the studies evaluating the effect on perceived self-efficacy (Jackson, 2004; Ross, 2004), only one reported an increase (Jackson, 2014). EHR-based interventions have consistently increased the uptake of preventative care services (i.e. immunisation (Wright, 2012; Nagykaldi, 2012) and breast cancer screening (Wright, 2012)).
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Participants</th>
<th>Study type</th>
<th>Intervention(s)</th>
<th>Measure(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schinpper et al, 2012</td>
<td>Primary care setting</td>
<td>Case control</td>
<td>Online access to EHR</td>
<td>↑ Identification of medication discrepancies</td>
</tr>
<tr>
<td>Delbanco et al, 2012</td>
<td>Primary care setting</td>
<td>Quasi-experimental study</td>
<td>Online access to EHR</td>
<td>↑ Medication adherence ↑ Number of face-to-face consultations</td>
</tr>
<tr>
<td>Wright et al, 2012</td>
<td>Hospitals and community based practices</td>
<td>Cluster randomised trial</td>
<td>Prevention / health maintenance reminders</td>
<td>↑ Uptake of preventative care services</td>
</tr>
<tr>
<td>Nagykaldi et al, 2012</td>
<td>Primary care setting</td>
<td>Cluster randomised trial</td>
<td>Prevention / health maintenance reminders</td>
<td>↑ Uptake of preventative care services ↓ Number of face-to-face consultations</td>
</tr>
<tr>
<td>Palen et al, 2012</td>
<td>Hospitals and community based practices</td>
<td>Retrospective cohort study</td>
<td>Online access to test results</td>
<td>↑ Number of face-to-face consultations ↑ Number of out-of-hours consultations ↑ Number of A&amp;E visits ↑ Number of hospitalisations ↑ Number of telephone consultations</td>
</tr>
<tr>
<td>Bergmo et al, 2005</td>
<td>Primary care setting</td>
<td>Randomised controlled trial</td>
<td>Online messaging system</td>
<td>↓ Number of face-to-face consultations</td>
</tr>
<tr>
<td>Zhou et al, 2007</td>
<td>Hospitals and community based practices</td>
<td>Retrospective matched control cohort</td>
<td>Access to EHR with secure messaging system</td>
<td>↑ Number of face-to-face consultations ↑ Number of telephone consultations</td>
</tr>
<tr>
<td>Katz et al, 2004</td>
<td>Primary care setting</td>
<td>Randomised controlled trial</td>
<td>Online patient-provider communication system</td>
<td>No effect on the number of telephone consultations</td>
</tr>
<tr>
<td>Fairhurst et al, 2008</td>
<td>Primary care setting</td>
<td>Randomised controlled trial</td>
<td>Texting appointment reminders</td>
<td>No effect on the number of telephone consultations</td>
</tr>
<tr>
<td>Lin et al, 2005</td>
<td>Internal medicine patients</td>
<td>Randomised controlled trial</td>
<td>Online patient-provider communication system</td>
<td>No effect on the number of telephone consultations</td>
</tr>
<tr>
<td>Ross et al, 2004</td>
<td>Chronic heart failure patients</td>
<td>Randomised controlled trial</td>
<td>Web-based EHR, educational guide and messaging system</td>
<td>No effect on self-efficacy ↑ Adherence ↑ Number of A&amp;E visits</td>
</tr>
<tr>
<td>Chen et al, 2009</td>
<td>Outpatient setting</td>
<td>Retrospective observational study</td>
<td>Health information system including EHR, secure patient-provider and interprovider messaging system</td>
<td>↓ Number of ambulatory office visits ↑ Number of scheduled telephone visits ↑ Rate of urgent care visits</td>
</tr>
<tr>
<td>Jackson et al, 2014</td>
<td>Primary care setting</td>
<td>Quasi-experimental</td>
<td>Caregiver's access to medical notes</td>
<td>↑ Ambulatory care experience ↑ Perceived self-efficacy ↑ Perceived adherence</td>
</tr>
<tr>
<td>North et al, 2014</td>
<td>Primary care setting</td>
<td>Retrospective cohort</td>
<td>Messaging portal</td>
<td>No effect on the number of face-to-face consultations</td>
</tr>
<tr>
<td>Fitton et al, 2014</td>
<td>Primary care setting</td>
<td>Retrospective observational study</td>
<td>Online access to EHR</td>
<td>↓ Number of office visits ↓ Number of telephone contacts</td>
</tr>
</tbody>
</table>
Risk of bias assessment

Authors did not mention protocol registrations in most of the studies, which made the ‘selective reporting’ domain difficult to assess. Additionally, aspects relevant for the assessment of outcome data were seldom detailed (Table 2). Most studies had, at least for one domain, an elevated risk of bias according to the Cochrane Collaboration’s risk of bias tool, highlighting the immature nature of the evidence available.

Table 2. Assessment of the risk of bias for the included studies. Risk of bias was classified and colour-coded in red (high risk), yellow (medium risk), green (low risk) or grey (non-applicable/insufficient information).
Measurable Benefits and Effectiveness Rates

For this framework, we extracted proxy measures for effectiveness from the available literature. These measures of effectiveness are the foundation for comparing health and economic outcomes before and after EHR-based interventions are introduced.

Some studies suggest that EHR-based interventions can reduce the total number of face-to-face consultations. According to Chen et al, access to EHR reduced the total office visit rate, adjusted primary care office visit rate and the adjusted specialty care office visit rate, respectively, by 26.2%, 25.3% and 21.5% (Chen, 2009). Fitton et al estimate that, assuming a consultation rate of 5.3% annually, an EHR-based intervention would promote a release of about 11% of appointments per year, with significant resource savings (Fitton, 2014). Similarly, Bergmo et al (2005) and Nagykaldi et al (2012) also found reductions on the total number of face-to-face consultations (-22.3% and -33.0%, respectively). One study could demonstrate a reduction in the number of telephone calls (less 255 to 325 per year) (Fitton, 2014).

A particularly relevant study, performed in the UK by Fitton et al (2014), evaluated the impact of patient record access on appointments and telephone calls in two English general practices. An overall reduction of the total number of appointments (n=110, n=212) and telephone calls (n=325, n=255) was observed in both practices. In a cost-benefit analysis, Fitton et al estimate that if 30% of patients accessed their medical records at least twice a year, a 10 000-patient practice would save 4747 appointments and 8020 telephone calls per year, with per-patient savings ranging between £29.08 and £44.39.

As previously mentioned, it is important to note that inconsistent results were found in other studies. Palen et al reported a significant increase in the per-1000-member rates of after-hours clinic visits (+18.7 per 1000 members per year; 95% CI, 12.8-24.3; p<0.001), emergency department encounters (+11.2 per 1000 members per year; 95% CI, 2.6-19.7; p =0.01), and hospitalisations (+19.9 per 1000 members per year; 95% CI, 14.6-25.3; p<0.001) for users versus non-users.

These inconsistencies may be partially explained by the immaturity of the available literature (as previously assessed by the risk of bias tool, see Table 2) and by the heterogeneous nature of the health care settings where the interventions took place. Despite the dearth of economic evaluations in this area and from the perspective of the NHS, these trends provide a preliminary assessment where, how and by how much EHR-based interventions impact health and economic outcomes.

Developing the framework

Only a few economic evaluations of EHR-based interventions were identified in the literature and of those, Cost-benefit Analysis were the preferred method of evaluation.

The literature search provided a systematic means of identifying the potential impacts of EHRs. These are summarised in Table 1.

The effectiveness rates were the most challenging to find, however, within the constraints of the limited data available, we can use these to determine the likelihood of a benefit occurring and attributing a cost to it. The difference between the money saved from the benefit, and the money spent on implementation will derive an efficiency saving in financial terms.

The process of conducting an economic evaluation of an EHR is represented in Figure 3 below, which demonstrates the process: from outlining the current position with baseline data, to understanding the needs of the population, through to capturing of the costs (inputs) and the benefits (outputs).

Sheill et al’s (2008) article commenting on the implications complex interventions have on the economic evaluations, highlighted how deep the challenges are. Though this paper is akin to analytical opinion piece, it is helpful in laying out some basic principles. They note that such interventions have active elements which themselves are subject to variations, for example, staff characteristics; management protocols; clinical practice, but, they specify the importance of teasing outcomes with clarity such that changes in resources can be measured. Furthermore, they also opine “no new economic methods are required, and the problems can all be solved with time, effort, and resources”. This supports the rationale for undertaking an economic evaluation.
Establishing baseline performance

Baseline measures of population health, costs, and utilisation rates are needed to decide on the type(s) of intervention that are needed to achieve target performance. The baseline is also needed for comparison before and after the implementation of interventions. The following information is needed to establish the causal effect of an EHR-based intervention:

1. **Patient utilisation data:** for primary or secondary care, to indicate where there is pressure on the system. This illustrates the needs of the population and tells us where the potential efficiency gains are. For example, how often patients interact with their GP or have unplanned admissions to hospital.

2. **Unit cost of each interaction:** each GP consultation and hospital admission has a cost attached (Curtis and Burns, 2015b). This illustrates how much could be saved with each unnecessary contact with the health service.

3. **Cost of implementing the intervention:** the initial set-up costs for the innovative technology and running costs once implemented. This might include the cost of software, staff costs or the costs of changing existing processes. This illustrates the immediate financial burden on the CCG, and it is against this that any potential future savings must be weighed.

**Inputs**

Each element of implementation will have a cost attached, which should be discussed with the implementing team. The number of patients is derived from the data discussed in the methodology section. Recurring costs may not apply to all elements, but include software licenses, and staff administration.

**Outputs**

The outputs are split into short, medium, and long-term outcomes as benefits in the short- and long-run will mature at different rates. As such, commissioners should expect returns on investment at separate times and in different settings.

**Challenges to measuring value**

This leads to the limitation of economic evaluations more generally. It is challenging to add monetary values to hypothesised benefits because these benefits may be tangible or intangible and therefore more or less easily estimated, causing measurement error(s). Many of the potential benefits identified through the literature review process were excluded as it is difficult to estimate a monetised value, such as behaviour changes from accessing medical notes. Because of these exclusions, the cost benefit analysis implicitly places greater weight onto benefits and costs that are quantifiable and therefore more reliably monetised.
6. Discussion and key messages

Main Findings

Benefits of EHR-based interventions

Ultimately, implementing EHR-based interventions can yield some positive outcomes for both patients and for the public purse, however, interventions should be deployed with careful consideration. Whilst EHR-based interventions are a tool for integration and align with the shift towards digitisation and patient-centred care, the crucial factor is whether it is being delivered in the right service. CCGs need to do the analytical groundwork to ensure they know whether their benefits do outweigh the cost of delivery in each case.

Many of the benefits of EHR-based interventions go beyond the cost saving potentials. The objective of implementing EHR-based interventions should not only be its potential for cost-saving, but the potential it has on improving patient information. Information asymmetry exists in many forms between doctors and patients. Angela Coulter’s paper on Effectiveness of Strategies for Informing, Educating, and Involving Patients highlights the absolute importance of information as a tool of empowerment. She states that “if people cannot obtain, process, and understand basic health information, they will not be able to look after themselves well or make good decisions”. Furthermore, those with low health literacy are in a worse health status and are more likely to be admitted to hospital. Though her paper deals generally with the power of information as an educational and empowerment tool, along with the cornucopia of benefits, such as improved patient safety, improved management of long term care, improved patient experience (to name but a few) she briefly touches upon the role of patient held records as a tool that “can enhance patients’ knowledge and sense of control”.

To illustrate the importance of noting the specific facilities offered by EHR-based interventions, Mold found a difference in the number of times a patient visited a GP depending on whether they communicated with a clinician, and whether they viewed test results online. Patients who communicated with their clinician correlated with a reduction in overall office visits (9.7-10.3% reduction), whereas patients who viewed online results and communicated with their clinician saw an average increase by 0.7 visits per year (Mold et al., 2015). The former can be explained by Andreassen and Bergmo’s findings, who saw patients use online communication in lieu of visiting face to face. Moreover, the online communication service allowed patients to carefully consider their questions and thoughts, further preparing them for future consultations. However, since communication is online, the informality has proven in this study to be a double edge sword as on the one hand, informality can make patients feel less anxious, but on the other hand, informality married with an error (such as using the wrong patient name as had occurred in one case), can alter the relationship entirely (Bergmo et al., 2005; Andreassen, 2006). The latter can be explained through asymmetric information. Providing patients with their online test results without supporting information is likely to cause consternation amongst patients who lack the training needed to interpret information. This could lead to an increase in visitations.
**Inputs and Activities**

The cost of implementing the Care Information Exchange (CIE) was requested. These items represent input costs for the first investment year for the CIE, encompassing all relevant activities. Other resources such as staff time to manage the system in subsequent years are not included here, but in a comprehensive economic evaluation these should be considered and further study and / or audits are required to estimate these direct costs. The estimates received are presented in the table below:

<table>
<thead>
<tr>
<th>Implementation</th>
<th>£320,000.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>£250,000.00</td>
</tr>
<tr>
<td>Build</td>
<td>£310,000.00</td>
</tr>
<tr>
<td>Test</td>
<td>£160,000.00</td>
</tr>
<tr>
<td>Training</td>
<td>£120,000.00</td>
</tr>
<tr>
<td>Hardware</td>
<td>£30,000.00</td>
</tr>
<tr>
<td>Evaluation</td>
<td>£139,000.00</td>
</tr>
</tbody>
</table>

Stephen Janering (Imperial College Healthcare NHS Trust ICT) provided the data used to estimate inputs and activities in Section 5.

**Outputs and Outcomes**

Outputs are the intermediate products between inputs, activities and health outcomes.

For instance, the implementation of CIE involves the input of the technology infrastructure, made available to patients for remote access. The activities that follow include patient training on the CIE system, which leads to patient activation - the output. The number of activate patients within a population is an important metric for expressing causal effects therefore. If the ratio of patients activated increases over time, and the health outcomes of interest (such as A&E attendances) fall in a similar pattern, then we can infer a causal link between the inputs, activities, outputs and the outcomes.

An activated patient should become more health literate and this should translate into short, medium and long-term health outcome improvements. It follows that these improvements should lead to economic benefits. The evidence base for these benefits is immature and this framework is needed to consolidate existing evidence and support the development of future evidence. For instance, a previously published UK-based study by Fitton et al. (2014), suggests that there might be an association between patients accessing their medical records and a reduction in GP consultations. The framework contextualises that study of outputs and outcomes, understanding gaps in the design and causal effects.

**Evaluation framework**

Economic evaluations of complex interventions such as EHR-based interventions require careful articulation of the inputs, activities, outputs and outcomes associated with them. The reasoning behind using an evaluation framework is to ensure that changes in health and economic outcomes of interest can be attributed to the EHR-based intervention itself. This is important for commissioners seeking to make value-based investments in technology.

A clear understanding of baseline data, such as illness burden and patient sociodemographic characteristics should be studied over time to understand which elements of a prospective EHR-based intervention system are likely to yield the most benefit. Moreover, it is a tool that forces the decision-maker to determine whether the service they have chosen to implement EHR-based interventions is appropriate, and if so why, and to what extent.

The framework can be used to evaluate the budgetary impact of investing in EHR-based interventions and for creating a business case for investment. The business case is separate to the economic evaluation because it does not consider the health impact of the intervention and reflects the expected financial position of regional commissioning groups from investing in EHR-based interventions.

**Limitations**

The conceptual toolkit relies on the availability of data from the CCG. To understand where EHR-based interventions are most needed, knowing where the immediate priorities are essential, for example, which care setting has highest patient utilisation. In lieu of such data, the toolkit could refer to a next-best source that could be an alternate service, however, given it is tailored to a patient population, the outputs may become irrelevant.

The limited data on effectiveness rates is a limitation as this has not provided effectiveness data that is completely relevant to the NHS (see below recommendations).
7. Health Policy Implications

Integrated care

Efforts to integrate care in the NHS are starting to materialise. Fragmented models of care have been addressed by the Health & Social Care Act of 2012 (DH, 2012) with the advent of Clinical Commissioning Groups (CCGs) who are beginning to work together in regional groups to address population health concerns in a coherent way. Much of this work has been supported by local Sustainability and Transformation Plans (STPs) (Alderwick et al., 2016).

In Manchester and Cornwall (McKenna and Dunn, 2015), the public sector is experimenting with local devolution and pooled budgets. This approach recognises that public services work best when focused around people rather than silo organisational boundaries. With these organisational structures evolving, CCGs are more able to tailor their services to patient needs by creating patient-centred integrated care. As this evaluation framework highlights, there is considerable complexity involved in achieving integrated care, especially because patients’ health needs are becoming increasingly complex. The number of providers needed to manage high-need and high-cost patient continues to rise and with that, the potential for information failures also rise. Sound information management between all providers, and coordinated by primary carers is needed and technologies that enable the confidential sharing of data about patients should be valuable to health systems seeking efficiency.

The impact of HIEs need to be systematically measured to determine where, how and to what extent we can attribute the features of HIEs to better integration of care and a commensurate improvement in the efficiency of care delivery.
8. Recommendations

Appropriate deployment

Patient held records are not a magic bullet policy response to a health system that is vastly under pressure. It is a policy tool that should be deployed given the right circumstances. Treating EHR-based interventions as complex interventions, by considering the variables within the surrounding context, can improve its effectiveness. The widely cited Colorado Kaiser Permanente (KP) (Palen et al., 2012) case study, which found an increase in patient utilisation after implementing an EHR-based interventions system is illustrative of the care required in determining the appropriate context. The KP case study is in fact an example of what happens when 1) implementing an EHR-based interventions system without understanding patient needs, and 2) providing patients with current information. It was hypothesised that patients accessing their medical records were prompted to seek out healthcare owing to current information gained through the EHR-based interventions. This is compounded with the fact that those who signed up were most likely to be already concerned with their care. This does not appear to be a surprising outcome, and a recommendation to ensure this is resolved is to ensure that CCGs actively promote a wider usage of EHR-based interventions as a tool for self-management to all patients, rather than to those who are already high need. This acts as a preventative measure, warming patients up to a new concept of accessing medical records.

For organisations such as NHS England and the Department of Health (DH), it is important to know that EHR-based interventions are a step in the right direction, by reducing per patient costs, improving population health and patient experience. Improving patient health literacy, patient activation, satisfaction and self-care – all which EHR-based interventions can do – are good for patient outcomes, and they should not disregard these reasons for encouraging widespread use.

Analytic capability in the NHS

On a national scale, central government policies are subject to rigorous impact assessments that demonstrate whether policies have a positive impact and are an effective use of public funds (HM Treasury, 2003). Local CCGs have limited resources to both deliver national policies as well as ensuring they deliver bespoke services for their local populations. CCGs do not have the same economies of scale as their larger Primary Care Trust predecessors, and often do not have direct access to analytic or economist support.

This can mean there is a gap in understanding the real impact of local policy decisions. National and local movements towards digitising the NHS will undoubtedly have cost attachments, which could seem counterintuitive to commissioners operating within a stretched budget. Therefore, it is important for CCGs to carry out impact assessments to understand whether interventions are worthwhile. Investment in innovative technology and interventions, whilst costly, could yield a handsome return in efficiencies.

Cost effectiveness analyses support public sector organisations to understand the value of their investment. On a local level, the NHS can lack the economic expertise to assess whether interventions offer fair value for money. An economic toolkit is needed to support commissioners’ investment decisions.

Given EHR-based interventions are a complex intervention, analytical capabilities must be enhanced in CCGs to ensure the right data and information is feeding the decision to invest in an online digital service. Whilst HES could be an important proxy for measuring patient utilisation, a more accurate portrayal of patient activity is needed. Live data illustrating where the hotspots of usage are can greatly inform CCGs as to where best to deploy EHR-based interventions.

Further Research

We recommend a continuation of the strong relationship with organisations such as Imperial College Healthcare NHS Trust to monitor the effectiveness of CIE as the service continues to roll out. More robust data is needed to make reasonable assumptions about the returns on investment in terms of health and economic gains to the NHS. If collected, this initiative has the potential to shape policy decisions in this area for the UK and abroad. The framework developed is an essential first step to ensuring that the methods of assessment are well articulated and reproducible. This reproducibility is needed to ensure that future research is credible and innovative.
9. Funding
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10. Acknowledgements
We are grateful to Stephen Janering (Imperial College Healthcare NHS Trust ICT) for providing the data used to estimate inputs and activities in Section 5.

11. Sowerby eHealth Forum Evaluation team
12. References


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