Canada Health Infoway

The emerging benefits of electronic medical record use in community-based care

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Executive Summary

This is a full report of a 2013 commissioned study by Canada Health Infoway (*Infoway*), authored by PwC, and is available in English only. An executive summary version of this report can be accessed from *Infoway*'s resource centre at www.infoway-inforoute.ca in English and French.

Contents

List of Tables

List of Figures

1.0 Introduction and Context

Health care systems across the globe are undergoing transformations to improve access and quality of care, value for money, and the patient experience.[1] In Canada, there has been an ongoing focus on improving access to and quality of community-based care as the foundation of a strong health care system. Electronic Medical Records (EMRs) are an integral enabler of these improvements with the potential to transform the delivery of care. Over the past six years in Canada, the adoption of EMRs by primary care physicians has more than doubled from 23% in 2006 to 56% in 2012 (CWF, 2006; CWF, 2012, Schoen et al., 2012). The adoption of EMRs by community-based specialists has also increased from 28% of physicians in 2007 to 41% in 2010 (National Physician Survey, 2010). Despite these gains, the use of EMRs in primary care in Canada lags behind that of many other countries - Australia, New Zealand, the United Kingdom and the Netherlands all report use of EMRs by over 90% of their primary care physicians (Schoen et al., 2012).

Since 2010, Canada Health Infoway (*Infoway*) has been supported by the federal government to focus on accelerating the adoption of EMRs. *Infoway's* objective is to "co-invest with the provinces and territories to support their efforts to significantly increase the number of clinicians adopting and using an EMR system."[2] *Infoway* defines an EMR as "a computer-based medical record specific to one clinician's (e.g. physician) practice or organization. It is the electronic record clinicians maintain on their own patients, and which details demographics, medical and drug history, and diagnostic information such as laboratory results and findings from diagnostic imaging. It is often integrated with other software that manages activities such as billing and scheduling." The increase in adoption has been supported to a large extent though investments by the provinces' and territories' EMR programs, clinician practices, and *Infoway*.

Infoway commissioned PwC to conduct a Benefits Evaluation Study ("the Study") to determine the current and emerging effects of implementing EMRs in community-based practices in Canada. Within scope for this Study was an assessment of the effects of EMR use by family physicians and specialists (medical and surgical), and their clinical and administrative teams who work in private offices or clinics, community clinics and community health centres, and free-standing walk-in clinics. Several critical contextual factors must be taken into consideration in order to understand the wider environment within which this work was undertaken. Perhaps most important is that EMRs are more than simply an additional tool to support care; EMRs fundamentally change the work, productivity and processes in community-based practices, and facilitate enhanced delivery of care. Resource-intensive administrative tasks and activities that relied on manual coordination in paper-based practices can now be completed with relative ease through the use of an EMR. Patient diagnostic and treatment data is consistently legible for all care providers and offers the benefit of a longitudinal existence, informing quality of care and continuous improvement, and proactive outreach for preventive or follow-up care. Interprofessional and provider-to-patient communications and exchange of information can be done more efficiently.

Despite the significant gains in adoption over the past six years, it is still early in the Canadian EMR journey and there remains much to be learned and accomplished. While some benefits are already being realized, there are many others which are still only seen by early adopters of more advanced functionality, and that will only be evident within the context of a more fully mature environment of EMR use. This is true in Canada and other countries, all of which see variations in how EMRs are used and have EMRs with differing functions. For example, some benefits will only accrue with training, experience and the availability and use of specific EMR functions and system interoperability (e.g., electronic prescribing that is integrated with community-based pharmacies). Also, it must be recognized that the impacts and benefits of EMRs will be realized differently by various stakeholders. For example, primary care providers and community-based specialists will achieve benefits related to productivity and workflow; patients may experience greater satisfaction with their engagement with the health system when their

[1] The Commonwealth Fund. (2011). International Profiles of Health Care Systems, 2011.
[2] Canada Health Infoway (2012). EMR Deploy Program Overview, July 18 2012 [PowerPoint Presentation].

care provider's EMR brings together information from other providers and care encounters; and the broader health care system may reap the benefits of enhanced preventive care and cost avoidance.

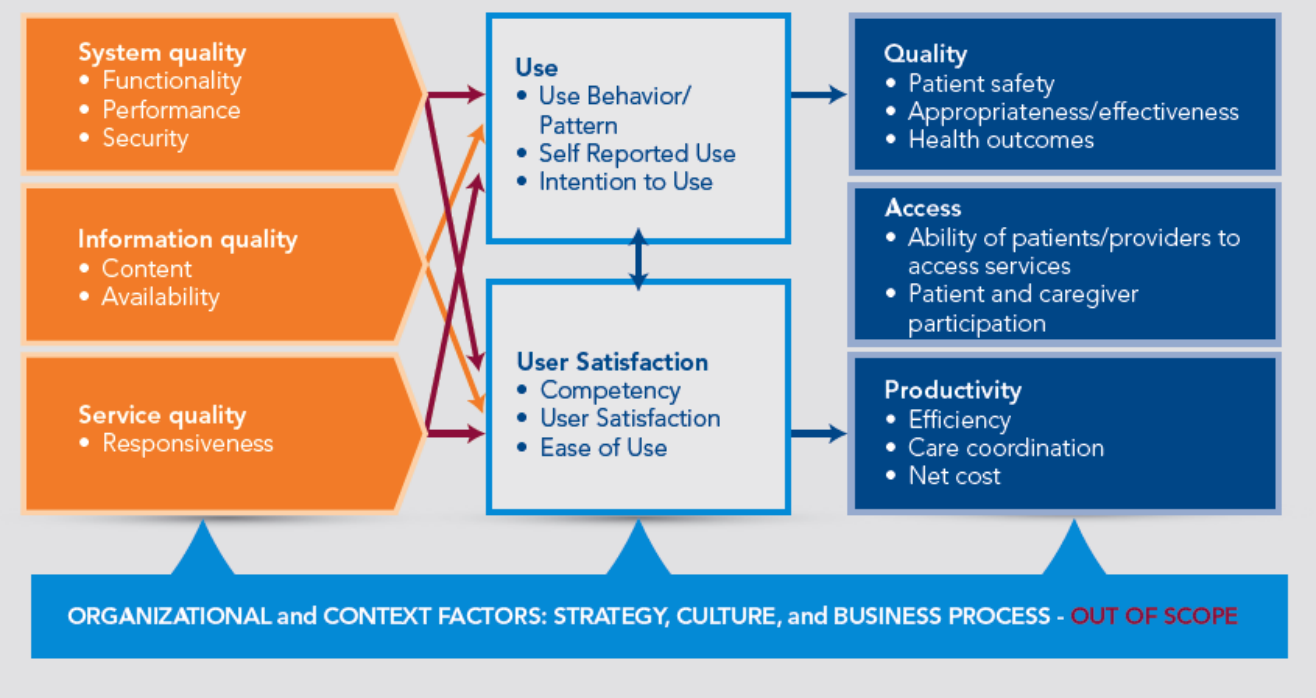
The benefits articulated in this Study are a reflection of the research and evidence currently available and are intended to be illustrative of the current and emerging effects of EMRs in primary care and community-based specialist settings. This report presents the Study findings in their entirety as follows:

- *Section 2*: *Approach* outlining the quantitative and qualitative approach used in the development of the EMR benefits model
- *Section 3: Benefits of EMR Use* presenting the current and emerging benefits from EMR adoption and use
- *Section 4*: *Priority Research Areas* outlining recommended future areas of research
- *Section 5*: *Facilitators and Barriers to EMR Adoption and Use* describing some of the critical success factors indicated to facilitate adoption and advanced use
- *Section 6*: *Recommendations* outlining key actions to be taken in order to realize potential benefits
- *Section 7*: *Conclusion*

2.0 Approach

The approach taken to complete this Study was generally guided by *Infoway's* Benefits Evaluation Framework which provides an evidence-based model to guide evaluations to assess benefits related to quality, access and productivity as described in Figure 1.[3,4] With this foundation, and further qualitative and quantitative analysis, current and emerging benefits were hypothesized.

Figure 1: Infoway Benefits Evaluation Framework



Based on the Delone & McLean IS Success Model

2.1 Stakeholder Engagement and Validation

Throughout this Study, internal and external stakeholders were engaged to validate the approach and findings. At the outset, *Infoway* established several structures, including an Advisory Panel and two internal governance structures. The Advisory Panel was comprised of jurisdictional representatives, clinicians and representatives of associations and colleges. Additional stakeholders (jurisdictional contacts, clinicians, representatives from associations and organizations, and academics) were also engaged throughout the Study. A summary of this engagement is described in the following table:

[3] Canada Health Infoway in collaboration with eHealth Observatory (2012, April). Canada Health Infoway Benefits Evaluation Indicators: Technical Report Version 2.0.

[4] Lau, Hagens and Muttitt (2007). A Proposed Benefits Evaluation Framework for Health Information Systems in Canada. *Healthcare Quarterly 10(1), 112-118.*

Table 1: Stakeholder Engagement Groups

Stakeholder	Engagement
Advisory Panel	• Validated jurisdictional scan and literature review findings • Validated model development and interim benefit estimates • Reviewed and validated final benefit model and estimates • Reviewed and validated the draft Report
Physician Reference Group (standing committee)	• Reviewed benefit estimates (led by Infoway)
Infoway Clinical Council (standing committee)	• Reviewed approach and general findings (led by Infoway)
Canadian researchers	• Provided feedback on the application of their research findings in the benefit model
Jurisdictional Leads	• Reviewed and validated draft Report
Key Informants	• Reviewed and validated draft Report and findings
Steering Committee (Infoway staff)	• Provided overall guidance to model development approach and context of findings • Reviewed and validated draft Report
Working Group (Infoway staff)	• Validated jurisdictional scan and literature review findings • Validated model development and interim benefit estimates • Reviewed and validated final benefit model and estimates • Reviewed and validated draft Report

Please refer to Appendix A for a list of Working Group and Advisory Panel members.

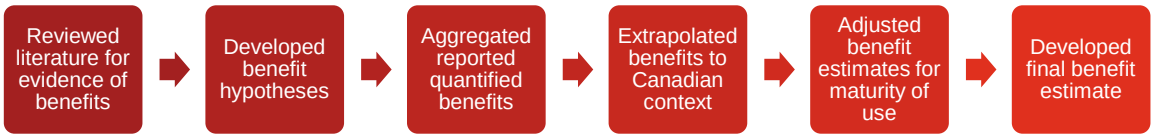
PwC also interviewed jurisdictional leads in order to determine progress and activities related to the use of EMRs across the country. This input further informed the Study's development.

2.2 Model Development Methodology

The development of the benefit estimates was an iterative process informed by multiple inputs (Figure 2). Hypotheses were initially developed based on Infoway's Benefits Evaluation Indicators Technical Report V2.0

(refer to Appendix B for a summary of the EMR Indicators) and further refined based on the findings from the literature review.[5] The hypotheses were quantified based on research and data provided in the literature, and where possible, extrapolated to the Canadian environment. Lastly, each benefit estimate was adjusted to reflect maturity of use of EMR functionalities or EMR data (i.e., the percentage of physician practices for whom benefits accrue).

Figure 2: Approach to Developing the Benefits Estimate Model



2.2.1 Literature Review and Hypotheses

In support of the development of the hypotheses and in order to quantify benefits, a scoping literature review and environmental scan were conducted by Infoway.

With the support of *Infoway's* Master of Library and Information Sciences staff with a specialization in health and health information and communication technologies, English-language articles published from 2000 through to May 2012 were searched via multiple databases and websites. Search terms were developed in two categories: i) benefits of EMRs for physicians, and ii) impacts of EMRs in primary care on practice productivity and efficiency. A search was conducted for articles that included medical subject headings (MeSH) terms or keywords including: electronic health records, cost-benefit analysis, cost savings, workload, quality of life, patient care management, efficiency, organizational, office management, organizational case studies, general practitioners, and primary health care. PubMed was consulted using a variety of search teams including: electronic medical records (EMR), practice workload, patient management, return-on-investment (ROI), administrative time savings, operational costs, operational savings, physician time savings and case studies. In addition, Canada Health Infoway's Virtual Library, a database of over 2,000 selected articles, e-documents, research-based literature, evidence and best practices on eHealth topics published by over 350 authoritative sources was also consulted. A targeted search of Canadian and international health and health administration websites rounded out Infoway's approach, including: Canadian EMR physician office organizations (e.g., OntarioMD, the Physician Information Technology Office, and the Physician Office System Program) and agencies such as the Canadian Medical Association, the Agency for Healthcare Research and Quality, the Healthcare Information and Management Systems Society, Commonwealth Fund, California HealthCare Foundation, American Medical Association, Congressional Budget Office (CBO), RAND, Booz Allen Hamilton, and the Organisation for Economic Co-operation and Development (OECD).

This search strategy yielded more than 250 relevant information sources which included peer-reviewed literature, publicly-available EMR Benefits Evaluation projects conducted by Canadian jurisdictions or university-based researchers, and grey literature materials. In general, information reviewed was predominantly from grey literature and peer-reviewed literature studying the U.S. health system. Notably, limited Canadian evidence was available. The literature search was updated in October, 2012 to include additional areas of research in alignment to each of the hypotheses developed during the course of the Study. The literature review was further augmented by additional data sources which included:

- *Infoway* funded research and evaluations (e.g., Physician Value Study, The Population Health Management Challenge, National Impacts of Generation 2 Drug Information Systems, EMR Integrated Labs Workflow Evaluation);

[5]Canada Health Infoway in collaboration with eHealth Observatory (2012, April). Canada Health Infoway Benefit Evaluation Indicators: Technical Report Version 2.0.

- Surveys (e.g., Commonwealth Fund Survey (2006, 2009, 2012), National Physician Survey (2007, 2010), and provincial surveys); and

- Over 20 key informants from across Canada.

To inform the development of the model, the literature and data were reviewed for alignment with benefit area themes. Where relevant, data were extrapolated and included in the model.

The use of different terminology for the point of care electronic medical records in community-based care by different jurisdictions must be noted. What is referred to as an "EMR" in the Canadian context is usually referred to as an "EHR" in the U.S. literature. Where appropriate, references to "EHRs" in published literature have been changed to "EMRs" for clarity in this report. When the term "EHR" is used, it is in reference to the longitudinal record of a patient across the continuum of care.

2.2.2 Aggregation and Extrapolation of Effects

The literature review provided relative benefit estimates (i.e., the extent to which EMRs improved certain variables relative to the base case in the absence of EMRs). For example, research could indicate that EMRs, on average, decrease diagnostic test duplication by 10%. In order to apply this relative measure to Canada, it was necessary to obtain a Canadian base case. A Canadian base case could be expressed in terms of dollars, units of time or number of cases, depending on the benefit being estimated. In this example, the Canadian base case would be comprised of the average number of duplicate tests in Canada and the average cost of diagnostic tests.

The Canadian base case was estimated from sources including Statistics Canada and CIHI (see Appendix D for data sources). Where data were not available, proxies were estimated using various techniques such as the extrapolation of provincial data to the national level.

The number of primary care physicians and specialists in Canada was obtained from Statistics Canada. The ratio of community-based specialists to all specialists who responded to the National Physician Survey 2010 (NPS 2010) was used to estimate the proportion and number of community-based specialists in Canada. The report provides disaggregated benefit estimates and discusses differences where relevant.

2.2.3 Maturity of Use

The findings from jurisdictional interviews and data were undertaken to inform this Study indicated that there is wide variability among Canadian jurisdictions with respect to EMR adoption rates and maturity of use.

For each of the benefit areas, maturity of use was determined to reflect the percentage of physicians expected to realize the stated benefits as a result of their self-reported use of specific EMR functionalities and/or reported conduct of practice management using EMR data. The maturity of use was then applied to the benefit estimates to adjust for variation in physician use of these EMR functionalities and/or use of EMR data in conducting practice based population health management. For the benefit to accrue, it is assumed that for all clinicians who use the functionality(ies) or EMR data for practice management, the full benefit will be realized, regardless of other practice or environment characteristics.

The most comprehensive, reliable and up-to-date sources for EMR maturity of use across Canada are the Commonwealth Fund Survey 2012 (CWF 2012) and the National Physician Survey 2010 (NPS 2010). Both surveys are national in scope, with specific questions pertaining to various elements of EMR use in practice. The CWF 2012 included questions related to the use of targeted functionalities (e.g., "Do you routinely send patients reminder notices when it is time for regular follow-up care?") and the NPS 2010 included high level questions around maturity of use (e.g., "Do you use an EMR to manage your patients' chronic conditions?").

The CWF 2012 was used as the primary source for determining maturity of use by primary care providers, as it posed a broader range of questions regarding functionality than the NPS 2010, and the data were more recent. The NPS 2010 was used to obtain relative maturity of use for community-based specialists and for validation wherever possible.

For each benefit area, key functionalities from the CWF 2012 were identified that were considered necessary in order to achieve that benefit. Identification was based on functionalities stated in the literature as well as input from the Advisory Panel. The weighted number of responses for each set of functionalities was calculated in order to derive the national percentage of primary care physicians who use these functionalities and thus experience that benefit. The weighted number included as a numerator the weighted number of physicians reporting the use of all required functionalities, and as a denominator the total weighted number of survey respondents[6]. Where multiple questions related to functionality or multiple data sources existed both a conservative and an optimistic percentage (range) were derived where possible.

The NPS 2010 contains responses from both primary care physicians and community-based specialists to questions around maturity of use (i.e., the percentage of physicians for whom benefits accrue). The ratio of community-based specialist to primary care physician weighted responses was used to adjust the maturity of use estimate obtained from the CWF 2012. Where a relevant maturity of use question could not be identified in the NPS 2010 for a benefit area, the ratio of overall EMR use of community-based specialists to primary care physicians was used as default.

2.2.4 Benefit Estimates Model

Benefit estimates (BE) were calculated by applying Canadian context data and maturity of use estimates to the relative EMR benefits obtained from the literature. The general calculation is as follows:

BE = EMR relative benefit x Canadian base case x Maturity of Use estimate

All financial estimates are expressed in 2012 Canadian dollars.

Ranges were provided for each benefit area based on the estimates in the literature and the range of maturity of use estimates. In certain instances, wide ranges in the literature and/or uncertainty in maturity of use led to wide ranges of benefit estimates. This reflects the uncertainty around some of the benefit values.

2.2.5 Cumulative Estimates

Cumulative estimates were generated in benefit areas where strong supporting evidence was available.

Benefit estimates for the period of 2006 through 2012 were calculated in order to estimate the total cumulative benefits as a result of increased EMR use and maturity of use in Canada. In order to arrive at a cumulative benefit, the model inputs remained constant while use and maturity of use were adjusted each year. Maturity of use in 2006 and 2009 were extracted from the Commonwealth Fund Survey 2006 (CWF 2006) and the Commonwealth Fund Survey 2009 (CWF 2009) where possible. A linear maturity of use trend was assumed between each 3-year interval. The survey question used to determine maturity of use associated with the duplicate testing benefit was not available in CWF 2006 therefore the ratio to overall maturity of use from 2009 was applied.

[6] In order to obtain conservative estimates, the denominator included all respondents, even if they did not respond to questions around EMR use or questions around specific functionalities used for the maturity estimate. This assumes that non-responders did not use an EMR and/or did not use these functionalities. Other studies citing the Commonwealth Fund Survey may produce different ratios by excluding non-responders.

2.3 Assumptions & Limitations

A number of limitations were identified in modeling the anticipated benefits of EMRs in Canada. These are explained below, as well as the steps taken to mitigate these limitations.

Available evidence on the benefits of EMRs and the ability to generalize findings

1) Limited evidence

There was considerable variability in the breadth of literature related to each of the benefit areas. While there were multiple studies and good evidence in some benefit areas, other benefit areas presented limited evidence to review. This suggests that a number of benefits associated with EMRs are emergent and have not yet been assessed through studies. It should be noted that several relevant Canadian research studies have recently been completed which have provided content for this Study. Furthermore, there are benefits which were not evaluated in this Study because they are still mostly anticipated and not currently being realized to a great extent based on current maturity of EMR use in Canada.

Studies often did not specify the type of EMR that was being evaluated and what functionalities were specifically available or being used. This finding identifies a gap in evidence regarding potential differences in benefits based on different EMR vendor solutions.

For certain aspects of EMR use, specifically related to preventive interventions and chronic disease management, there was good emerging evidence on the impact of EMRs in increasing short- to medium-term outcomes; however, analysis was limited by the paucity of research on how this translates into longer-term outcomes and health system savings.

2) Variation in findings and study quality

For some anticipated benefits, there were a number of studies available which raised challenges in terms of aggregating findings to one consistent benefit estimate. For reasons related to the methodological approach, unit of measurement or sample context, the studies provided different benefit estimates, direction (positive, negative, and neutral), and size, (for example daily time savings compared to a percentage decrease in time for a particular administrative task).

This difference in estimates is the result of wide variation in study contexts, methodologies and analyses. For example, studies may have been conducted in a variety of practice settings ranging from solo practitioners, group practices or interprofessional team practices. Benefits may also be expected to vary according to EMR vendor solutions, incentive structures and other factors. For example, providers across Canada have different remuneration schemes and fee schedules which may influence the cost savings and increases in revenue they may experience from the use of the EMR. In turn, this may influence how and to what extent physicians optimize their practice and use of the EMR.

Studies also differed in their method to assess the impact of EMRs, ranging from physician surveys to case studies, to pre- and post- EMR implementation analyses, to cross-sectional analyses. Implications of the variability in study approach is exemplified by a pre- and post-EMR implementation study that may capture the initial effect of practice transition and adaptation to the EMR versus a cross-sectional study at advanced stages of adoption that eliminates this effect. Much of the literature, particularly as it relates to productivity benefits, consists of case studies of specific physician practices. This raises questions in terms of the ability to generalize findings and the degree to which benefits are specific to unique circumstances.

A limitation of a majority of studies is that they did not use a control group (or a group of practices with similar characteristics where EMRs had yet to be implemented), or an incremental design where an intervention site (a

physician practice implementing an EMR) serves as its own control over an implementation period where all eligible sample cases receive the intervention.

3) Reliance on American studies

Most of the studies reviewed for this Study were based on physician practices located in the United States. Although many features of EMRs are expected to yield similar benefits, there are nevertheless limitations in applying U.S. findings to a Canadian context.

Some location-specific features that may alter benefits include:

- **Costs**. The cost of health care goods and services may differ significantly in the U.S. and any absolute cost estimates may not be easily extrapolated to Canada, particularly in relation to productivity benefits.
- **Workflow**. Community-based physicians in the U.S. may have different workflow patterns than Canadian physicians which could impact how EMRs affect the practice. Physicians may also differ in how they use their administrative and clinical staff.
- **Vendors**. The features and functionalities offered by U.S. EMR vendors may differ from those in Canada.
- **Maturity of use and integration**. As demonstrated by the Commonwealth Fund Survey 2012, Canada lags other OECD countries including the U.S. in the adoption of EMRs. U.S. physician practices may have differing levels of integration with other clinical systems and EMR functionalities available and in use.
- **Ambulatory practices**. A number of U.S. studies focus on the impact of EMRs in ambulatory practices connected to academic centres. The added connectivity or continuity of care that these practices may experience may impact the value they obtain from their EMR.

4) Timeliness of evidence

Finally, health IT and EMR technology is rapidly evolving and as a result, evidence and research may quickly become dated. A number of studies were conducted in the 1990s and early 2000s and while largely applicable, their specific applicability to the current health care system is uncertain.

Further detail relating to the assumptions and limitations for specific benefit areas are provided in Appendix C.

Attribution of EMR benefits from EMR use in Canada

Each estimated EMR benefit was applied to a proportion of community-based providers in Canada, based on their reported use of EMRs and their use of functionalities specific to each benefit (or "maturity" of use). The following assumptions were made:

- Each benefit can be attributed to an EMR functionality or set of functionalities. This is a reasonable assumption as most studies in the literature focused on a specific functionality in estimating the benefit of EMRs, such as alerts for duplicate tests. However, in some instances, assumptions had to be made in terms of which functionalities or use of EMR data would lead to a specific benefit (e.g., improved chronic disease management) or how to interpret responses, (e.g. benefits only counted if a provider reported tasks were "easy" to complete, rather than "difficult").
- Any provider with an EMR using the identified functionality would experience the full benefit. In practice, however, some users may not experience the full (or any) benefit if they are not using a functionality optimally (e.g., receiving a reminder for preventive care does not guarantee the provider will act on it). Also, the size of the benefit accrued to the user may vary according to the type and sophistication of EMR in use. This may be of significant impact as physicians have indicated anecdotally that the current EMRs available on the market vary greatly in their functionalities and ease of use. Likewise, some practices and their patients may experience a benefit through mechanisms other than the use of EMR functionality tracked in this Study, (e.g. chronic disease management tools not linked to an EMR) that would not be reflected in these estimates.

- The maturity of use estimates for each benefit area were based on responses to the Commonwealth Fund Survey and National Physician Survey and therefore rely on self-reported numbers. Physicians may overestimate their use of EMR functions, and may also have varying interpretations of the degree of difficulty or frequency of completing certain tasks when using the EMR. .

The maturity of use estimate was based on survey responses from community-based physicians. For benefit estimates applied to the number of patients, this assumes that the use among other primary care health care providers, such as nurse practitioners, would be identical. This could be an underestimate or overestimate of EMR benefits depending on whether nurse practitioners are more or less likely to use an EMR and various functionalities than physicians.

When benefits were accrued to the patient, the maturity of use estimate was applied in a linear fashion. If X% of physicians were using a specific functionality, it was assumed that X% of Canadian patients would experience the benefit. For example, in the case of influenza immunizations, 3% to 10% of individuals over the age of 65 were assumed to benefit from their physicians' use of an EMR (either by reminding physicians to immunize or by flagging patients who should be immunized) based on a 3% to 10% reported use of the associated functionality among primary care physicians.

Benefits are estimated based on EMR adoption at the time of the 2012 Commonwealth Fund Study, for which data was collected from March to July 2012. EMR adoption and maturity of use has likely increased in Canada since that time and EMR adoption and maturity of use is likely to continue to increase going forward. Straight-line extrapolation of benefit estimates based on increased adoption in Canada may not be appropriate, as the benefits of EMR use are not likely to accrue in a linear fashion.

Adoption of EMRs varies significantly across provinces and territories. Reported benefits are aggregated to the national level although specific benefits of EMRs may be concentrated primarily in select jurisdictions. The benefit estimates rely on third party data to extrapolate benefits to the national level. Validation of third party data was not undertaken.

Aggregation of EMR benefits in Canada

This Study measures various independent benefits arising from the use of EMRs. All benefits were measured in isolation, and not all benefits could be measured based on available data, and therefore the overall impact of EMRs, whereby all possible impacts are included, is unknown. In a number of areas, benefit estimates are conservative and are limited to EMR functionalities, populations or diseases for which evidence is present in the literature. In other areas not covered in this Study, EMRs may have other impacts not measured here (e.g. the transfer of certain administrative duties from office staff to physicians). Therefore, the benefit estimates presented are illustrative. The sum of specific individual benefits cannot be assumed to represent the total benefit for the country.

Approach to address assumptions and limitations

In order to address the above stated assumptions and limitations, the following approach was taken by the Study team in its estimation of benefits. The Study team:

- focused on benefit areas where the most evidence was available;
- used Canadian findings to the extent possible;
- prioritized higher quality studies;
- prioritized recent studies and excluded dated studies to the extent possible;
- established EMR adoption and usage rates of specific functionalities from physician self-reported survey data;
- calculated benefit estimates from research evidence and Canadian source data;
- used ranges and conservative assumptions to increase the reliability of estimates; and

- cross-referenced and validated with multiple sources of data and reviewed with experts from the clinical and research communities.

3.0 Benefits of EMR Use

The benefits articulated in this Study are preliminary and intended to be illustrative of the benefits of EMR use in primary care and community-based specialist care. The findings represent a positive trend for benefits realization, and it is anticipated that, as EMR adoption and maturity of use increase over the long term, additional benefits will accrue. Evidence to date and described in the Study indicates that use of EMRs can improve efficiencies in workflow as staff time is redeployed, contribute to system level benefits, have the potential when used effectively to improve quality of care outcomes through preventive care and chronic disease management, and support improved interactions and communications between care teams, providers and patients.

Both current and emerging benefits were investigated. Current benefits are those for which strong and comprehensive evidence was available to quantify the benefit in the model. "Emerging" benefits are intended to reflect those currently being realized, but for which quantitative evidence is limited. In certain instances, quantitative estimates were measured based on the evidence available, and in other instances emerging benefits are discussed qualitatively. Benefits which are currently only anticipated and have not yet been demonstrated have not been included in this Study.

The following table summarizes the benefit areas included in this Study and which are explored in further detail in this section.

Table 2: Current and Emerging Benefits of EMR Use in Canada

Benefits	
Community-based practices experience efficiencies in workflow as staff time is redeployed	EMR use reduces staff time spent on specific paper-based administrative tasks
	EMR users can expect a positive return on investment
EMR use results in health system level benefits, such as reduced numbers of duplicate tests and adverse drug events	EMR use reduces the number of duplicate diagnostic tests ordered
	EMR use improves patient safety through reduced adverse drug events
	EMR use increases the appropriateness of diagnostic tests*
Advanced use of EMRs can improve health outcomes and patient safety through preventive care and chronic disease management (CDM)	EMR use has the potential to improve chronic disease management*
	EMR use supports preventive care*
	EMR use improves immunization rates*
	EMR use may lead to faster responses to changes in care and treatment guidelines*

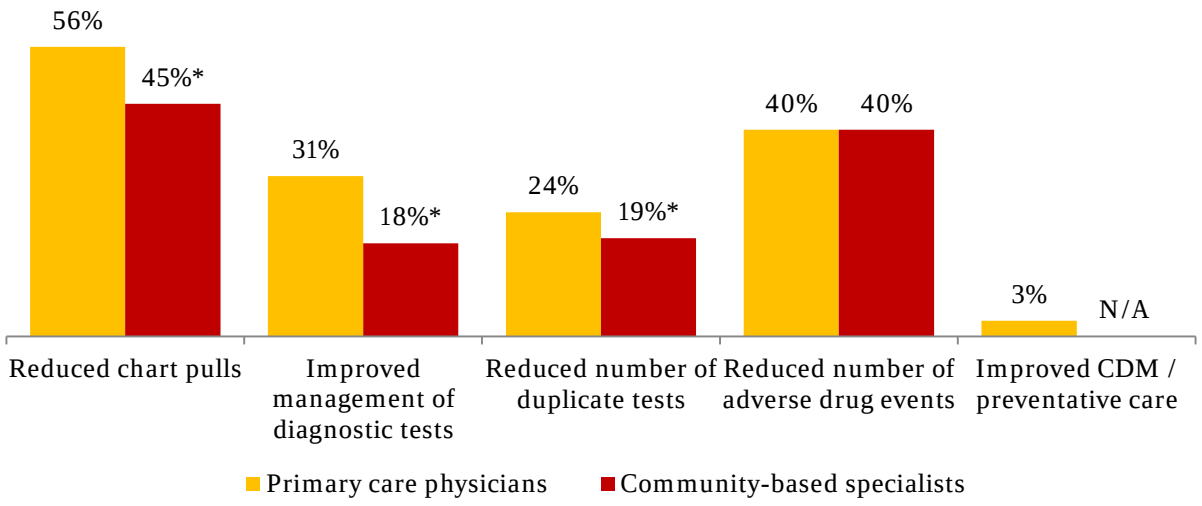
Benefits	
EMR use supports improved interactions and communications among care team members and between providers and patients	EMR use supports the improvement of team-based care and continuity of care*
	EMR use facilitates improvements in the overall patient experience*
	EMR use improves the quality of the patient/provider encounter*

* Asterisks denote areas of emerging benefit

For each of the benefit areas, maturity of use was determined to reflect the percentage of physicians expected to realize the stated benefits as a result of their self-reported use (CWF 2012, NPS 2010) of specific EMR functionalities and/or reported conduct of practice management using EMR data. The maturity of use was then applied to the benefit estimates to adjust for variation in physician use of these EMR functionalities and/or use of EMR data in conducting practice based population health management.

Figure 3 describes maturity of use estimates used for quantified benefit areas for both primary care physicians and community-based specialists. All primary care physicians who use an EMR (56%) are expected to realize the benefit of "reduced chart pulls" (i.e., the time it takes for staff members to pull and re-file paper charts). In contrast, as few as 3% of physicians are expected to realize the benefit of "improved chronic disease management (CDM)/preventive care" as few physicians report using EMR data in practice based population health management activities and/or use of a specific bundle EMR functionalities. Please refer to the Technical Appendix (Appendix D) for detailed measures supporting the maturity of use estimates for each benefit area.

Figure 3: Maturity of use for benefit estimates: % of physicians estimated to realize benefit by area



* Asterisks denote maturity of use estimates from NPS 2010 that were adjusted for 2012

The following sections of the Study describe each of four benefit areas. For those benefits where quantification was possible, a review of the evidence, description of the model development and findings are presented. For benefit areas that are emerging and where little quantifiable evidence was available, findings from the literature, anecdotal input from stakeholders, and survey results are summarized.

3.1 Community-based practices experience efficiencies in workflow as staff time is redeployed

The decision to adopt an EMR system has significant financial implications for individual practices and funding organizations. Efficiencies in workflow can be expected as administrative staff gain increased capacity to focus on value-added tasks as staff time is redeployed. These practice efficiencies include reduced or eliminated chart pulls (i.e., the time intensive task of retrieving and refiling a patient chart for a visit) and improved efficiencies in laboratory and diagnostic test management (i.e., the time to sort, archive and retrieve reports). While quantitative evidence is not available, it is also anticipated that emerging benefits are being realized related to other clinical and administrative tasks such as enhanced patient scheduling and billing practices. Furthermore, financial considerations beyond start-up costs include those related to ongoing maintenance and system upgrades, as well as changes in productivity during and after the transition. A detailed Canadian study of practice finances found that primary care physicians recoup their investment in 10 months on average. 14 of 17 primary care clinics had a positive return on their investments in EMRs and for those, time to break-even ranged from 1-37 months (Lortie et al., 2013). The use of EMRs is also believed to fundamentally change the mix and nature of tasks undertaken by physicians. However, there is insufficient research to date to determine the net productivity impact.

Benefits related to reductions in "chart pulls" and efficiencies in laboratory and diagnostic test management are estimated at $177 million in 2012.

Table 3: Summary of Estimated and Emerging Benefits

	Estimated benefits	**Emerging benefits**
Description of benefit	• Efficiencies realized in community-based practices by reduced or eliminated chart pulls **$84M ($56-$112M) in 2012** • Efficiencies in community-based practices by improved laboratory and diagnostic test management **$93M ($41M-$103M) in 2012**	• Administrative task efficiencies realized through enhanced patient scheduling and billing practices • Clinical task efficiencies realized through changes in clinical processes, including documentation, order entry, and patient encounter management
2012 total benefit	**$177M in 2012 ($97M - $215M)**	Evidence not available
2006-2012 cumulative benefit	**$800M**	

3.1.1 EMR use reduces staff time spent on specific paper-based administrative tasks

Summary

Clinicians engaged in the development of this Study indicated that efficiencies gained in practice workflow and overall productivity are among the greatest early achievable benefits expected with EMR adoption and use. Administrative tasks can be completed more easily and efficiently and some tasks which would have been very difficult to complete in paper-based practices (due to complexity and time required) can be completed with relative ease through EMR use (e.g. conducting reviews of all active patients as per Lapointe et al., 2012).

EMRs may have the ability to reduce time spent on administrative tasks by various members of the inter-professional team. These tasks could potentially include:

- *Pulling charts*. As EMRs reduce or eliminate the need to maintain paper patient files, office staff do not need to retrieve or refile paper charts for office visits or other transactions, and time wasted looking for misplaced charts is eliminated (Girosi et al., 2005).
- *Managing laboratory results*. Benefits of EMR use can also include faster, more accurate lab order entry, accurate matching of lab results to charts, correct routing of results to the ordering provider, auto-completion of EMR lab order status, and validation of complete insurance information (Wolfram et al., 2009).
- *Scheduling*. Although electronic scheduling does not require an EMR, EMRs enable scheduling features to connect directly to patient-specific information.

> Since implementing EMRs, 67% of Saskatchewan's family physicians, office managers and specialists report that their medical practices are more or significantly more productive.
>
> *Saskatchewan Physician EMR Satisfaction Survey Results Report, 2012*

- *Billing*. EMRs enable the capture of billable events as they happen clinically, reducing the chance of missing billable activities and providing a thorough clinical documentation record (POSP, 2011). Some EMRs also generate diagnostic and billing codes from plain language which can reduce the time spent retrieving codes (POSP, 2011).
- *Clinical documentation*. Computerized data entry may reduce time spent recording patient and visit information through shortcuts and automation; and legibility across the care team is ensured. The latter can reduce follow-up visits and callbacks (Deloitte, 2010).
- *Order entry*. EMRs reduce the time required to complete all fields to transmit, print, or otherwise complete the process of ordering laboratory testing and radiology procedures. EMRs can also produce downstream time savings resulting from more complete order requests and/or improved legibility (Johnston et al., 2003).
- *Encounter management*. EMRs provide increased accessibility to information required during a patient encounter (Pizziferri et al., 2005).

The current evidence of benefits related to efficiencies gained through EMR use arises primarily from research focused on administrative staff time savings, specifically related to pulling charts and managing diagnostic tests. Accordingly, the benefit estimates are focused on these two specific tasks.

This Study estimated that EMRs have contributed to administrative staff time savings of 3.8 hours per physician per week (ranging from 2.1 to 3.6 hours per physician per week). These time savings are **valued at $177 million (ranging from $97 million to $215 million)** in 2012, with just over 45% of time savings resulting from reduced chart pulls and 55% of time savings accruing from improvements in laboratory and diagnostic results management.

Findings from Literature

Numerous sources and publications have concluded that EMRs reduce the time spent pulling and filing patient charts in primary care offices. In one Canadian study (Keshavjee et al., 2001), it was estimated that the time spent by administrative staff to pull charts for patient visits and for patient-related inquiries decreased by over 50%. Other findings pertaining to a reduction in time spent pulling charts pre- and post-EMR implementation include (see Appendix D for those included in the model):

- 79% reduction in chart pulls six months after implementation of the EMR and a 96% reduction at two years post-implementation (Grieger et al., 2007).
- An average reduction of 230% in electronic filing time on a page per minute basis (Grieger et al., 2007).
- Ambulatory CPOE generated time savings of 1 hour per nurse and 30 minutes per file clerk per day (Johnston et al., 2003).
- Reduction in chart pulls of 17% after 60 days, 73% after 120 days and 85% after 180 days (Babbitt et al., 2003).
- The number of requests for paper charts decreased 47%, from 116,000 chart pulls per month in 1995 to 60,000 per month in 1998. Record clerk positions were reduced by 49%. (Kalata et al., 1998).
- Staff were redeployed with the reduction of six hours per day previously spent pulling charts (Compeau, 2012).
- One clinic with eight physicians reduced chart pulls by 54% over the first nine months after implementation, and a clinic with two physicians eliminated chart pulls completely, saving $24,500 per year. A third practice with six physicians saw an 84.3% decrease in chart pulls (MedicaLogic Whitepaper, 2004).

EMRs also have a role in redistributing the time allocated to certain tasks among office and clinical staff. Carayon et al. (2009) reported that administrative and clinical staff spent less time distributing charts, master files and mail, and more time maintaining the EMR.

- Clinical staff spent less time distributing charts, master files and mail (from 6.6% to 0.3%), and performing tests (from 18.6% to 11.2%).
- Office staff spent approximately 50% less time distributing charts, master files and mail (from 5.6% to 2.5%), performing general clerical assistance and office tasks (from 27.8% to 13.1%), and transcription (from 13.3% to 7.5%).
- Clinical staff spent more time accompanying patients (from 17.5% to 22.9%), examining patients (from 4.3% to 12.7%), and maintaining EMRs (from 5.6% to 10.9%).
- Office staff spent more time maintaining the EMR (0% to 19.8%).

There is some evidence that in the U.S., time savings from reduced chart pulls have resulted in cost savings. Girosi et al. (2005) estimated that the potential savings from the reduction in chart pull activities in the U.S. were $1.7 billion, amounting to mean yearly savings of $800 million and cumulative savings over 15 years of $11.9 billion.

The literature related to exclusively managing laboratory results is limited, however one study conducted by the Centre for Research in Health Care Engineering at the University of Toronto (CRHE, 2012) found that the time to sort, archive, and retrieve an electronic lab report was 87% faster than with paper reports and 50% faster than that of scanned reports. The authors noted additional non-measurable benefits such as an increased ability to compare

and trend reports, the ease of sharing reports with colleagues, and follow-up actions taken as a result of alerts and reminders for physicians.

Model

A model was developed to estimate the benefit resulting from time savings related to two administrative tasks: pulling charts and managing diagnostic tests. The methodology and findings pertaining to each are presented in this section.

Chart pulls

Based on the evidence available, the potential time savings in Canada arising from reductions in the time spent pulling paper charts in community-based practices was estimated. The percentage reduction in the number of chart pulls was estimated by averaging rates found in the literature, yielding an average reduction of time of 72% (with 48% and 96% as the lower and upper bounds).

This rate was then applied to the number of annual community-based visits in Canada, assuming that each visit requires one chart pull. This is likely a conservative estimate, as a single visit may result in multiple chart pulls (for example, if the visit leads to additional tests and the results are discussed over the phone with the patient). The proportion of specialist visits that are community-based was assumed equal to the proportion of specialists in the community as per analysis of the NPS 2010 data. The number of chart pulls was multiplied by an estimated 4 minutes spent per chart (Girosi et al., 2005).

It is estimated that all practices where an EMR is in use will benefit from reductions in staff time on administrative work. All 56% of primary care physicians who reported using an EMR in the CWF 2012 were therefore assumed to benefit. The maturity of use for specialists was assumed to be 81% that of primary care providers (or 19% lower) based on analysis of NPS 2010 data, whereby 19% fewer community-based specialists than primary care physicians reported using an EMR.

The estimate per physician was obtained by dividing hours by the number of community-based physicians in Canada. The benefit estimate was calculated by multiplying hours saved by medical secretaries and nurses working in primary care offices by their respective salaries, assuming that they would complete the majority of chart pulls. The inputs and benefits estimate are described in the table below.

Figure 4: Inputs for Chart Pulls Model (details in Appendix D)

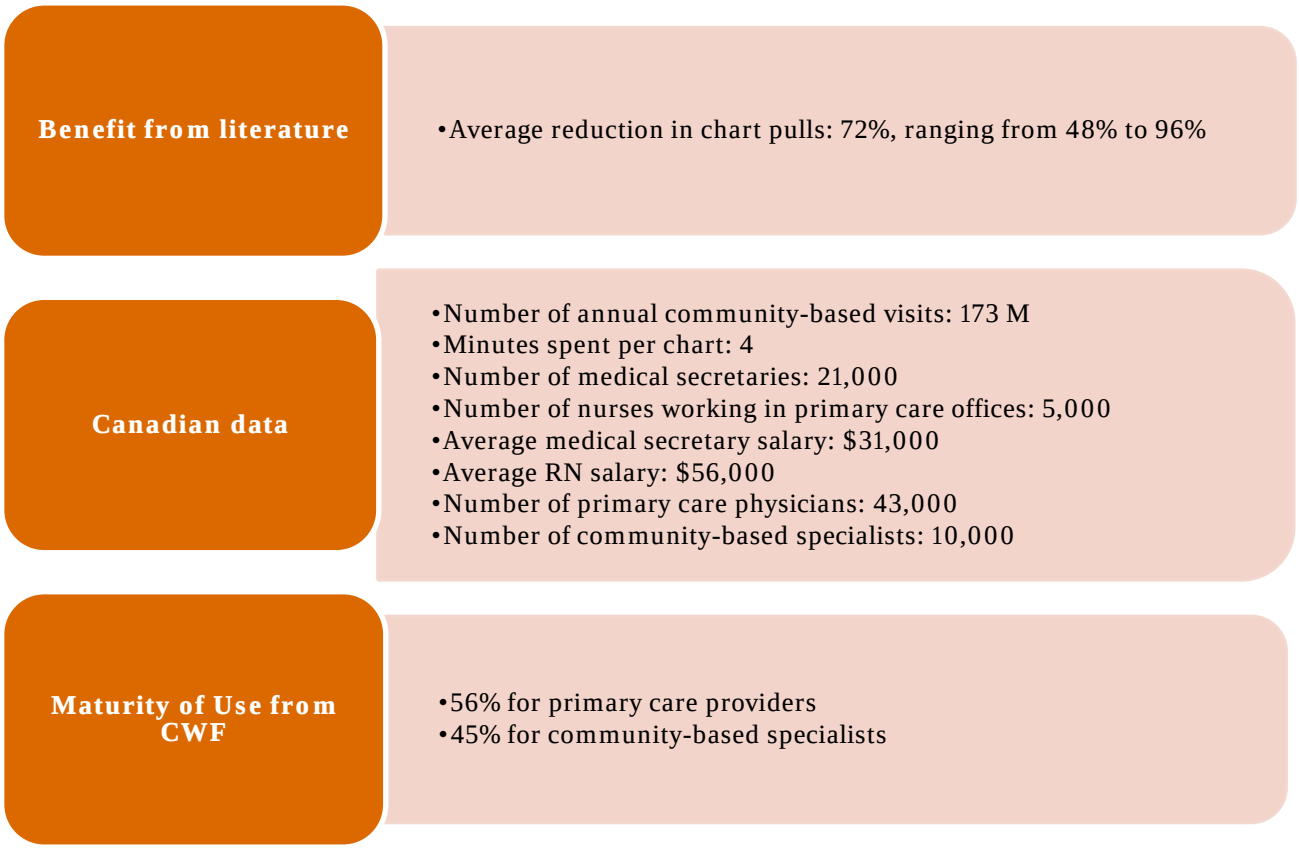


Table 4: Benefits estimated from reduced chart pulls

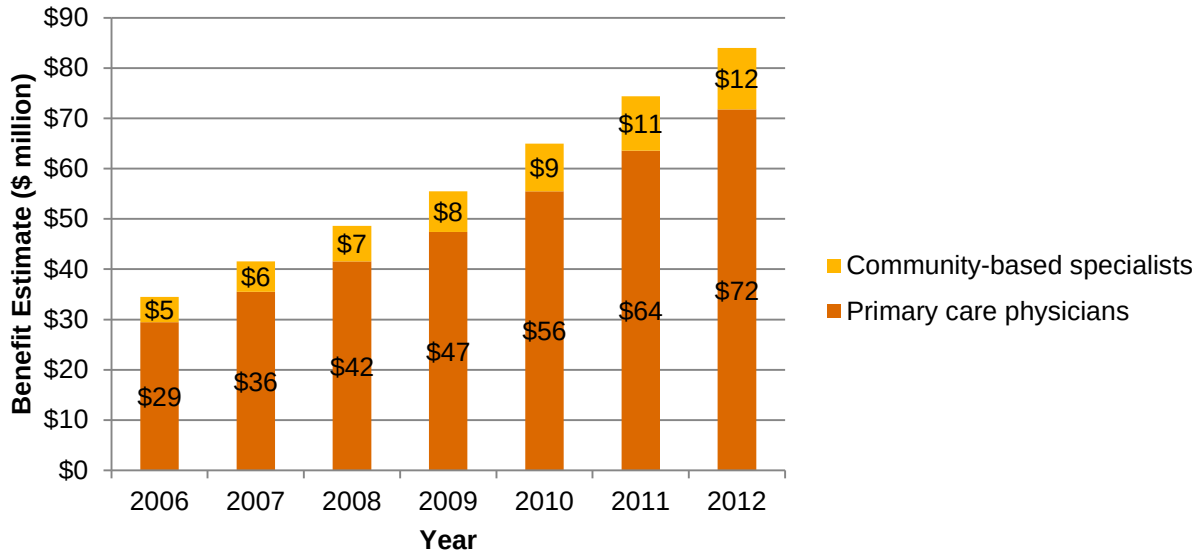
Benefit area	Benefits estimate	Range
Time savings from reduced chart pulls in 2012	4.5 million hours 1.8 hours per physician per week	3.0 million - 6.0 million hours 1.2 - 2.4 hours per physician per week
Benefit from reduced chart pulls in 2012	$84 million	$56 million - $112 million

It is estimated that EMRs have contributed time savings to community-based practices of approximately **1.8 hours per physician per week (ranging from 1.2 to 2.4) valued at $84 million (ranging from $56 to $112 million)** in 2012 by reducing the time administrative staff spend pulling charts. Practices may re-adjust their workflow based on the time saved from chart pulls, such as by increasing time spent with patients, improving chronic disease management and reallocating administrative staff (for those practices large enough to have multiple staff).

Efficiencies realized in primary care practices represented 85% of this benefit at $72 million, while community-based specialists realized benefits valued at $12 million. This difference is a result of both fewer specialists having adopted an EMR and among those who have, an assumed lower maturity of use.

The figure below illustrates the benefits accumulated from 2006 to 2012 as a result of increasing maturity of use over time (CWF 2006 and CWF 2009, see Appendix for details). As demonstrated, the benefit has more than doubled over six years, from $34 million in 2006 to $84 million in 2012.

Figure 5: Cumulative benefits from reduced chart pulls, 2006-2012



Diagnostic Test Results Management

Time savings from changes in diagnostic test results management were also estimated. Based on the CRHE study findings presented above, EMRs can reduce the average time to sort, archive and retrieve diagnostic reports in primary care offices by 15.6 minutes per lab report from a paper-based environment. Time savings by the worst-performing and best-performing practices were used as lower and upper bounds. This was multiplied by the number of lab and diagnostic imaging (DI) reports ordered in Canada every year by community-based physicians to obtain annual time savings. The estimation of the number of reports is provided in Appendix D[7].

According to PwC analysis of CWF 2012 data, 31% of primary care physicians in Canada use an EMR and routinely or occasionally order lab or diagnostic imaging tests electronically, therefore this share of physicians was assumed to benefit from lab and DI test management time savings. Based on analysis of the NPS 2010 data, community-based specialists were 41% less likely to report using an electronic interface to external laboratory/diagnostic imaging systems, therefore their maturity of use was estimated to be 41% lower than that of primary care physicians. As a conservative estimate of maturity of use (17%), the percentage of physicians who could generate lists (either tests per patient or patients by test result) was used as a proxy for the integration of test management, since many EMR practices still scan a proportion of their charts.

The estimate per physician was obtained by dividing hours by the number of community-based physicians in Canada. The benefit estimate was calculated by multiplying hours saved by medical secretaries and nurses working

[7] A lab report or DI report is the report submitted by the physician to order diagnostic tests. It is estimated that reports in Canada contain an average of 7.2 tests. See Appendix D for details.

in primary care offices by their respective salaries, assuming that they would be the primary resource for sorting and archiving tests.

It can be reasonably assumed that some time would be saved in searching for lost or missing paper charts. This was not included in the model due to the lack of evidence around the time spent by practices in doing so.

The inputs and benefit estimate are described in the figures below.

Figure 6: Inputs for Diagnostic Test Management Model (details in Appendix D)

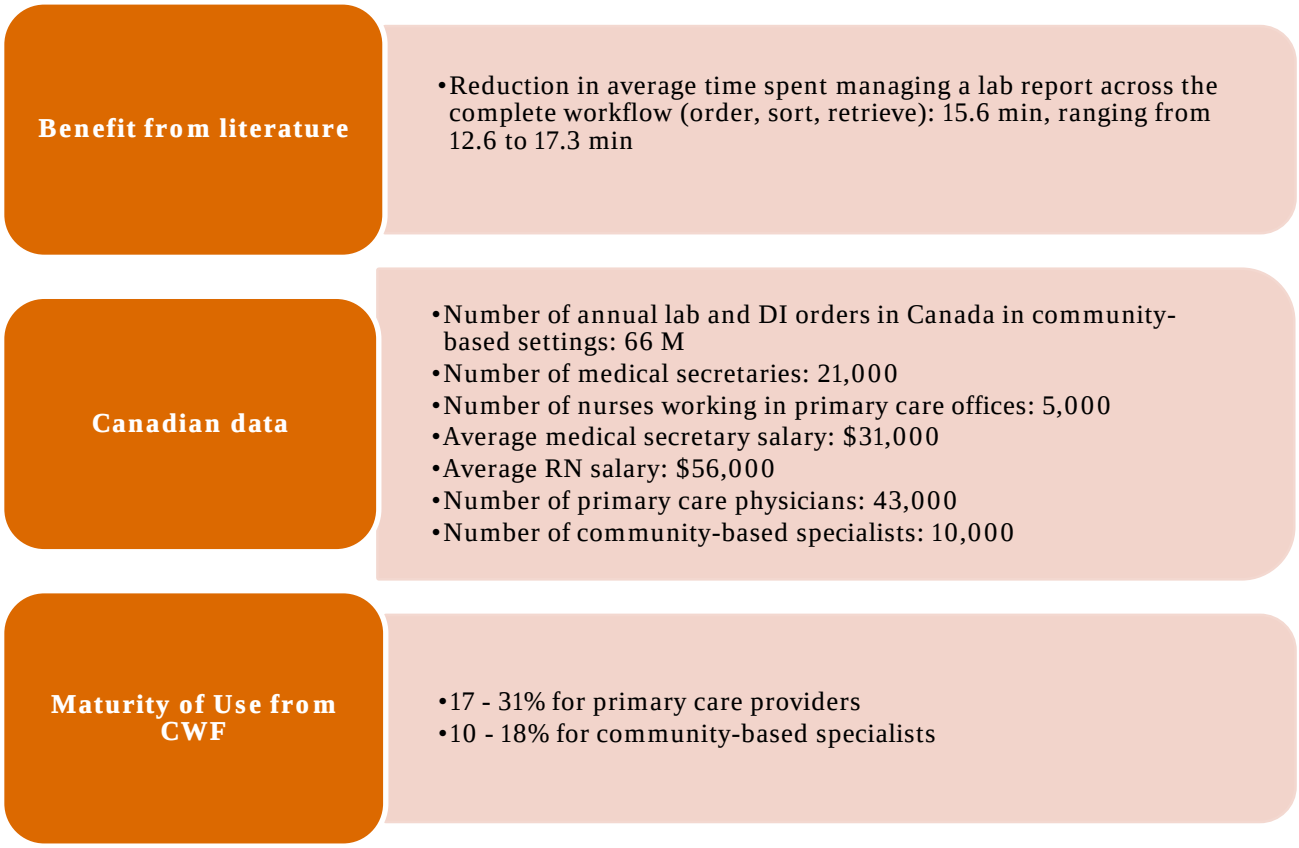


Table 5: Benefits estimated from diagnostic test results management

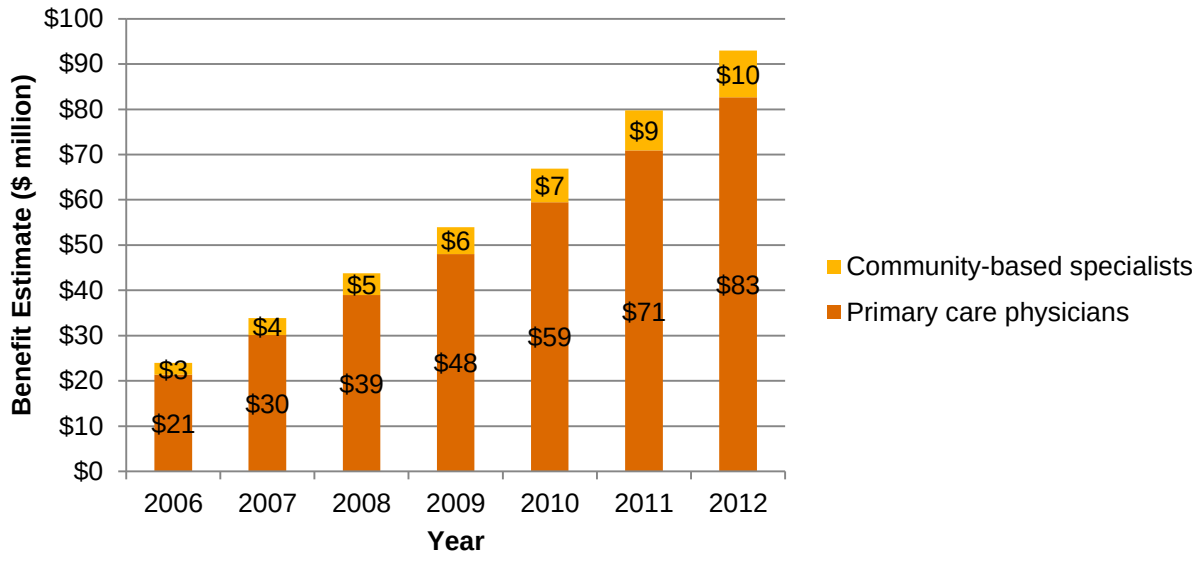
Benefit area	Benefits estimate	Range
Time savings in diagnostic test results management in 2012	5.0 million hours 2.0 administrative hours per physician per week	2.2 - 5.5 million hours 0.9 - 2.2 administrative hours per physician per week
Benefit from diagnostic test results management in 2012	$93 million	$41 million to $103 million

It is estimated that EMRs have contributed time savings to primary care practices of about **2.0 administrative hours per physician per week (ranging from 0.9 - 2.2 administrative hours) valued at $93 million (ranging from $41 - $103 million)** in managing diagnostic test results. Practices may readjust their workflow based on the time saved by managing tests to increase capacity for other staff activities.

The benefits experienced by community-based specialists are estimated at $10 million, or 11% of the total benefit estimated in community-based practices. Fewer specialists are using EMRs to obtain electronic diagnostic test results, which contributes to this lower estimate.

The figure below illustrates the benefits accumulated from 2006 to 2012 as a result of increasing maturity of use over time (CWF 2006 and CWF 2009, see Appendix D for details). As shown, the benefit has more than tripled over 6 years, from $24 million in 2006 to $93 million in 2012.

Figure 7: Cumulative benefits from test results management, 2006-2012



3.1.2 Most EMR users have a positive return on investment

Summary

The use of EMRs has been associated with a number of financial effects to physician practices which can be central to the decision to adopt EMRs. Physicians have cited excessive cost in relation to uncertain benefits as an obstacle to EMR adoption (Moshman et al., 2006). However, financial benefits can be realized, notably through reductions in administrative costs and overall improvements in practice efficiency. In a survey of physicians conducted in Saskatchewan, 63% of physicians reported that decreased administrative overhead was one of the rationales to adopt an EMR. Moreover, 85% of physicians reported an overall increase in clinic efficiency as an expected benefit that led to EMR implementation (Moshman et al., 2006).

The expected financial benefits include:

- *Net overhead cost savings*. Overhead costs may be reduced through lower administrative costs (e.g. chart pulls and filing, transcriptions, phone calls, photocopying charts, faxing medical information), reduced storage costs, and reduced costs from increased provider and staff efficiency.

- *Increased revenue*. Physicians may be able to increase their revenue from billings through enhanced charge capture and reduced billing errors. For example, physicians are able to enter charges in real time and are provided with drop down menus which enable more accurate billing.
- *Positive return on investment (ROI)*. EMRs can provide a positive ROI for practices if the cumulative sum of reduced overhead costs and/or increased billing revenues are greater than the costs associated with EMR investment and implementation.

Evidence in the international literature suggests that EMRs are associated with a positive return on investment. In a Canadian study most practices were found to recoup **their investments in an average of 10 months,** with a **range from 1 to 37 months**. 14 of 17 primary care clinics in the study had a positive return on investment (Lortie et al., 2013).

Findings from Literature

Findings from a pan-Canadian study of primary care clinics suggest that it takes an average of ten months from the date of implementation to recoup costs, and these time estimates range widely across practices from 1 to 37 months (Lortie et al., 2013). It should be noted that three of the 17 clinics did not recoup their original investment. Results suggest that differences are largely a result of varying implementation and change management strategies, and practice size.

Other recent contributions have described the overall positive effect on revenue generated from the implementation of EMRs for Canadian primary care physicians. Findings from the Canadian literature and surveys include:

- According to a survey of physicians, 42% reported improved revenues after adopting an EMR (OntarioMD, 2010).
- Physician billings remain stable from the date of EMR implementation over the 18-month follow-up period. No decline in overall physician office billings was observed from the date of EMR implementation (Jaakkimainen et al., 2012).
- Since implementing EMRs, 67% of Saskatchewan's family physicians, office managers and specialists report that their medical practices are more or significantly more productive (Saskatchewan Physician EMR Satisfaction Survey Results Report, 2012).

Literature from the U.S. suggests significant gains can be realized by EMR users through enhanced charge capture and reduced billing errors (Wang et al., 2003; Johnston et al., 2003). Increased efficiency may also allow for increased volume of patients and reductions in missed appointments, which could reduce foregone billings. Findings from the U.S. literature include:

- Financial benefits averaged $33,000 per FTE provider per year, with $16,929 per FTE from increased coding levels (Miller et al., 2005).
- Of the estimated 5-year net benefit from using an EMR, approximately 30% came from increased revenue. Half of this increase was derived from decreased billing errors and half came from improvements in charge capture (Wang et al., 2003).
- A case study in the U.S. reported that EMRs lead to better charting and less conservative coding. EMRs help to ensure that all services provided are charged (Bradley et al., 2008).

A number of U.S. studies also reported cost savings from EMR implementation. Findings include:

- Financial benefits averaged $33,000 per FTE provider per year, with $15,808 per FTE from efficiency-related savings. The largest efficiency savings derived from a decrease in personnel costs, followed by transcription savings, revenue gains from increased visits and paper supplies savings (Miller et al., 2005).

- In one ambulatory clinic using an EMR system, there was no longer a need for medical records staff or transcription leading to annual cost savings of $20,000 (HIMSS Analytics, 2011).
- The number of administrative staff required to handle patient charts decreased by 76.7% in three ambulatory care clinics comprising of 24 physicians, leading to annual savings of more than $120,000 in administrative costs (HIMSS Analytics, 2011).
- Salary savings for support staff were the second largest percentage of savings, at 23% of total savings. A total of 4.5 positions were eliminated despite the addition of 6 providers throughout the study period, reflecting increased efficiency. Salary savings of $28,050 to $100,000 have been reported elsewhere (Grieger et al., 2007).
- $5,000 saved annually by eliminating storage costs for one physician practice (HIMSS Analytics, 2011).

Overall, the international literature suggests that providers who invest in EMRs will experience a positive return on investment, but that the time to recoup their investment may vary from 16 months to 6 years (Grieger et al., 2007; Kaelber et al., 2007). Longer periods of time to recoup the EMR investment than those reported in Canada (Lortie et al., 2013) may be the result of shared co-investments by Canadian practices with provincial and federal funding. Although EMR investment may be associated with financial risk during the period of transition from a paper to electronic system due to the fundamental changes to practice management that are required, this risk is less prominent for Canadian practices that may share the initial capital cost.

A number of U.S. studies have conducted cost-benefit analyses and estimated the overall financial benefit associated with EMRs. Although these studies are not directly applicable to a Canadian context, they did find that EMRs provided a net benefit over time:

- The total initial cost per provider was $18,182 and the ongoing annual expenses were $4,072 per provider. Given per provider savings of $14,055 annually (mainly as a result of reduced time pulling charts), the initial expense was recaptured in 16 months. Others have reported recapture of initial expense within 18 to 36 months (Grieger et al., 2007).

- Post-implementation analysis showed recovery of capital expenses within six years and authors reported significantly greater returns than originally forecasted (Kaelber et al., 2007).

- Initial EMR costs averaged $44,000 per FTE provider, and ongoing costs averaged $8,500 per provider per year. The average practice paid for its EMR in 2.5 years and profited after that; however, some practices could not cover costs quickly, most providers spent more time at work initially, and some practices experienced substantial financial risks (Miller et al., 2005).

- The estimated net benefit from using an EMR for a 5-year period was $86,400 USD per provider. Of this amount, savings in drug expenditures made up the largest proportion of the benefits (33% of the total). Of the remaining categories, almost half of the total savings came from decreased radiology utilization (17%), decreased billing errors (15%), and improvements in charge capture (15%) (Wang et al., 2003).

3.2 EMR use results in health system level benefits, such as reduced numbers of duplicate tests and adverse drug events.

While EMRs support transformational initiatives to enhance patient care, their use may also result in reduced health system utilization. With the use of EMRs, there are demonstrated quantifiable impacts in reducing the number of duplicate tests ordered and adverse drug events (ADEs) resulting in benefits at the system level.

The use of EMRs can reduce test duplication by displaying past test results, highlighting redundancy of ordering through alerts, and decreasing the number of test results that are lost or misplaced through electronic filing. This benefit is likely to be substantially enhanced as decision support is optimized and focussed, and when there is more integration between EMRs, Electronic Health Records (EHRs), and other systems external to the community-based care setting.

Since implementing the EMR, 94% of physicians enrolled in Alberta's EMR program report that patients receive their test results faster, and 97% report that tests and investigations are no longer needlessly repeated.

Alberta Physician Office System Program (POSP) Benefits Survey, 2012

63% of Ontario family physicians and specialists report that patient safety has improved within the first year of implementing their EMR.

OntarioMD Physicians EMR Usage and Satisfaction Survey, 2013

With electronic prescription entry, EMRs can: alert the physician to potential prescribing errors and potential ADEs due to interactions with other medications; flag patient allergies; and improve prescription legibility and completeness. Avoidable ADEs are just one of the many medication management benefits which EMRs have the potential to facilitate. Availability of a current and accurate list of medications within the EMR has substantial value as a trusted source of clinically relevant data. When full medication profiles and e-prescribing functionality become widely available to community-based clinicians, the benefits will include the ability to counsel patients on appropriate use of medications in order to reduce ADEs and achieve better patient outcomes.

It is also expected that the use of EMRs may improve the appropriateness of diagnostic tests ordered through the availability of decision support features that can reduce the misuse or overuse of certain diagnostic tests.

Benefits related to fewer duplicate tests and ADEs are estimated at $123 million in 2012.

Table 6: Summary of Estimated and Emerging Benefits

	Estimated benefits	Emerging benefits
Description of benefit	• Reduced laboratory and imaging test duplicates: **$99M ($29M-145M) in 2012, 6.5M fewer duplicate tests in 2012** • Reduced ADEs due to prescription legibility: **$24M in 2012**	• Reduced duplicates with increased system connectivity to Electronic Health Records, interoperability and access to data repositories • Reduced inappropriate imaging tests with decision support: e.g. Sinus CTs and head and lumbar MRIs*: **$5.7M in 2012, 6,000 fewer inappropriate CTs & MRIs**
2012 total benefit	**$123M In 2012 ($53M - $169M)**	Evidence not available
2006-2012 cumulative benefit	**$584M**	

*CT = Computed Tomography, MRI = Magnetic Resonance Imaging

3.2.1 EMR use reduces the number of duplicate diagnostic tests ordered

Summary

An estimated 9% of all lab tests and 10% of diagnostic imaging (DI) tests are redundant and duplicate (Bates et al., 1998; You et al., 2008). While some duplicate tests are legitimate follow-up procedures, the duplication of diagnostic tests may also arise when records make it difficult to determine which tests have or have not been administered, or when patients are seen by different physicians in multiple facilities (Congress of the United States Congressional Budget Office, 2008), or when paper records are lost, misfiled or not readily available. EMRs can reduce test duplication by displaying past test results, highlighting redundancy through alerts and decreasing the number of test results that are lost or misplaced through electronic filing. This benefit is likely to be substantially enhanced when there is more integration between EMRs, EHRs, and other systems external to the community-based setting.

This Study estimated the benefit from reduced duplicate testing as a result of EMRs at **$99 million in 2012 (ranging from $29 million to $145 million)** with 6.5 million fewer duplicates in 2012 (ranging from 2.2 million to 9.1 million).

This section estimates the potential benefit from appropriately reducing duplicate laboratory and DI tests in community-based settings in Canada, given the current ability of EMRs to notify physicians of duplication. As more functionalities become available and adoption increases, the potential for reduced duplication may increase. Also, there are benefits to patients who will not have to undergo additional testing with the associated anxiety, potential loss of income due to work absence, or the burden of travel costs. These additional benefits are not estimated here.

Findings from Literature

The literature suggests that EMRs have the ability to substantially decrease diagnostic test redundancy. The primary tests measured in studies were laboratory and radiology testing. It should be noted that some studies report the percentage decrease in all tests, whereas others report the percentage reduction in duplicate tests.

Estimates of the size of the effect varied from study to study and reductions ranged from less than 1% to nearly 14% of tests. A number of studies rely on the Bates et al. (1999) finding that 69% of redundant tests can be cancelled with reminders and the Bates et al. (1998) finding that 9% of laboratory tests are redundant, meaning that approximately 6% of all laboratory tests (69% of 9%) could be eliminated through an alert notice of redundancy.

The majority of studies were conducted in a hospital setting, and results may differ in a community setting. However, Tierney et al. (1987) compared in an outpatient setting, the pre and post levels of testing after implementation of a computer program displaying previous test results and found an 8.5% reduction.

Although the studies above combined radiology and laboratory tests, findings related to diagnostic imaging were limited in demonstrating reductions in duplicate testing. You et al. (2008) examined the impact on imaging frequency with the use of Picture Archiving and Communication Systems (PACS) and found a reduction in duplicate X-rays within a 60 day period of 0.9% but an increase in duplicate CT scans of 0.5%. This may be a result of the feature being compared (PACS vs. redundancy alerts) but could also be a result of the tests being measured. For instance, some tests may be more subject to redundancy and may be more heavily impacted by the use of an EMR.

Key findings are described in the tables below.

Table 7: Findings on Test Duplication Reductions

Study	Setting	Feature	Test Reduction
Tierney et al. (1987)	Primary care	Previous test results	8.5% reduction in tests
Bates et al. (1999)	Hospital	Alert of redundancy	69% reduction in duplicate tests
Congress of the United States Congressional Budget Office (2008), Moshman et al. (2006), based on Bates	Hospital	Alert of redundancy	6% reduction in tests
Walker et al. (2005)	Hospital	Advisory panel opinion	13.7% reduction in tests
Daurio et al. (2009)	Hospital	EMR	48% reduction in duplicate tests
You et al. (2008)	Hospital	PACS	0.9% reduction in duplicate X-rays, 0.5% increase in duplicate CT scans

Model

The benefits in Canada of a reduced number of duplicate diagnostic tests in community-based practices were estimated. The reduction in duplicate testing was estimated from the average of study findings, using lower and upper estimates to describe the full range of reductions experienced. The estimate from Walker et al. (2005) was excluded from the average as it was based on the opinion of an advisory panel. The estimate from You et al. (2008) was also excluded from the average reduction for lab tests but was included in the average for DI because it focused on imaging alone whereas other studies included both labs and radiology.

The reduction in lab and imaging tests was applied to the annual number of lab reports and DI reports in Canada to obtain the potential estimate of reduced testing volumes. The number of annual lab and DI tests was adjusted for the volume that is expected to be ordered from community-based physicians (see Appendix D for details). Also, Magnetic Resonance Imaging (MRI) scans and Computed Tomography (CT) scans were excluded under the assumption that they are less likely to be duplicated due to the sometimes long wait lists for these tests. The number of lab tests and DI tests prevented were multiplied by their respective average costs to obtain a projection of potential annual benefits.

Based on PwC analysis of CWF 2012 data, it was assumed that nearly one quarter (24%) of primary care physicians currently using an EMR in Canada would experience reductions in duplicate testing by using an EMR to review all labs results for any of their patients. As a conservative estimate, this 24% was reduced to 9% based on the number of physicians who could also generate a list of patients due or overdue for tests or preventive care. The maturity of use for specialists was assumed to be 81% that of primary care providers (or 19% lower) based on the ratio of specialist to primary care physician EMR use from analysis of NPS 2010 data.

Input and benefits estimates are described in the tables below.

Figure 8: Inputs for Duplicate Test Model (details in Appendix D)

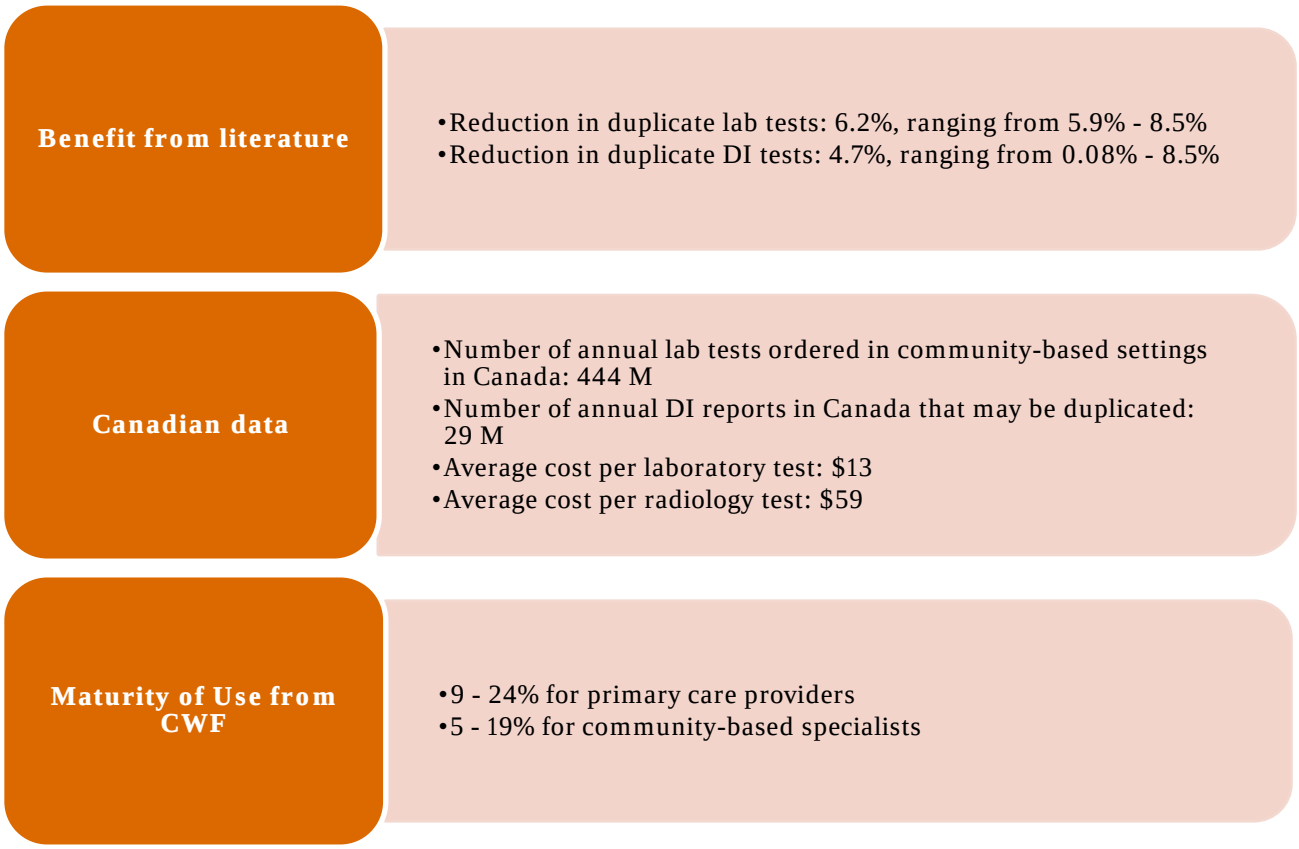


Table 8: Benefits estimated from reduced duplicate testing

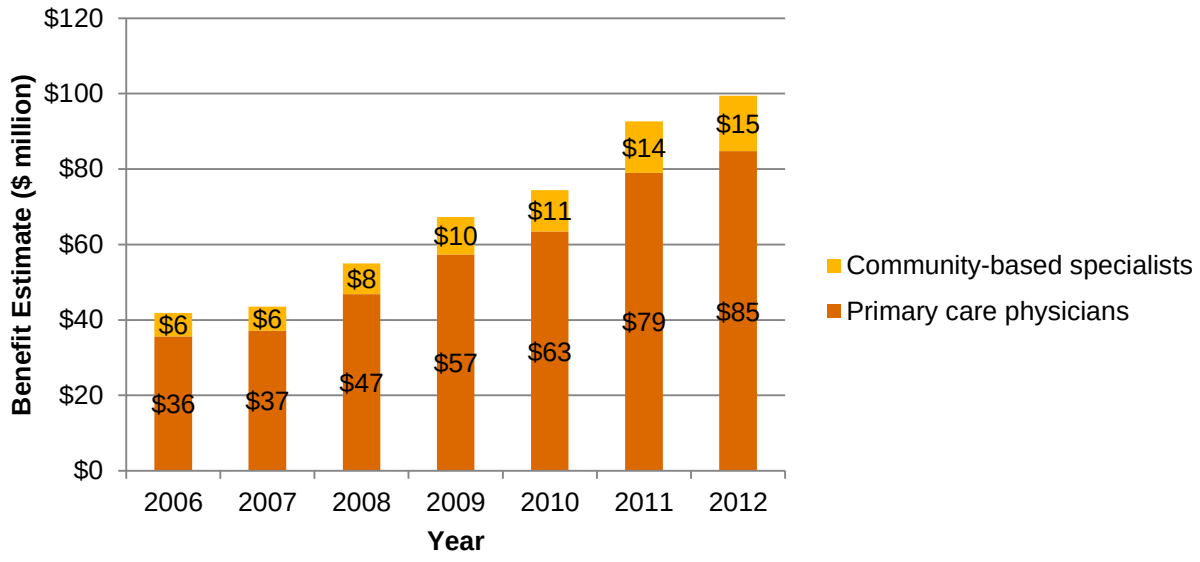
Benefit area	Benefits estimate	Range
Benefit from reduced duplicate testing due to EMRs in 2012	$ 99 million	$ 29 - $145 million
	6.5 million fewer duplicates	2.2 - 9.1 million fewer duplicates

The benefit from reduced duplicate testing as a result of EMR use is estimated at **$99 million in 2012 (ranging from $29 million to $145 million)** with 6.5 million fewer duplicates in 2012 (ranging from 2.2 million to 9.1 million). On top of this monetary benefit, there are benefits to patients who will not have to undergo additional testing with the associated anxiety, potential loss of income due to work absence, or the burden of travel costs. These additional benefits are not estimated here.

The benefits experienced by community-based specialists are estimated at $15 million, or 15% of the total benefit estimated. Although it is unknown to what extent specialists use EMRs to reduce unnecessary testing, their overall use of EMRs is lower than primary care physicians which contributes to a lower estimated benefit.

The figure below illustrates the benefits accumulated from 2006 to 2012 as a result of increasing maturity of use over time. The CWF 2009 was used for 2009 maturity of use and maturity of use in prior years was estimated based on EMR adoption rates (see Appendix D for details). As shown, the benefit has more than doubled over six years, from $42 million in 2006 to $99 million in 2012.

Figure 9: Cumulative benefits from reduced duplicate tests, 2006-2012



3.2.2 EMR use improves patient safety through reduced adverse drug events

Summary

Medication errors and adverse drug events (ADE) in primary care are associated with negative health outcomes and significant health care costs. It has been reported that one-third to one-half of ADEs are preventable (Hillestad et al., 2005).

With the use of computerized physician order entry (CPOE), EMRs can alert the physician at time of entry to potential errors or ADEs such as interactions with other medications or patient allergies. Reducing legibility and completeness issues related to handwritten prescriptions also reduces the risk of ADEs.

The benefits associated with a reduction in ADEs have been addressed in a previous *Infoway* commissioned study (Deloitte, 2010). The study estimated the total annual benefits of early ePrescribing at $83.4M, of which $24.1M accrues from avoided ADEs due to printed/typed prescriptions).

This Study estimated that EMRs have contributed to benefits valued at **$24.1 million in 2012** by reducing the number of ADEs resulting from illegible prescriptions.

Findings from Literature

Overall, research has indicated that with the use of health IT, there is a potential for 50% to 90% reduction in error rates, with medication errors being a common form of error (Congress of the United States Congressional Budget Office, 2008). Medication errors and adverse drug events in ambulatory settings have been studied much less than in hospitals (Hillestad et al., 2005; Congress of the United States Congressional Budget Office, 2008); however, the literature points to a positive impact of EMRs in primary care on medication error rates and inappropriate prescriptions.

Johnston et al. (2003) found that the number of ADEs may vary widely with the maturity of use of adoption and EMR functionalities used, ranging from 8% of prevented ADEs with a basic system to 76% with an advanced system. Taking a closer look at the Canadian primary care setting, Tamblyn et al. (2003) assessed the effectiveness of computerized decision support (CDS) in curbing inappropriate prescribing. In addition to current and past medication history, physicians were provided with a medication alert if any prescribing problems were identified by the CDS software. Findings suggest that access to complete drug profiles coupled with prescribing alerts reduced the rate of initiation of potentially inappropriate prescriptions. The study also suggested a more selective effect when discontinuing potentially inappropriate prescriptions.

Positive findings on medication error rates or inappropriate prescriptions include:

- A benefit of $63.5 million was measured in Canada for reduced ADEs resulting from use of the medication profile in the Drug Information System (DIS) (Deloitte, 2010).
- Another $24.1 million benefit was estimated for reduced ADEs resulting from reductions in medication errors due to greater legibility of prescriptions (Deloitte, 2010).
- The number of new, potentially inappropriate prescriptions was significantly lower (18%) in groups receiving computerized decision support than in the control group. There was no significant impact on the discontinuation of pre-existing inappropriate prescriptions (Tamblyn et al., 2003).
- Approximately 8 million outpatient adverse events occur each year, of which 33-50% are preventable. Approximately 67% of preventable ADEs might be avoided through widespread use of ambulatory CPOE (Hillestad et al., 2005).
- Approximately 25-33% of ADEs in an ambulatory care environment may be preventable by using such tools as computerized prescribing (Moshman Associates et al., 2006).

Estimates of the change in costs due to ADEs include:

- One study estimated the average cost of ADEs to be approximately $2,262 per event within an acute care setting (Moshman Associates et al., 2006). This estimate is similar to the cost estimates in the ambulatory setting. In another study, the estimated cost of preventable ADEs in the ambulatory setting was approximately $1,900 per event (Moshman Associates et al., 2006).
- Each avoided event saves $1,000–$2,000 related to avoided office visits, hospitalizations, and other care (Hillestad et al., 2005).
- In Canada, the average weighted cost of an ADE was estimated at $646 dollars (Deloitte, 2010).

Model

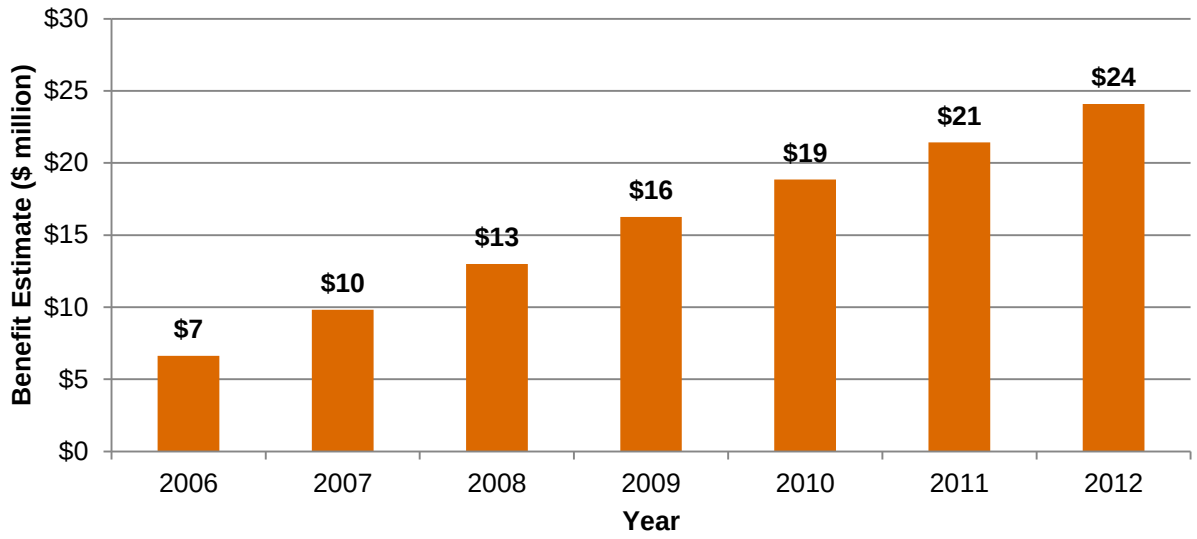
The benefits estimate associated with reduced ADEs as a result of printed or typed prescriptions (rather than handwritten prescriptions) was extracted from the *Infoway* DIS study. The study estimated that the annual benefit in 2010 was valued at $24.1 million.

This estimate was based on 40% of all 466 million prescriptions filled in community pharmacies in Canada arriving in printed or typed format. Therefore the benefit is associated with physicians practicing in a community-based setting and it is expected that the benefit is largely the result of EMRs given few paper-based physicians print prescriptions. Consistent with this approach is the fact that 40% of primary care physicians in the CWF 2012 reported prescribing medication electronically (PwC analysis).

The benefits accumulated from 2006 to 2012 were estimated by adjusting the percentage of printed or typed prescriptions in the model from the *Infoway* DIS study. Maturity of use in terms of electronic prescribing from the CWF 2006 and CWF 2009 were used as proxies for the historical percentage of printed or typed prescriptions (see Appendix D for details).

The figure below illustrates the benefits accumulated from 2006 to 2012 as a result of increasing maturity of use over time. As shown, the benefit has more than tripled over six years, from nearly $7 million in 2006 to over $24 million in 2012.

Figure 10: Cumulative benefits from reduced ADEs, 2006-2012



3.2.3 Emerging benefit: EMR use increases the appropriateness of diagnostic tests

Summary

Aside from duplications and redundancy, some tests may be inappropriately ordered or avoidable. Inappropriate testing may be a result of a provider's habits or preferences or other factors. EMRs can provide a number of decision support features (such as guidelines, tests costs, alerts for abnormal ordering) that can reduce the misuse or overuse of certain diagnostic tests.

This Study estimated that EMRs could help reduce the number of inappropriate tests by 6,000 for three specific diagnostic tests ordered in community-based practices, leading to a benefit to the health care system of approximately **$5.7 million** per year. EMRs likely reduce a range of inappropriate diagnostic tests; however, the existing research is limited to three specific tests that are included in this estimate. Also, this relatively low benefit (compared to duplicate test estimate) is linked to low maturity of use which may be due to the early stage of diagnostic imaging decision support in EMRs currently offered in Canada. Additionally, there are benefits to patients who will not have to undergo additional testing with the associated anxiety, missed work time, or travel expense.

Based on available evidence in the literature, the three types of diagnostic tests modeled here to generate benefits estimates include: sinus CT, lumbar MRI and brain MRI. These three tests represent approximately 15% of all MRIs and CTs ordered by community-based physicians in Canada (You et al., 2007). The ordering of other high cost and/or high use tests may be impacted by EMRs and are not included here due to lack of available evidence. Moreover, decision support around diagnostic tests is in its infancy in Canada and observed benefits are at an early stage. As EMR adoption, maturity of use and functionality improve, associated benefits may increase.

Findings from Literature

Studies have largely found a positive impact of EMRs on testing, both on reducing the number of tests ordered and reducing costs associated with testing (Chaudhry et al., 2006). Estimates of the impact vary from study to study and appear to be dependent on a number of factors, including the test and EMR feature (e.g. cost information vs. decision support) being investigated. Some tests may be more subject to inappropriate or overuse and some EMR features may be more successful than others at curbing use.

Interventions that have been shown to increase the appropriateness of testing include: 1) displaying test charges (and highlighting the cost of ordering unnecessary tests), 2) using order forms with fewer laboratory tests options, 3) automating calculation of pre-test probability for diagnostic tests (and alerting for ordering anomalies), and 4) providing guideline-driven decision support tools. In the case of guideline decision support, the EMR may, for example, suggest an optimal but restricted list of diagnostic tests based on patient presentation. (Poley et al., 2007, Chaudhry et al., 2006)

The literature has suggested that physicians may be more selective in ordering tests as a result of using an EMR. Poley et al. (2007) found that the number of orders remained unchanged but that the number of tests per order dropped, suggesting that physicians may be ordering fewer but more targeted and appropriate tests. Similarly, Furukawa et al. (2011) found that physicians with an EMR were more likely to submit an order for a laboratory test, but requested fewer tests within that order compared to their counterparts who did not use EMRs and who submitted an order.

Focusing on procedures which are both high use and high cost, Blackmore et al. (2011) found reductions of more than 20% for lumbar and brain MRIs and CT scans. The authors suggested that reductions in costs and inappropriateness of requesting these types of procedures are the most likely to benefit from the use of an EMR in this area.

Other findings are described in the table below (see Appendix D for those included in the model):

Table 9: Findings on Inappropriate Test Reductions

Study	Setting	Feature	Test Reduction
Tierney et al. (1988) from Chaudhry et al. (2006)	Primary care	Pretest probabilities for diagnostic tests on utilization of care	8.8% decrease (from $12.27 to $11.18) in diagnostic test costs per patient visit
Tierney et al. (1990) from Chaudhry et al. (2006)	Primary care	Information on test costs	14.3% decrease (from 1.82 to 1.56) in number of diagnostic tests ordered per visit; 12.9% decrease (from $51.81 to $45.13) in diagnostic test costs per visit
Furukawa et al. (2011)	Primary care	Overall EMR use	Higher probability of any laboratory test (5.7%); and fewer laboratory tests (−7.1%)

Study	Setting	Feature	Test Reduction
Blackmore et al. (2011)	Primary care	Decision support	Reduced lumbar MRI (23.4%,), brain MRI (23.2%), and sinus CT (26.8%) tests
Poley et al. (2007)	Primary care	Decision support	Mean cost decrease of 3% in the intervention group, compared with a 2% increase in the control group

Model

Findings from Blackmore et al. (2011) were used to estimate reductions in three specific tests. These reductions were applied to the respective number of these tests per 100,000 conducted in Canada annually by population. Tests were then prorated by the share of community-based physicians in the physician population to adjust for the fact that some tests are ordered outside of a community-based setting.

The total number of prevented tests was then multiplied by their respective costs to obtain annual benefit estimates. Other tests such as x-rays were not included as there is little evidence as to the impact of EMRs on the appropriateness of these tests. Duplication of x-rays was included in the previous benefit estimate.

Based on analysis of CWF 2012 data, it was assumed that about 6% of primary care physicians in Canada use their EMR in a way that enables them to reduce inappropriate test ordering. Indeed, prompts related to appropriate test ordering (i.e. other than past test results) based on standard guidelines is not a commonplace feature of EMRs in Canada[8]. Few physicians reported in CWF 2012 of being able to easily generate lists of lab results for individual patients, lists of patients due for tests or preventive care, as well as routinely receive reminders for guideline-based intervention and/or screening tests. Since similar information was not available for community-based specialists it was assumed that maturity of use would be 19% lower given that 19% fewer specialists use an EMR (PwC analysis).

Input and benefits estimates are described in the figures below.

[8] The Nightingale EMR recently incorporated Clinical Decision Support for Diagnostic Imaging and, to the authors' knowledge, is the only system to currently offer this feature.

Figure 11: Inputs for Inappropriate Test Model (details in Appendix D)

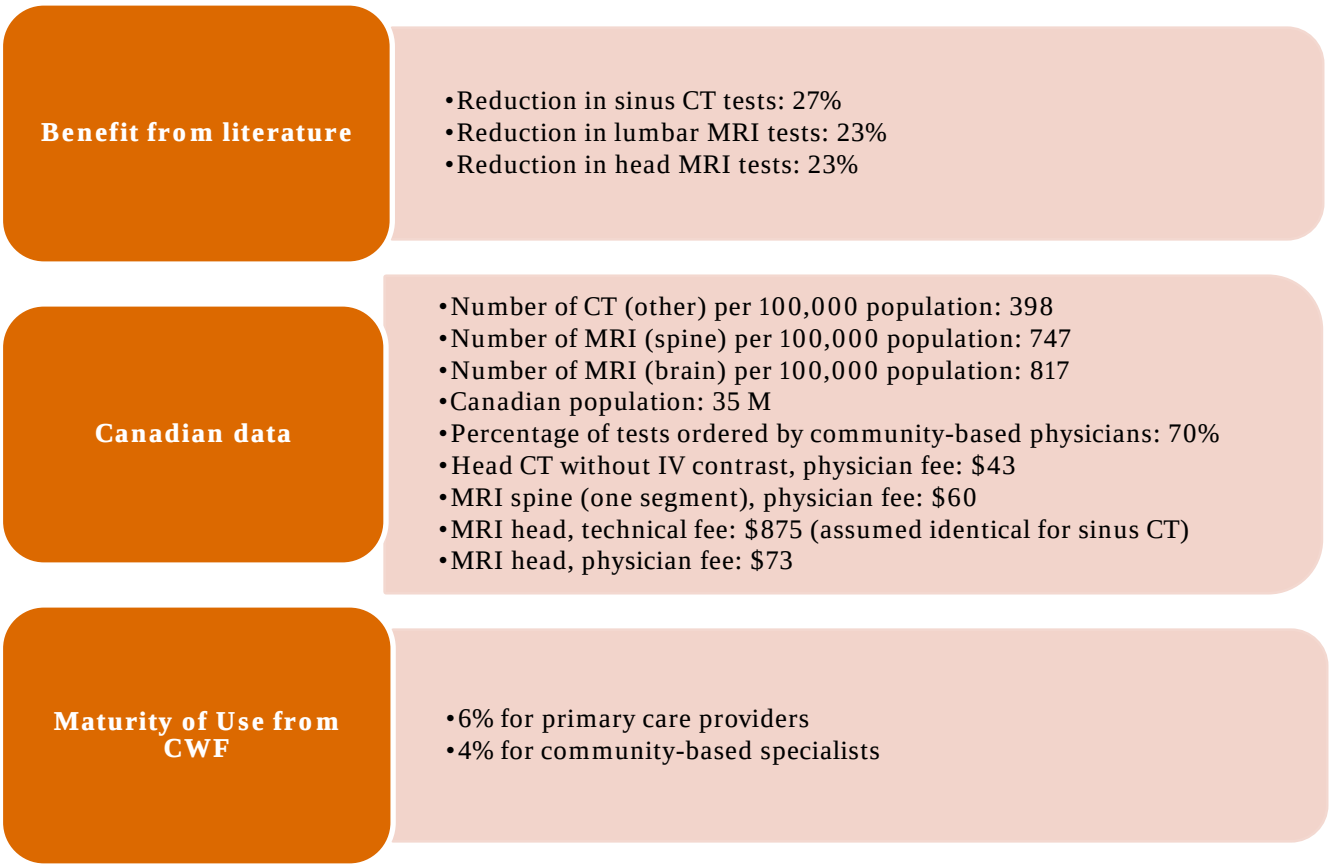


Table 10: Benefits estimated from reduced inappropriate testing

Benefit area	Benefits estimate	Range
Benefit from reduced inappropriate testing in 2012 for selected tests	$ 5.7 million for selected tests 6,000 prevented inappropriate tests for selected tests	N/A
Benefit from reduced inappropriate testing in 2012 for all tests	N/A	

The emerging benefit from reducing inappropriate testing was estimated at **$5.7 million in 2012**, based on reducing the number of three specific diagnostic tests alone by 6,000. In addition to this benefit, reductions in inappropriate tests performed lead to improved quality of life and cost savings for patients who are not subjected to the anxiety, missed work days and traveling time commitments associated with undergoing testing.

3.3 Advanced use of EMRs can improve health outcomes and patient safety through preventive care and chronic disease management.

The costs of managing chronic diseases currently account for 58% of all health care spending in Canada and are estimated at $68 billion annually and growing; in addition, the indirect costs associated with income and productivity loss are estimated at $122 billion, or double the costs of managing chronic diseases (Public Health Agency of Canada, 2011). As such, with advanced use of EMRs (i.e., use of a broader range of available functionalities) there is a significant opportunity to support improved chronic disease management (CDM) and preventive care and potentially reduce the associated costs to the health care system. However, self-reported national survey responses revealed that only 3% - 18% of primary care physicians in Canada were estimated to effectively use EMRs for this purpose.

86% of physicians in Alberta's EMR program report that their ability to manage patients' chronic diseases is improved through the use of such EMR tools as alerts, flow sheets, reminders and goals.

Alberta Physician Office System Program (POSP) Benefits Survey, 2012

Research has indicated that with advanced EMR use, positive impacts can be expected such as:

- improved identification of at-risk or in need of follow-up patients/populations;
- improved screening rates and testing frequency;
- enhanced adherence and responsiveness to guidelines and changes in guidelines;
- improved physiological outcomes; and
- improved immunization rates.

Table 11: Summary of Estimated and Emerging Benefits

Estimated benefits	Emerging benefits
Insufficient evidence to estimate benefits	• Time savings to respond to 1 change in guideline or medication recall per year **0.2M hours - $3.7M in 2012** • Reduced health services utilization due to influenza and pneumococcal vaccinations for Canadians over 65 **$2.4M to $8.2M, 400 – 1,300 fewer hospital visits**

3.3.1 Emerging benefit: EMR use has the potential to improve chronic disease management and preventive care

Summary

Costs for managing chronic diseases represent 58% of all annual health care spending in Canada, at a cost of $68 billion annually and growing. In addition, the indirect costs associated with income and productivity loss are estimated at $122 billion, or double the health care costs (Public Health Agency of Canada, 2011). Costs associated with diabetes alone were estimated at approximately $12.2 billion in 2010 and are expected to rise by another $4.7 billion by 2020 (Canadian Diabetes Association, 2009).

EMRs can support chronic disease management and prevention by assisting clinicians in (Hillestad et al., 2005):

- Identifying people with an active or potential chronic disease (e.g., through predictive-modeling algorithms);
- Targeting services to patients based on their level of risk. Sicker patients can benefit from more tailored, more-intensive interventions;
- Monitoring conditions. Condition-specific encounter templates implemented in an EMR system can ensure consistent recording of disease-specific clinical results, leading to better clinical decisions and outcomes;
- Improving screening and testing by tracking the frequency of preventive services and reminding physicians to offer recommended tests;
- Modifying patient behavior. Electronic messaging offers a low-cost, efficient means of distributing reminders to patients and responding to patient inquiries. Also, web-based patient education can increase the patient's knowledge of a disease and compliance with protocols;
- Adjusting therapy (e.g., based on the use of easily accessible and regularly updated guidelines);
- Improving case management for higher-risk patients (e.g., by improving communication between multiple specialists and patients); and
- Connecting to national disease registries allows practices to compare their performance with that of others.

Another benefitthat has been reported by stakeholders is the longitudinal existence of data. For providers, there is an ease to viewing test results over long periods of time informing quality of care and continuous improvement, whereas in a paper-based practice it is far more difficult to trend and assess a patient's complete disease history. In addition, it has been noted that patients also benefit as the data is more easily accessible and they can visually observe the management of their condition over time.

This section estimates the potential health outcome benefits from improved diabetes management and prevention, given the current use of EMRs and their ability to assist providers in CDM. Health benefits and avoided costs are expected to grow as more providers adopt EMRs, and as EMR capabilities become increasingly sophisticated. Also, while there are many prevalent chronic diseases for which management may improve through the use of an EMR (e.g., chronic obstructive pulmonary disease, congestive heart failure), there is little to no research available to substantiate the potential avoided costs and improvement in long-term outcomes.

Findings from Literature

Impact on Preventive Care

The literature has shown preventive care to be an area where EMRs can have a substantial positive impact. In a systematic review of controlled health information system (HIS) studies, Lau et al. (2010) found that 72% of studies had positive results using preventive care reminders, mostly through guideline adherence such as immunization and health screening. In another systematic review focused on the impact of EMRs specifically, Lau et al. (2012) found that preventive care had the most positive findings (about 67% of studies showed a positive effect of EMRs).

In a Canadian study aimed at identifying organizational factors associated with superior preventive care, Dahrouge et al. (2012) found that practices with an electronic reminder system had superior prevention scores, as measured by cervical cancer / breast cancer / colorectal cancer screening, influenza immunization, visual impairment screening, and auditory impairment screening. A demonstration project funded by the Ontario Ministry of Health found that combined automated provider and patient reminders delivered not through EMR but with a system-wide data-integrated and guidelines-driven preventive care/chronic disease management system and bonus incentives increased the rate of Pap and mammography screening for eligible women by 6.3 percentage points and 5.3 percentage points, respectively, over one year (Kaczorowski, et al., 2013).

Other international studies estimated the following impacts of EMRs on preventive care:

- Frequently used multifunctional EMRs were associated with increased screening for eligible individuals: 3.3 percentage points higher for breast cancer, 4 percentage points higher for colorectal cancer, 7.6 percentage points higher for Chlamydia[9] (Friedberg et al., 2009).
- Access to EMR information coupled with an alert (e.g. hypertension, cardiovascular disease, lipid metabolism disorders, obesity) identified 28% of the patient population to be at risk for undiagnosed type 2 diabetes (Klein Woolthuis et al., 2007).
- Mammogram screening rates increased by more than 10% and cholesterol screening rates increased by nearly 12% with computer-generated reminders (Johnston et al., 2003).
- Computerized reminders led to a 33% absolute increase in fecal occult blood testing and pneumococcal vaccination, 16% absolute increase in screening mammography, and 12% absolute increase in metronidazole for trichomonas infections. Other preventive care processes evaluated showed no statistically or clinically significant improvement with electronic reminders (Chaudhry et al., 2006).
- More patients received the recommended preventive and care management services. The number of mammograms rendered increased by 10% (Chapman et al., 2009).
- Bone density screening was completed in 17.7% of patients in the control group, 19.7% of the EMR reminder group, and 30.5% of the EMR reminder group who also had an assistant that supported patients and physicians in achieving guidelines (Loo et al., 2011).
- EMR systems increased the number of breast examinations, pelvic examinations, Pap tests, Chlamydia tests, cholesterol tests, mammograms, and bone mineral density (BMD) tests. Furthermore, the level of sophistication of the EMR increased the number of breast examinations and Pap, Chlamydia, cholesterol, and BMD tests (Tundia et al., 2012).

It is important to note that, although reminders and other decision support features may exist within an EMR, physicians must be willing to utilize the recommendations for the tools to be effective. For example, one study reported that although decision support was available to 65% of EMR adopters in ambulatory care practices, only 23.5% were found to be using this feature (Zhou et al., 2009). Similarly, “alert fatigue” has also been studied where, due to the large number of alerts/ notifications, providers tend to ignore or override them (Lee et al., 2010).

EMRs may also improve the efficiency of conducting prevention activities. One study examined the ability of EMR decision support to assess the cardiac risk in patients and target patients in need of antiplatelet and lipid-lowering therapy (Persell et al., 2009). EMR assessments were compared to manual chart reviews and it was found that EMRs targeted similar rates of at-risk individuals but more rapidly.

One Canadian study did not find a positive impact of EMRs on prevention. After examining the provision of four preventive services (Pap tests, screening mammograms, fecal occult blood testing, and influenza vaccinations) in the first two years of EMR implementation, Greiver et al. (2011) found that combined preventive services for the EMR group increased by 0.7% only, less than the non-EMR group. The rate of Pap tests and mammograms were shown individually to increase, although this was not statistically significant. It should be noted that these practices were observed shortly after implementation and the lack of improvement may be a result of timing (i.e. EMRs must be populated with patient data by the provider; providers must learn how to use the tool for preventive care).

[9] Breast cancer screening was measured as the percentage of women aged 42 to 69 years who had at least 1 mammogram in the measurement year or year before the measurement year. Colorectal cancer was measured as the percentage of adults aged 51 to 80 years who had 1 or more of the following: fecal occult blood test during the measurement year, flexible sigmoidoscopy during the past 5 years, double-contrast barium enema or air-contrast barium enema during the past 5 years, or colonoscopy during the past 10 years. Chlamydia screening was measured as the percentage of sexually active women aged 21 to 26 who had at least 1 test for Chlamydia during the measurement year.

Impact on Cost

While there is good emerging evidence on the impact of EMRs in increasing use of certain preventive interventions, there remains limited research on how this translates into longer-term outcomes and health system savings.

The impact of EMRs on reducing system level costs from disease prevention has not been widely measured; however, the broad impact of health information technology has been estimated using various assumptions. Hillestad et al. (2005) estimated the potential avoided costs enabled by health IT by assuming 100% compliance with cancer screening guidelines. Although the screenings did not achieve cost savings, they produced significant health benefits at relatively low cost:

- Cervical cancer screening was associated with 13,000 life-years gained at a cost of $0.1–$0.4 billion.
- Screening for colorectal cancer was associated with 138,000 life-years gained per year at a cost of $0.5 - $5 billion per year.
- Screening for breast cancer was associated with program costs of $1-$3 billion and financial benefits up to $643 million per year.

In Canada, Manitoba Health estimated the impact of specific screening guidelines[10] (enabled by EMRs) for breast, colorectal and cervical cancer (Prairie Research Associates, 2011). Outcomes associated with the use of screening guidelines were projected as follows:

- Breast cancer screening was associated with a potential avoided cost of $2.6M over no screening, and a potential avoided cost of $717,000 over current screening practice over 25 years.
- Colorectal cancer screening was associated with avoided costs of $57.5M and $10.6M over 25 years.
- Cervical cancer screening was associated with increased health system costs due to the low incidence of this condition (i.e. the costs of delivering the program were not recovered by the reduced costs associated with earlier detection).

Impact on Chronic Disease Management (CDM)

The literature has focused on two types of outcomes in order to measure the impact of EMR use on CDM:

- Improved adherence to evidence-based guidelines, or process outcomes; and
- Improved health outcomes such as cholesterol, blood pressure and glucose levels in patients with diabetes.

Findings related to EMR use supporting CDM have been mixed. Studies have predominantly focused on diabetes. Key findings are described in the tables below.

[10] Breast cancer screening guidelines consisted of a mammography test within the past 24 months for women aged 50 to 69 years without mammography exemptions. Colorectal screening guidelines consisted of a FOBT in the past 24 months or colonoscopy in the last 10 years for individuals aged 50 to 74 years of age. Cervical cancer screening guidelines consisted of a Pap test in the past 36 months for women aged 18 to 69 years without Pap exemptions.

Table 12: Findings on Diabetes Process Outcomes

	Peterson et al. (2008)	Russell et al. (2009)	Cebul et al. (2011)	Crosson et al. (2012)
Foot examination in last 2y	35% higher achievement	No significant impact of electronic patient records or electronic reminder system	N/A	N/A
Eye examination in last 2y	25.9% higher achievement		25% higher achievement	N/A
ACEI/ARB in last 2y	N/A		N/A	N/A
2 HbA1C tests in last 1y	8.1% higher achievement		7.2% higher achievement	No significant difference between EMR and non-EMR practices on composite
Microalbumin in last 1y	28.5% higher achievement	N/A	13.3% higher achievement	
Smoking status in last 6mo	N/A	N/A	N/A	
LDL-C in last 1y	8.6% higher achievement	N/A	N/A	
BP in 3 previous visits	3.5% higher achievement	N/A	N/A	
Pneumococcal vaccination	N/A	N/A	57.1% higher achievement	N/A

Legend: N/A = not available; 6mo / 1y / 2y = 6 months / 1 year / 2 years; ACEI = angiotensin-converting-enzyme inhibitor; ARB = angiotensin receptor blocker; HbA1C = Glycated hemoglobin; LDL-C = low-density-lipoprotein cholesterol; BP = blood pressure.

Table 13: Findings on Diabetes Health Outcomes

	Peterson et al. (2008)	Russell et al. (2009)	Cebul et al. (2011)	O'Connor et al. (2011)	Holbrook et al. (2011)	Crosson et al. (2012)
HbA1C<7%	49% EHR vs. 43.8% non-EHR	No significant impact of electronic patient records or electronic reminder system	10.9% higher achievement	Significantly better A1c levels with EHR but no significant difference in % at target A1C	N/A	No significant difference between EMR and non-EMR practices
BP<130/85	45% EHR vs. 40.6% non-EHR		11.1% higher achievement	80.2% EHR vs. 75.1% non-EHR for systolic; 85.6% EHR vs. 81.7% non-EHR for diastolic	No significant difference in mean levels	
LDL-C<100	43% EHR vs. 35.5% non-EHR	N/A	18.1% higher achievement	No significant difference between EHR and non-EHR practices		
BMI<30	N/A	N/A	2.9% lower (worse) achievement	N/A		N/A

Legend: N/A = not available; HbA1C = Glycated hemoglobin; LDL-C = low-density-lipoprotein cholesterol; BP = blood pressure; BMI = body mass index.

EMR Functionalities in Use and Diabetes Management

The apparent conflicting findings may be a result of the sophistication of each EMR and whether all available functionalities are being used on a regular basis. When the functionalities that support CDM are in use (e.g., population-based reminders and decision support), there are significant benefits to be realized.

Miller et al. (2005) conducted case studies of fourteen solo or small-group primary care practices using EMRs and found that only two extensively used their EMRs to improve chronic and preventive care. Only five had reminders set by the practice for at least one type of chronic care patient (rather than having physicians set reminders for specific patients). Only four practices created lists of at least some patients requiring needed services—for example, patients with diabetes who were overdue for a glycosylated hemoglobin test—or had a routine way of following up with patients on lists for needing services.

When a more complete range of EMR functionalities are used for CDM, however, the impacts appear to be large as shown by Cebul et al. (2011) and Peterson et al. (2008) in the tables above. Better Health in Cleveland, Ohio assisted providers in using their EMRs in meaningful ways, such as prompts for treatment of chronic conditions, techniques for medication reconciliation, and alerts for appropriate follow up care appointments. They found that, in 2011, 51% of patients with diabetes in EMR practices received care they needed as compared to 7% in practices with paper records[11].

There may be several reasons to explain why there may be a lower use of all functionalities. In certain practices, use of all/more sophisticated functionalities may be linked to early stages of EMR maturity of use. The use of advanced features or query of EMR data such as practice searches to identify potential chronic disease patients tends to occur once an EMR implementation has reached a degree of maturity of use (Balka et al., 2011). It may also be as a result of the poor quality of some EMR features or the lack of ability to customize the technology to the needs of an individual practice (Congress of the United States Congressional Budget Office, 2008). Lastly, Cebul et al. (2011) suggested that results may differ across studies based on the quality of clinical decision support available and the continuity of care.

An additional EMR benefit may also be improved provider productivity during visits for routine chronic care. Furukawa et al. (2011) reported that general EMR use during routine visits for chronic conditions was associated with 11.2% more total services and 15.3% increase in diagnostic/ screening services. Reed et al. (2012) found that EMR use was associated with improved drug treatment intensification with greater improvements among patients with worse control and less testing in patients already meeting guideline-recommended glycemic and lipid targets.

EMRs and Management of other Chronic Diseases

Studies on chronic diseases other than diabetes find very little evidence regarding the impact of EMRs. Findings from Linder et al. (2007) suggest no significant difference in performance on select indicators of medical management of common diseases: antithrombotic therapy for atrial fibrillation (AF), aspirin use and beta-blocker use for coronary artery disease (CAD), diuretic and beta-blocker use for hypertension (HTN), inhaled corticosteroid (IC) use for asthma and treatment of depression. However, Linder did find that practices using EMRs had better performance in avoiding benzodiazepine use for patients with depression and worse performance in prescribing statins to patients with hypercholesterolemia.

Similarly, Russell et al. (2009) found no significant impact of electronic patient records or electronic reminder systems on improved aspirin, beta-blocker and statin prescribing in CAD patients or improved angiotensin-converting-enzyme inhibitor (ACEI)/angiotensin receptor blocker (ARB) and beta-blocker prescribing in congestive heart failure (CHF) patients.

Impact on Cost

The impact of EMR use on health care system costs has not been measured but the impact of broader health IT has been estimated using various assumptions. In a U.S. study for example, Hillestad et al. (2005) estimated the potential of health IT by assuming a 100% participation of eligible patients in four chronic disease management programs: asthma, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and diabetes. They found that total spending would decrease by over $28 billion, with more than half attributable to the disease management program.

In Canada, Manitoba Health estimated that increasing the likelihood of diabetic control (i.e. the percentage of diabetic patients with their disease under control) from 70% to 100% in patients with diabetes in the province would generate a total avoided cost of $1.1 million over a 40-year period. This estimate provides the upper bound of

[11] Better Health Greater Cleveland (n.d.). Reform in Action: Does use of EHRs help improve quality? Insights from Cleveland [Data Brief].

avoided costs from achieving diabetic control for all patients who currently are diagnosed with diabetes (note that prevention is addressed in another section).

Maturity of Use in Canada

The potential for EMRs to improve preventive care and CDM were largely found to depend on the maturity of use. Indeed, when the EMR functionalities that support prevention and CDM are used (e.g., population-based reminders and decision support), there are significant benefits to be realized. However, self-reported survey responses suggest that only 3% - 18% of physicians in Canada were estimated to effectively use EMRs for this purpose.

Various methods were used to estimate the maturity of EMR use for CDM in Canada. Three data sources were used:

- Commonwealth Fund (CWF) Survey 2012;
- National Physician Survey (NPS) 2010; and
- Environmental scan of the volume of Canadian primary care physicians involved in EMR-enabled chronic disease management initiatives such as EMR data abstraction-analysis, and audit and quality of care indicator report back initiatives (Canada Health Infoway, unpublished).

The table below presents estimates from these data sources. The estimate from analysis of CWF 2012 data (3%) was based on the number of physicians who 1) reported using an EMR, and 2) are able to easily list, using a computer, their patients due or overdue for tests or preventive care, and 3) routinely send preventive or follow-up care reminders to patients, and 4) receive reminders for guideline-based interventions and/or screening tests. A less conservative maturity of use estimate (7%) from the CWF excludes the requirement for routine reminders to patients, as patient involvement through EMRs is not currently standard in Canada.

The estimate from analysis of the NPS 2010 data (18%) was based on the proportion of physicians who reported using a combination of paper and electronic charts or electronic records only for their record keeping, **and** use an EMR to manage their patients' chronic conditions. A more conservative maturity of use estimate (17%) includes all physicians who responded that they have summary information on their patient population with chronic diseases (PwC analysis).

The environmental scan estimated that approximately 1,308 physicians are involved in formal CDM quality improvement or incentive programs across Canada. Based on a total of 36,000 general practitioners in 2011, this represents 4%.

Table 14: Maturity of use Estimates for CDM

Estimate	Commonwealth Fund Survey 2012	National Physician Survey 2010	Infoway Environmental Scan
Baseline	3%	17%	4%
High	7%	18%	N/A

Through self-reported data, 3 to 10% of primary care physicians were estimated to use their EMRs for prevention activities. The lower bound of the range is based on the number of physicians who reported in the Commonwealth Fund Survey 2012 that they used an EMR and were able, using a computerized system, to easily generate a list of patients overdue for test/care, routinely send reminders of preventive care and interventions/screenings, as well as receive reminders (PwC analysis). The upper bound of the range is based on the number of physicians who reported that they used an EMR and were able, using a computerized *or a manual* system, to easily generate a list of patients

overdue for test/care and routinely send reminders of preventive care and interventions/screenings *(receiving reminders was omitted)*.

3.3.3 Emerging benefit: EMR use improves immunization rates

Summary

EMRs have the ability to improve immunization rates by helping to identify patients in need of specific immunizations and providing reminders to physicians (and potentially patients) for updates. Some EMRs integrate evidence-based recommendations for vaccines using patient demographic and clinical data such as gender, age and family history to target patients requiring immunization. Others may also provide reminders to offer or review immunizations during routine visits or provide reminders to patients to schedule care. Reminders to patients generated by EMR systems have been shown to increase patient compliance with preventive care recommendations (Hillestad et al., 2005).

This Study estimated the benefit of EMRs to the health care system at **$2.4 million to $8.2 million in 2012** by increasing rates of influenza and pneumococcal immunization in the population over 65 in Canada. On top of this monetary benefit, increased immunization leads to improvements in health outcomes. Current influenza immunization rate increases from EMRs are estimated to have reduced GP visits by 1,000 to 3,500, ED visits by 480 to 1,600 and hospital visits by 370 to 1,200 in 2012. Increased pneumococcal immunization is estimated to have reduced the number of pneumonia cases by 120 to 400 and the number of hospitalizations by 30 to 100 in 2012.

This Study estimated the benefit of EMRs on two types of immunization in the over 65 age group, based on available evidence. EMRs have the potential to improve other immunization rates not measured here and may lead to health care system benefits for other patient populations, such as young children.

Findings from Literature

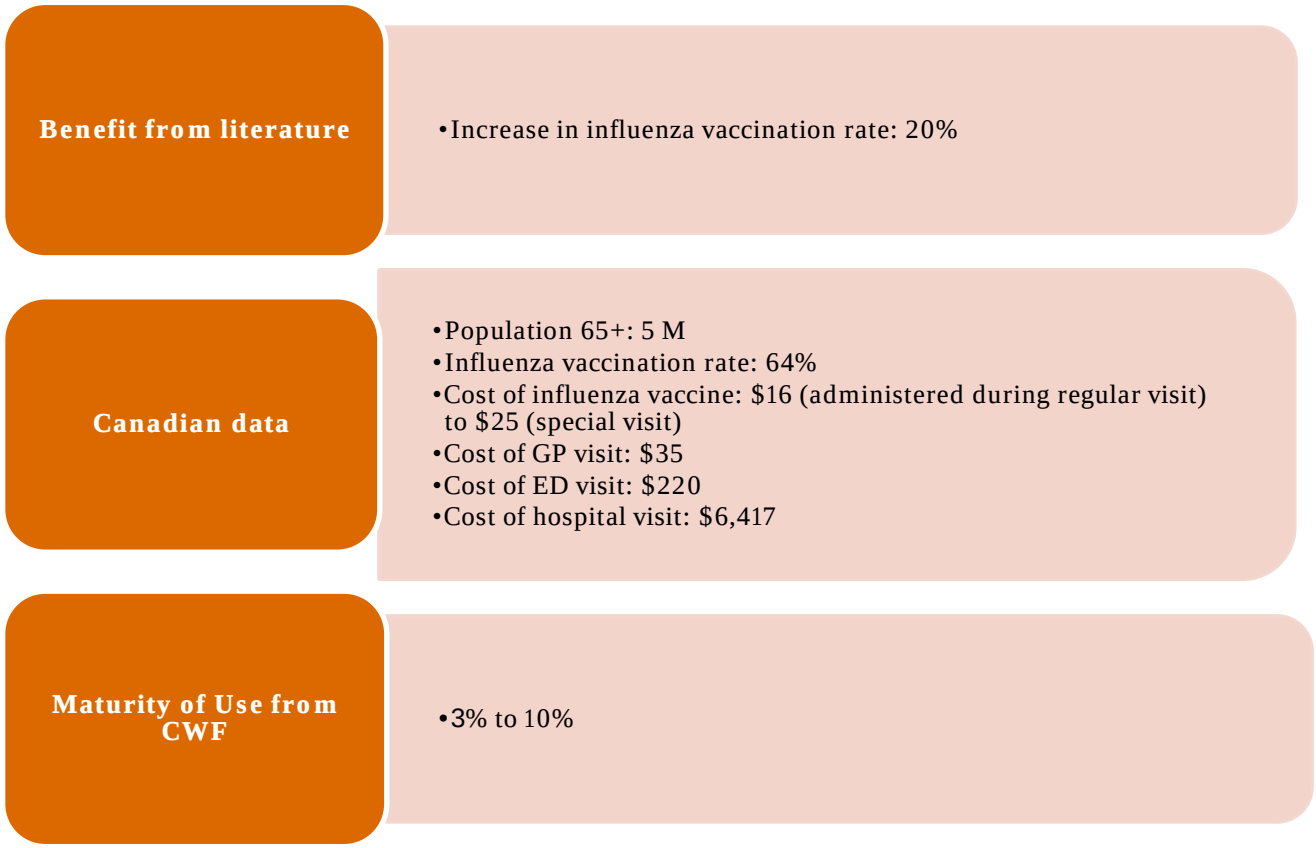
Immunization has been a focus of research in terms of the impact of EMRs on preventive care. Based on the literature, overall immunization rates do increase with the use of EMRs. In a systematic review of the literature, Chaudhry et al. (2006) reported an increase in primary influenza vaccination rates averaging 12 to 18 percentage points and an improvement in pneumococcal vaccinations of 20 to 33 percentage points. Johnston et al. (2003) also reported that practices using electronic reminders were three times as likely to have their patients up to date on immunizations (including influenza, pneumococcal and tetanus). These findings, however, were based on older studies that focused on the impact of computer-generated reminders rather than EMRs. In a more recent controlled trial, Loo et al. (2011) found a 49% increase in pneumococcal vaccination (19.5% rate in EMR reminder group vs. 13.1% in control group) and a 20.7% increase in influenza vaccination (56.5% rate in EMR reminder group vs. 46.8% in control group).

Hillestad et al. (2005) estimated the financial impacts and health benefits of influenza and pneumococcal vaccination in a population aged 65 and older in the US. Their model assumed that all people who were currently not complying with screening recommendations would be immunized as a result of EMR use. Pneumococcal vaccination was found to save U.S.$410 to U.S.$910 million per year (gains of U.S.$500-$1,000 million per year for a one-time program cost of U.S.$90 million since the population is only vaccinated once). Moreover, 15,000 to 27,000 deaths per year would potentially be avoided. Influenza vaccination, on the other hand, was found to modestly increase health care costs, while also procuring large health benefits. For an additional U.S.$62 to $295 million per year in program costs, extending influenza vaccination in the elderly were projected to save 5,200 to 11,700 lives annually.

Model

The financial impacts of increased influenza and pneumococcal vaccination related to EMR usage in Canada were estimated for the 65+ population. A cost-effectiveness model was built for each vaccination strategy using Canadian data as well as increases in immunization rates from the literature. The model for influenza was based on a Canadian model (Dahrouge et al., 2012) which models the difference in the number and costs of General Practitioner (GP), Emergency Department (ED) and hospital visits for vaccinated patients compared to unvaccinated patients, resulting from prevented flu episodes as a result of the vaccine. It is estimated that 64% of the population over 65 is vaccinated in Canada (Statistics Canada). Based on a 20% increase in rates from Loo et al. (2011) and a 3% to 10%[12] usage across Canada of EMR functionalities that would enhance immunization, it was assumed that EMRs have contributed to an increase in influenza immunization from 64% to an additional 0.4% to 1.3% (based on 3% and 10% maturity of use respectively). This relatively low increase is a result of the current low usage in Canada, according to analysis of CWF 2012 data based on primary care physicians' self-reports of use, of EMR functionalities such as generating lists of patients overdue for a test and sending reminders. Costing data and other assumptions for the model are described in the Appendix.

Figure 12: Inputs for Influenza Immunization Model (details in Appendix D)



[12] The lower bound of the range is based on the number of physicians who reported in the Commonwealth Fund Survey 2012 that they used an EMR and were able, using a computerized system, to easily generate a list of patients overdue for test/care, routinely send reminders of preventive care and interventions/screenings, as well as receive reminders. The upper bound of the range is based on the number of physicians who reported that they used an EMR and were able, using a computerized *or a manual* system, to easily generate a list of patients overdue for test/care and routinely send reminders of preventive care and interventions/screenings *(receiving reminders was omitted)*.

Table 15: Benefits estimated from increased influenza vaccination rates

Benefit area	Benefits estimate
Net benefit from increased influenza vaccination rates in 2012	$2.1 million - $6.8 million per year
Reduction in GP visits from increased influenza vaccination rates in 2012	1,000 - 3,500 fewer GP visits
Reduction in ED visits from increased influenza vaccination rates in 2012	480 - 1,600 fewer ED visits
Reduction in hospital visits from increased influenza vaccination rates in 2012	370 - 1,200 fewer hospital visits

The model for pneumococcal vaccination was based on a cost-effectiveness analysis performed by Akin et al. (2011). It models the difference in hospitalizations arising from cases of Bacteremic Pneumococcal Pneumonia (BPP) and Non-Bacteremic Pneumococcal Pneumonia (NBPP) in an elderly population as a result of the vaccine. It is estimated that 60% of the population over 65 is vaccinated in Canada, based on international literature. Based on a 49% increase in rates from Loo et al. (2011) and a 3% to 10% usage across Canada of EMR functionalities that would enhance immunization, it was assumed that EMRs have contributed to an increase in pneumococcal immunization from 60% to an additional 1-3%. Again, the low increase is a result of current low usage in Canadian primary care settings of relevant EMR functionalities. Costing data and other assumptions for the model are described in the Appendix.

Figure 13: Inputs for Pneumococcal Immunization Model (details in Appendix D)

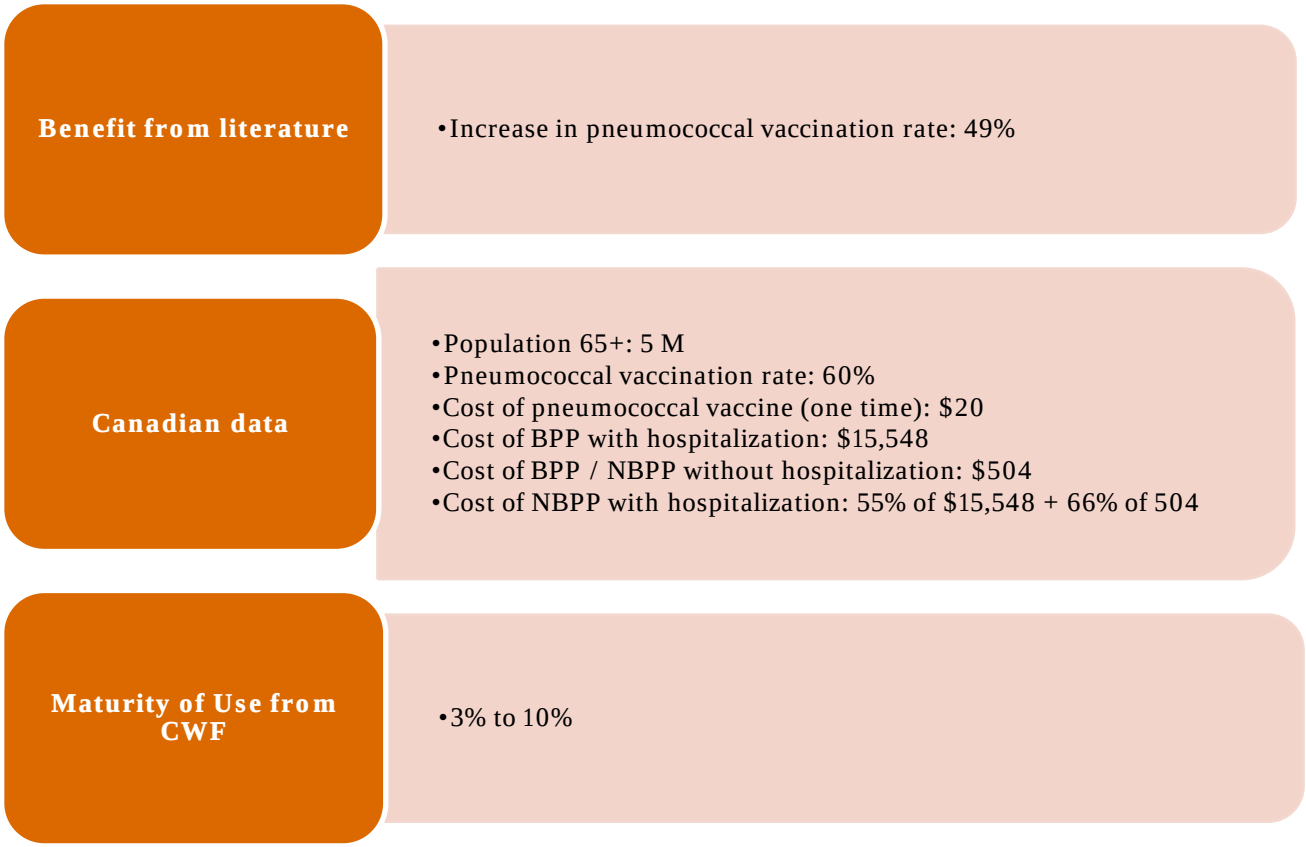


Table 16: Benefits estimated from increased pneumococcal vaccination rates

Benefit area	Benefits estimate
Net benefit from increased pneumococcal vaccination rates in 2012	$0.3-0.4 million - $1.1-1.4 million per year[13]
Reduction in number of pneumonia cases from increased pneumococcal vaccination rates in 2012	120 - 400 fewer cases
Reduction in number of hospital visits from increased pneumococcal vaccination rates in 2012	30 - 100 fewer hospital visits

It is estimated that EMRs have contributed emerging benefits to the health care system valued at **$2.4 million to $8.2 million** by improving rates of immunization in targeted populations. In addition to this monetary benefit, increased immunization leads to improvements in health outcomes. Current influenza immunization rate increases from EMR use in primary care are estimated to have reduced GP visits by 1,000 to 3,500, ED visits by 480 to 1,600 and hospital visits by 370 to 1,200 in 2012. Increased pneumococcal immunization is estimated to have reduced the number of pneumonia cases by 120 to 400 and the number of hospitalizations by 30 to 100 in Canada in 2012. Other immunizations, such as tetanus (as per Johnston et al., 2003), may also benefit from increased usage of EMRs; however, they have been less well researched in the literature and are not included here.

3.3.4 Emerging benefit: EMR use may lead to faster responses to changes in care and treatment guidelines

Summary

By using an EMR, physicians can run queries to generate patient lists based on defined parameters and a set of criteria (e.g., age, gender, medication profile) with relative ease. In the case of medication recalls or changes to medication guidelines, physicians using EMRs can more proficiently generate reports of patients currently taking specific medications without having to sort through hundreds of paper charts. Letters to patients informing them of the change or recall can also be quickly and automatically generated. In many circumstances, the ability to create a patient list through the EMR is the benefit unto itself; in paper-based practices it may be far too difficult or onerous to review all paper charts in an effective or efficient manner.

The estimates in this section describe the benefit of EMRs in responding to medication recalls and changes in care and treatment guidelines.

This Study estimated that EMRs have contributed to improved preparedness and capacity to respond faster to medication recalls or changes in care and treatment guidelines through time savings of **200,000 hours** for a niche example of 1 medication recall or change in guideline**, valued at $3.7 million,** as a result of an improved ability to review patient records. This time saving is a safety benefit to the patients for whom, for example, medications are discontinued in a timely manner, reducing the potential incidence of adverse drug events. The benefit to providers is a potentially significant time savings.

It is anticipated that in the future physicians will be able to access patient registries – large central repositories of data held at a jurisdictional level. For example, the U.S. Department of Veterans Affairs' (VA) has a successful system-wide, patient-centric EMR in developing registries to support population-centric delivery and evaluation of VA medical care (Backus et al., 2009).

[13] Lower bounds include the one-time cost of vaccination in the annual avoided costs. Higher bounds split that one-time cost over a 10 year period.

Findings from Literature

Although literature in this area is limited, findings are positive for improved capacity for population health management with EMR use. Wright et al. (2009) suggests that physician practices with an EMR were more likely to construct specific patient lists. Of the physicians surveyed, 79.8% of physician practices reported an ability to generate lists by patient diagnosis, 56.1% by laboratory result and 55.8% by medication usage. Although a large number of physicians reported being able to create lists, the functionality is not universal, making it difficult for some practices to use lists for a variety of quality improvement activities.

A Canadian study by Lapointe et al. (2012) indicates that when conducting a review of all active patients (e.g., for medication recall), practices with EMRs were not only able to perform this task in a substantially shorter amount of time than paper-based clinics, but were also more confident in their review. The study commissioned by Canada Health Infoway reported that primary care practices with EMRs identified patients needing preventive or follow-up care approximately 30 times more quickly than paper-based clinics.

Model

Findings from Lapointe et al. (2012) were used to estimate potential time savings during medication recalls or guideline changes due to an improved ability to review patient medical records. In this study, clinics were challenged to review patient records and identify patients with various conditions or requiring procedures. EMR clinics completed the full review of patient records across six evidence-based review exercises (including 2 simulated medication recalls) in 1.4 hours on average. Paper-based clinics on the other hand only reviewed approximately 10% of charts in 3.9 hours (and did not complete the challenge), which can be extrapolated to an estimated 40 hours to complete the full practice review.

Based on PwC analysis, CWF 2012 data suggests that approximately 12% of physicians use an EMR and are able to easily generate a list of all patients taking a particular medication, using a computerized process. Therefore this estimate was used as the proportion of physicians who use EMRs in a way that would enable a timely response to facilitating a medication recall for their patient population. The same maturity of use was assumed for any changes in care or treatment guidelines.

Time savings per practice were multiplied by the number of primary care physicians[14] in Canada, then by the percentage of providers with the ability to realize these savings (as per CWF maturity of use). The practice-level savings was estimated for one medication recall or guideline change that would require pulling full lists of patients. Input and benefits estimates are described in the table below.

Community-based specialists were excluded from this model as they are considered to provide more episodic care, whereby pulling patient records would be less frequent.

[14] Although time savings were reported by practice in Lapointe et al. (2012), practices were defined as the roster of patients for a single physician. Therefore, the number of primary care physicians was applied to the benefit estimate.

Figure 14: Inputs for Response to Guidelines and Recalls Model (details in Appendix D)

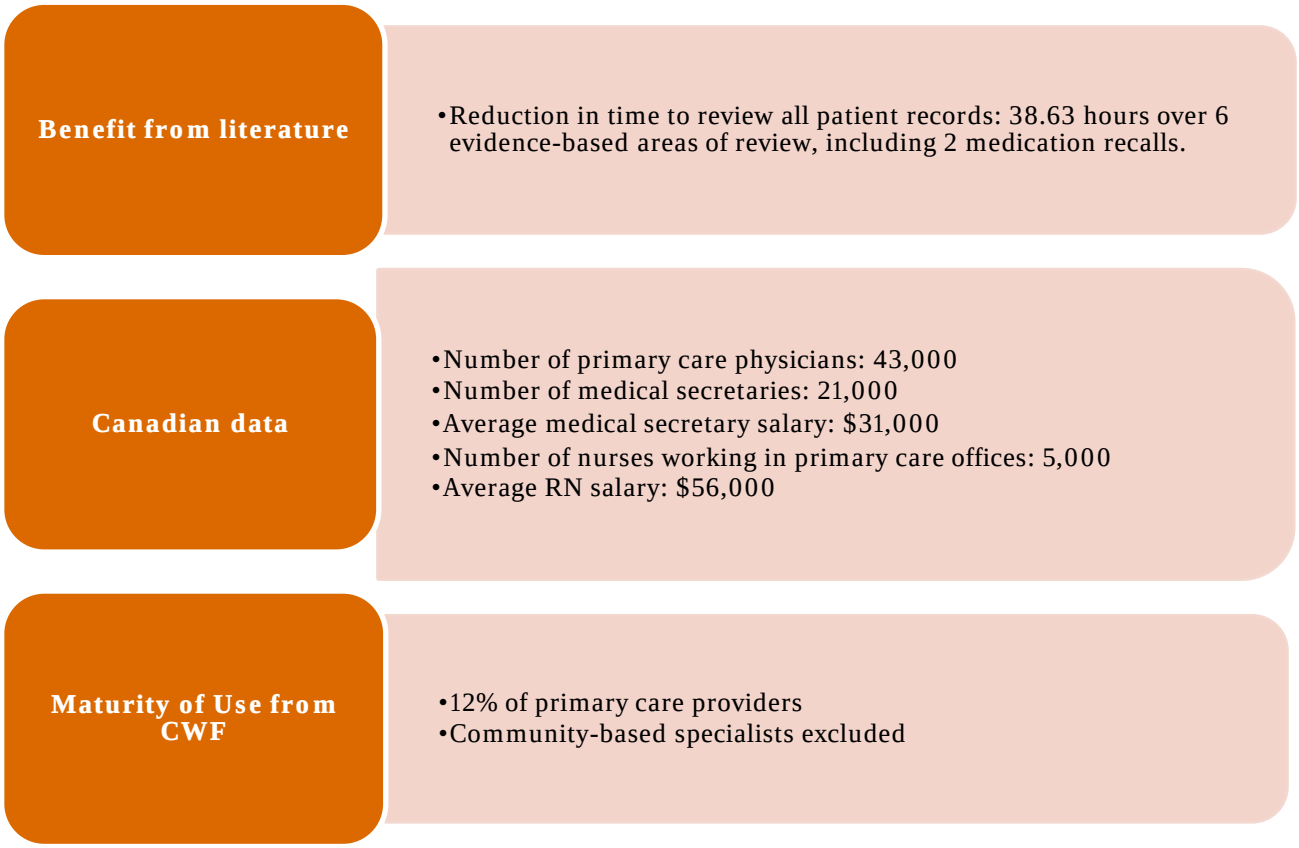


Table 17: Benefits estimated from improved response to guideline changes and recalls

Benefit area	Benefits estimate
Time savings in performing medication recalls / guideline changes in 2012	200,000 hours for 1 medication recall / guideline change
Benefit in performing medication recalls / guideline changes in 2012	$3.7 million for 1 medication recall / guideline change

It is estimated that EMRs contribute to time savings in the range of **200,000 hours for 1 medication recall or guideline change per year, valued at $3.7 million,** from an improved ability to review patient records. This time saving is both a benefit to the patients for example when they are pulled off a medication sooner and may suffer from fewer adverse drug events, but also to the provider, who can allocate their time more efficiently in responding to a guideline change or recall by focusing on contacting patients or pharmacies and arranging visits for adjusting treatment.

3.4 EMR use supports improved interactions and communications among care team members and between providers and patients.

EMRs can improve interactions between care teams, providers and patients when used as a communication tool.

The use of EMRs may support improvement in the quality of care by fostering a collaborative environment with inter-professional teams. Anecdotally and through surveys, physicians have indicated that they are better able to share patient information with members of their team, whether onsite or remotely when comprehensive, legible and accurate patient histories are available.

The patient-provider relationship may also improve through additional opportunities for patient education (e.g., trending of test results over time, access to the internet in the examining room), availability of information in real time so decisions can be made more promptly, and options for the patient and physician to communicate without having to schedule an office appointment. However, the use of EMRs may introduce challenges to building rapport between patients and providers (e.g., due to the placement of the computer in the examination room).

3.4.1 Emerging benefit: EMR use supports the improvement of team based care and continuity of care

Summary

A significant benefit of EMRs is their ability to support care within a practice, across a care team. EMRs may support improvement in the quality of care by fostering a collaborative environment with inter-professional teams, and physicians have indicated anecdotally that they are better able to share patient information with members of their team, whether onsite or remotely when comprehensive, legible and accurate patient histories are available. Continuity of care between providers also improves within a practice on a temporary basis (e.g., when on vacation within a care team, or with a locum), but also in real time as office staff can communicate with each other during a patient encounter.

EMRs support team based care and continuity of care by:

- *Fostering a collaborative environment* - Team members are able to readily exchange information and work collaboratively in the delivery of care. For example, a multidisciplinary practice in Prince George, British Columbia uses their EMR as a communication tool at weekly team meetings where the patient file is visible to all team members while discussing the care plans (Canada Health Infoway & Canadian Medical Association, 2009). Another example is an Ontario inter-professional diabetes program comprised of physicians, a nurse and a dietician who use their EMR to facilitate collaboration. They reported that the sharing of information through their EMR prevents duplication of effort among the team members (Goldman et al., 2010). In addition, 63% of Ontario family physicians and specialists report that continuity of care has improved within the first year of implementing their EMR (OntarioMD Physicians EMR Usage and Satisfaction Survey, 2013).
- *Supporting knowledge transfer between care teams* - As patients are seen by different providers, the information exchanged may be incomplete. During stakeholder engagement activities, physicians often commented on the gaps in necessary information when seeing patients from other physicians, and the illegibility of reading other providers' notes (or their own notes from previous visits). EMRs provide a tool for the sharing of comprehensive, legible information, supporting continuity of information between providers and within care teams. Findings from an Ontario survey reported that, from 2008 to 2010, nearly 7 in 10 GPs felt that EMRs helped improve the continuity of care and the level of safety provided to their patients (OntarioMD, 2010).

There is limited research available describing and/or quantifying the impact of EMRs in supporting team-based care and continuity of care, especially in regards to continuity of care across settings. Recommended areas of future research include better understanding the effects of:

- Information sharing within inter-professional teams and between providers - It is expected that improvements in overall quality and safety of patient care will be demonstrated.
- EHR interoperability - It is also anticipated that the integration of EMRs into jurisdictional EHRs will further support the exchange of information, e.g., eReferral and improvements in the continuity of care.

3.4.2 Emerging benefit: EMR use facilitates improvements in overall patient experience

Summary

As the model of health care delivery transforms to better support patient centred care, it is anticipated that EMRs will facilitate improvements not only in the clinical encounter, but the overall patient experience. However, there is limited literature describing and/or quantifying the impact of EMRs on the overall patient experience in primary care. Several surveys have been conducted regarding current use of EMRs. A health care information technology survey reported that 78% of respondents believed that EMRs would likely improve their care and 64% believed EMR benefits outweigh privacy challenges (Gaylin et al., 2011). A recent survey reported that Canadian adults whose regular doctors look up information about their health using computers or mobile devices are more likely (62% versus 53%) to say that their regular doctor always knows important information about their medical history than those using paper records alone (Harris Interactive, 2012). It is expected that, as consumer expectations evolve, patients will demand more access to their healthcare records, supporting their active engagement in their care or as caregivers to aging family members. EMRs can facilitate this collaborative engagement.

Based on research and anecdotal input from stakeholders and users, EMRs may enable improvements in overall patient experience by:

- *Improving accessibility to primary care and decreasing wait times* – A recent Canadian study found that physicians using electronic records reported shorter wait times and improved access to primary care. 75% of physicians using electronic records were able to see an urgent patient within a day or less versus 62% of physicians without electronic records. In addition, wait times for both urgent and non-urgent appointments where shorter for physicians using electronic records – the average wait for an urgent appointment was 1.01 days for physicians using electronic records versus 1.69 days for physicians not using electronic records (Safarov et al. 2012).
- *Improving the communication of results* - Patient satisfaction was found to increase in a study that assessed the impact of an automated test result notification system built within an EMR. Patients whose physicians used the test results management tool to communicate results between visits were more likely to be satisfied with the overall communication and the amount of information communicated (Matheny et al., 2007).
- *Improving the patient encounter* - 93% of physicians in Alberta report that access to a summarized patient history means that patients spend less time repeating the same information to care providers; and 97% report that they and their clinic associates and care team have more complete patient information (Alberta POSP Benefits Survey, 2012).
- *Minimizing unnecessary office visits* - Rather than scheduling a short in-person visit, some patient/provider discussion may be done virtually or through email. Physicians report anecdotally that email communication with patients is increasing and will continue to increase as patient/provider communication becomes integrated into the EMR or through patient portals. A recent Canadian survey reported that 8% of respondents consult with their health care provider online (Harris Interactive, 2012).
- *Improving scheduling of office visits* - By linking patient information to scheduling tools, EMRs enable workflow improvements such as:

- Quick access to patient information for routine scheduling inquiries, e.g., have test results been received, when was the last wellness check, are immunizations up to date, etc.
- Physicians and care team members are able to insert reminders in the patient EMR notifying and tracking appointments that need to be scheduled.
- Faster appointment scheduling. For example, a pilot implementation of eReferral from primary care EMR to outpatient clinics found improvements in transmission of documentation, enabling appointments to be booked on the same day. In comparison, paper-based referrals were booked on average in 7 days (Dennison et al., 2006).

The National Physician Survey (2010) suggests that physicians with EMRs are more able to see an urgent patient within a day or less and have shorter average waits for urgent appointments.

3.4.3 Emerging benefit: EMR use may improve aspects of the quality of the patient/provider encounter

Summary

Patient safety and the quality of care delivered in primary care settings are current health system priorities. There is evidence that EMRs may improve aspects of the quality of the patient/provider encounter by:

- *Providing complete and comprehensive information* - EMRs provide members of the care team with access to more comprehensive patient information to better inform clinical decision making. For example, 96% of physicians enrolled in Alberta's EMR program report that access to a summarized patient history has improved continuity of care (Alberta POSP Benefits Survey, 2012). Findings suggest that, although there is no significant difference in direct patient care activities after implementation of an EMR, there was a 0.88 minute increase in the amount of reading to support patient care (Pizziferri et al., 2005).
- *Enabling access to real-time information* - Increasingly, EMRs are being connected to external information systems. Through the jurisdictional scan that was completed for this Study, a number of Canadian jurisdictions reported that EMRs are able to receive laboratory and diagnostic imaging reports in real time. Having access to real-time information enables physicians and care teams to make more timely clinical decisions. Canadian adults whose regular doctors look up information about their health using computers or mobile devices are more likely to say that their regular doctor always knows important information about their medical history than those using paper records alone (Harris Interactive, 2012).
- *Improving the longevity, readability, and ability to search of information* - Clinicians have indicated that less time is spent during the encounter searching for information in an EMR and that it is presented in easy to read categories (Smith, 2011). In a paper-based practice, clinicians may have had to review deep piles of paper reports. In contrast, with the use of an EMR, the lifecycle of useable data is very long as it can be available in an easily-accessible, easy to read format. Archived information can be much easier to retrieve electronically without concerns that the ink or paper have been degraded across a variety of documentation (e.g., laboratory results, carbon copies, EKGs). In addition, providers have anecdotally indicated that improved legibility is of great benefit – both the legibility of their own notes from previous encounters, and of the notes of other providers.
- *Improving patient education* - EMRs enable access to customized tools such as graphing and trending features, and 3D diagrams. For example, a longitudinal picture of blood pressure, weight or integrated laboratory results can quickly be created to visually educate patients during care planning activities. In addition, by using an EMR, providers are able to access the internet during the encounter which may be used to provide additional sources of patient educational materials or to show patients credible web sites for further information.
- *Identifying alternatives to in-person visits* - In some instances, patient/ provider contact may be better suited to alternative means. For example, two years after EMR implementation, one ambulatory care setting reported

an increase in telephone contact as physicians, where appropriate, replaced some office visits with telephone conversations (Garrido et al., 2005).

While EMRs have been shown overall to improve the quality of patient/provider interactions, some research evidence and anecdotal findings have indicated that there can be some negative impacts related to communication and establishing rapport when introducing a computer into the examination room setting. Physicians and patients have indicated that it can be more challenging to maintain eye contact, which is critical in relationship building. Some of these impacts may be lessened though spatial organization (e.g., placement of the monitor, behaviour style and physician computer skills) (Shachak and Reis, 2009).

There is limited literature describing and/or quantifying the relationship between quality of the patient/provider encounter and EMR use and benefits realized to date. Current literature findings are somewhat inconsistent and provide an unclear picture of the range of short- and long-term benefits that may be realized in community-based primary care settings in this regard.

4.0 Priority Research Areas

Through the course of this Study, a range of research and evaluations were reviewed that investigated diverse areas of benefit related to the use of EMRs in community-based practice settings. Quantified evidence exists that demonstrates current benefits of EMR use, while emerging areas of benefit continue to be studied. While recent studies have filled some research gaps, it is recommended that additional research questions be explored in the Canadian context, using rigorous research methodologies that include large and representative samples, controlled and randomized studies, prospective rather than retrospective studies, and time and motion studies. The following section describes research questions to be explored which could further inform critical success factors for EMR adoption and maturity of use to contribute to benefit evaluation studies in the future.

Topics that warrant future research in Canada include:

- The range of factors which impact improvements in quality and safety of care and health outcomes in practices with EMRs;
- Opportunities for the EMR infrastructure to advance patient engagement and patient-centred care;
- The ability of EMRs to serve as a data source for research and evaluation studies;
- The impact of EMRs in enabling primary care transformation; and
- Factors that enable maturity of use (e.g., with respect to opportunities for alignment with EMR vendors, connectivity, training and support, remuneration model).

Regarding evidence related to the specific benefit estimates that were included in the Study, only partial estimates were reflected in the available literature. Further research questions to explore and strengthen the estimates in this Study include:

- Impact on staff time on a wider range of administrative tasks (i.e., beyond chart pulls and results management);
- Changes in immunization rates for populations served (i.e., children) and for immunization type, resultant improvements in health outcomes, and potential cost avoidance; and
- Impact of EMRs on health outcomes and costs that can be avoided due to improved preventive care and chronic disease management; additional evidence beyond intermediate physiological parameters would improve understanding the potential impact of EMR use in preventive care and chronic disease management.

For other benefit areas where quantitative research was not available, qualitative and/or anecdotal evidence was used to describe the benefit area. It is recommended that for these benefit areas, further quantitative research be undertaken to assess the impacts of EMR use on:

- Quality of care, including management of chronic disease;
- Team-based care;
- Continuity of care;
- Patient safety;
- Clinical decision-making;
- Provider productivity;

- Access to care, and
- Overall patient experience.

Further studies should be conducted in order to understand the impacts of using EMRs for improved quality of care on avoided health care system costs. In a majority of studies, intermediate outcomes were measured and then extrapolated to potential cost avoidance (e.g., improved adherence to chronic disease physiological targets extrapolated to avoided costs to the system). In the long term, the engagement of patients in the use of an EMR and self-management may potentially have an impact on other system costs.

Lastly, there are several areas where it is hypothesized that benefits may accrue with EMR use; however, no research was available to develop a conclusion. For example, the following areas could be explored:

- Wait time between initial visit to the family physician and consultation with specialists
  - In comparison to paper-based practices, research areas could include: time from referral letter to visit to consult letter in primary care physician's EMR (building on research completed to date), time from primary care physician referral to appointment booked or actual clinic appointment, patient attendance rate, completeness of referral, ability to share standardized information, and number of lost or misfiled referrals.
- Referrals to appropriate specialized services, including diagnostics
  - Explore whether access to a comprehensive, up-to-date patient record better informs primary care physicians about the appropriateness of specialized services.
- Time to prescribe
  - Determine whether overall time to prescribe is affected by: EMR pre-population of prescription forms, clinician access to complete and real-time medication history, and availability of alerts/notifications to help mitigate prescribing errors resulting in decreased pharmacy call backs and the potential for adverse drug events.
- Capacities for professional planning and development
  - Examine whether clinicians use their EMR to assess the needs of the patient populations, and pursue continuing education in these areas.
- Attraction and retention of clinicians
  - Identify whether clinicians are hesitant to move between practices that use different systems.
  - Assess considerations of new graduates when deciding whether to accept or decline a job offer.
- Avoidable admissions
  - Determine whether avoidable admissions are reduced because EMRs provide access to real-time information, decision support tools, clinical practice guidelines, reminders for screenings and immunizations, and access to real-time information for hospital discharge summaries and specialist consults.
- Number and type of repeat prescriptions
  - Impact of using evidence-based guidelines and reminders in community-based care.
- Rates and frequency of medication reviews and alerts
  - Rates and frequencies of: changes, medication reviews/reconciliations performed at predetermined intervals, and frequency of alerts/reminders generated, accepted and overridden.

Research gaps also exist in certain areas where the functionalities of EMRs are nascent or not fully used by physicians in Canada. As these functionalities develop and benefits are accrued, studies should be conducted to estimate their impact. For example, functionalities aimed at improving the appropriateness of diagnostic tests are still in their early stages but could provide significant benefits and cost avoidance when used optimally in Canada.

5.0 Facilitators and Barriers to EMR Adoption and Use

Findings from the Commonwealth Fund Survey (2012) the jurisdictional scan and the National Physician Survey (2007, 2010) indicate that EMR adoption is increasing across Canada. Over the past six years, EMR adoption by primary care physicians has more than doubled from 23% in 2006 to 56% in 2012 (CWF, 2006; Schoen et al., 2012). Despite these gains, Canada lags behind compared to other countries surveyed by the Commonwealth Fund in the use of EMRs: Australia, New Zealand, the UK and the Netherlands all report use at over 90% (Schoen et al., 2012).

Research and anecdotal stakeholder input indicate that there are a number of factors that either facilitate or act as barriers to clinicians adopting EMRs. If and when addressed, it could be reasonably assumed that adoption and use of EMRs across Canada would improve. Some examples of factors that facilitate EMR implementation include:

- *Training and engagement* - In order for clinicians to be comfortable with their EMR and the resultant change in clinical and administrative workflow, training upon EMR implementation is essential. It can be expected that ongoing training post-implementation and coaching from clinician peer leaders would result in physicians "climbing the maturity curve" and using additional, more sophisticated functionalities. A jurisdictional EMR Physician Satisfaction survey reported that 72% of physicians felt they could benefit from more training to advance use of their EMR (Saskatchewan EMR Program, 2012).
- *Leadership* – Strong leadership is necessary in most transformations – whether in healthcare or other industries. Strong leadership can guide community-based practices through change, motivate peers to re-engineer their workflows, and provide an environment ready for transformation. A Canadian study reported that the presence of a clinician leader/organizational leader regarded by peers with a strong knowledge of technology was the most important facilitator of EMR adoption for the study site (Gagnon et al., 2010).
- *Improved support from vendors* – A Canadian study found that there were opportunities for improvement in the services provided by vendors. Clinicians indicated that too little training was provided, and that training was too soon after implementation. At that stage, physicians had not had sufficient experience with their systems to be able to ask meaningful questions. In addition, the study reported that there was poor post-sale experience with a lack of confidence in services being provided and an understanding of the clinical environment, and access to vendor technical support (Ludwick et al., 2009).
- *Funded EMR programs* – The presence of funded jurisdictional EMR programs have reduced the financial barriers to the adoption of EMRs in community-based practices. In reducing the costs associated with implementation and adoption of EMRs, jurisdictional programs have lessened the direct investment required by physicians themselves. Jurisdictions which have established EMR programs have higher adoption rates (Health Council of Canada, 2013).

Through research and stakeholder input, multiple barriers were described which inhibit clinician adoption and use of EMRs.

- *Financial* – Clinicians have expressed concerns regarding whether there will be a positive return on investment and whether the benefits of implementing an EMR outweigh the costs. Note that these costs include purchasing, coordinating, monitoring, upgrading, and governance (Boonstra & Broekhuis, 2010). Input received from jurisdictional leads across the country has also revealed two financial considerations that negatively impacting adoption and use: lack of evidence to demonstrate significant return on investment, and concerns with funding.

- *Product innovation* – Anecdotally, physicians have indicated that there are many opportunities for EMR product improvements with regards to ease of use, functionalities, availability of data and overall appeal of EMRs currently available. The challenges with user-friendliness and intuitiveness of current products may act as a barrier to EMR adoption and to the full suite of functionalities being used. One Canadian study noted that physicians reported that they hunt for menus and buttons to the extent they sometimes stop using the EMR in interviews because of the disruption (Ludwick et al., 2009). Another Canadian study reported a wide variation in the level of satisfaction with functionality (Paterson et al., 2011).

- *Time constraints* - A study of Canadian physicians reported that a significant factor in their ability to successfully procure and implement an EMR is the required time commitment (Ludwick et al., 2009). A physician's primary focus is delivering care, limiting the time available to manage time-consuming administrative tasks such as researching, acquiring and being trained on an EMR. Other time considerations which may inhibit adoption and use of an EMR include time to learn the system, time required to enter data, and time to convert patient records from a paper-based to electronic system (Boonstra & Broekhuis, 2010).
- *Computer literacy* – Aligned with "training and engagement", it has been suggested that clinicians and practice staff don't have the technical competencies, including the typing skills, to be comfortable with EMR systems, and that vendors underestimate the necessary level of skill required to use the EMRs (Boonstra & Broekhuis, 2010).
- *Connectivity and information exchange* – Feedback received from stakeholders and published literature suggests that a barrier to implementation is the current inability of EMRs to connect and share information with external entities outside of primary care (Ramaiah et al., 2010). Input received from jurisdictional leads provided further confirmation that physicians would be more willing to adopt EMRs if external connectivity such as ability to send/receive electronic laboratory results, prescriptions, or referrals to specialists were embedded into the systems. These capabilities exist in some environments already but not in all.
- *Flexibility of IT investment* - Clinicians have indicated during stakeholder engagement sessions that there is some hesitancy in committing to a vendor product, when their platform may become obsolete if/when in the future, the requirements and connectivity to external sources of data change.

- *Tailored processes and customizability* - Members of the care team and their clinical and administrative workflows vary. Therefore, a standardized "one size fits all" approach to implementation may be problematic. Clinicians have indicated that having an implementation strategy customized to their local environment and their pace of adoption was valued (Gagnon et al., 2010). It is also suggested that information systems should be able to adapt to changes in the provider workflows as they become more experienced and mature in use of advanced features such as decision support, etc. (Lau et al., 2010). An additional reason why physicians may not adopt EMRs it that the systems available don't meet their needs or they can't use them to meet their requirements (Ludwick et al., 2009).

While addressing the facilitators and barriers described will likely improve the adoption and use of EMRs, it must also be noted that a strong change management approach must be implemented. Change management strategies could include the designation of clinician champions, workflow and process redesign, a clear articulation of vision and expected benefits, communication, and system support (Nagle & Catford, 2008).

6.0 Recommendations

This Study has demonstrated some of the benefits that have been realized with the implementation of EMRs in community-based care practices. In practices demonstrating advanced EMR use, further emerging benefits at the practice and health system level are being realized. The evidence indicates that there is a compelling reason to continue to advance EMR adoption and maturity of use across Canada.

With the implementation of a number of focused recommendations and with the ongoing engagement and involvement of clinicians, the potential for wide ranging and transformative benefits can be further realized by providers, patients and the health care system as a whole.

The following recommendations are presented to policy-makers, governing agencies, funders, researchers, implementers and adopters of EMRs in support of continued realization of benefits associated with the mature use of EMRs.

1. *Continue to increase EMR adoption and maturity of use in community-based settings to realize benefits* - As essential enablers of transformation in community-based care, continued investments in EMRs should be pursued to encourage increased adoption and maturity of use. By doing so, it can be expected that further benefits will be realized at the pan-Canadian level.

2. *Extend leading change management support and evidence-based best practices to reflect clinician and practice needs and priorities* - While programs are in place to support physicians during initial EMR adoption, strong leadership and ongoing training and support is essential to promote advanced use of EMRs.

3. *Continue to improve the accessibility and flow of information to and from community-based EMRs through enhanced connectivity and system interoperability* - A focus should be placed on improving connectivity to electronic systems and databases outside of primary care in order to enhance continuity of care.

4. *Broadly initiate applied privacy-sensitive approaches to population management through EMR use* - EMRs are large repositories of data which clinicians and researchers are increasingly engaging with to inform analyses and decision making such as practice-based and system-level population health planning. Practice-level data are increasingly being integrated with provincial data sources and/or being used as a source of data for evaluation or comparative effectiveness research. This activity is also important within physician practices, supported by effective use of their own patient data to support proactive care and quality outcomes.

5. *Address priority research areas using rigorous health services research methodologies in Canadian community-based settings to estimate the full scope of current and emerging benefits related to the optimized use of EMRs and patient outcomes* - It is recommended that additional research questions be explored with greater coordination and prioritization of projects in order to develop a better understanding of EMR adoption and benefits in Canada.

    - The range of factors which impact improvements in quality and safety of care and health outcomes in practices with EMRs;
    - Opportunities for the EMR infrastructure to advance patient engagement and patient-centred care;
    - The ability of EMRs to serve as a data source for research and evaluation studies;
    - The impact of EMRs in enabling primary care transformation; and
    - Factors that enable maturity of use (e.g., with respect to opportunities for alignment with EMR vendors, connectivity, training and support, remuneration model).

7.0 Conclusion

Across Canada, there is an ongoing focus on improving access to and quality of community-based care as the foundation of a strong health care system. EMRs are an integral enabler of these improvements with the potential to fundamentally transform the delivery of care. Over the past six years, the adoption of EMRs by primary care physicians has more than doubled from 23% in 2006 to 56% in 2012. This increase in adoption has been realized to a large extent through the support of *Infoway's* investment programs (e.g. Electronic Medical Records and Integration) in conjunction with investments by the provinces and territories and clinicians. However, despite these gains, Canada lags behind many other countries in the adoption of EMRs.

This Study was completed to develop a better understanding of the current and emerging impacts of EMR use in community-based settings. Evidence to date and described in the Study indicates that use of EMRs can improve efficiencies in workflow as staff time is redeployed, contribute to system level benefits, have the potential to improve quality of care outcomes through preventive care and chronic disease management, and support improved interactions and communications between care teams, providers and patients.

The model developed for this Study relied heavily on available evidence. As the scoping of the available literature was narrow, it must be noted that the estimates described represent only a segment of benefits that are likely being realized. Emerging benefits are also described and are intended to reflect those benefits which are currently being realized by clinicians, but for which quantitative evidence is not available to be included in the model.

While evidence of EMR benefits, particularly in the Canadian context, remains sparse in several areas, the evolving maturation of EMR use will lead to new learnings in the future. The early evidence does indicate that there is a compelling reason to continue to advance EMR adoption and accrue benefits to providers, patients and the health care system as a whole. But a significant finding of this Study is the need for substantially more research to generate new evidence and further validate and track the realization of the benefits described in this Study.

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Appendices

Appendix A: Working Group and Steering Committee Membership

Working Group	Role within Canada Health Infoway
Chad Leaver (project lead)	Benefits Realization Leader
Simon Hagens	Director, Benefits Realization
Colleen Rogers	Program Director, EMR & Integration
Rashaad Bhyat, MD	Clinical Leader
Christina Scicluna	Director, Advisory Services, Communications
Jeff Green	Director, Investment Programs & Reporting
Brent McGaw	Project Director, Ontario
Keren Taylor-Hughes	Change & Evaluation Specialist, Mid-west

Steering Committee	Role within Canada Health Infoway
Jennifer Zelmer (chair)	Senior Vice President, Clinical Adoption & Innovation
Maureen Charlebois	Chief Nursing Executive & Group Director, Clinical Adoption
Lynne Zucker	Vice President, Clinical Systems Integration
Terry Moore	Executive Regional Director, Ontario
Shelagh Maloney	Vice President, Communications
Jane Holden	Executive Director, Investment Programs Management

Appendix B: Summary of EMR Indicators

Category & Sub-category	Benefit Sub-Area
Access	Primary care patient volume
Access	Access to specialized services
Quality	Quality of non-routine care visits (after-hours and emergency care)
Quality: Patient Safety	Medication reviews and alerts
Quality: Patient Safety	Change in medication actual/ potential error rates
Quality: Patient Safety	Capacity to respond to public health priorities and medication recalls/ warnings
Quality: Patient Safety	Inappropriate prescriptions
Quality: Appropriateness/Effectiveness	Capacity for common health risk screening and prevention / support to use/adhere to practice standards and guidelines
Quality: Appropriateness/Effectiveness	Agreement with system recommendations
Quality: Appropriateness/Effectiveness	Population immunization
Quality: Appropriateness/Effectiveness	Repeat prescriptions
Quality: Appropriateness/Effectiveness	Chronic Disease Management (CDM)
Quality: Health Outcomes	Health outcomes (Physiological parameters)
Productivity: Efficiency	Clinical and administrative tasks
Productivity: Efficiency	Prescribing time
Productivity: Efficiency	Management of laboratory information
Productivity: Efficiency	Timeliness of transitions in care (wait times)
Productivity: Efficiency	Response time
Productivity: Efficiency	Process time
Productivity: Efficiency	Capacities for professional planning and development
Productivity: Care Coordination	Practice capacity to attract/ retain clinicians

Category & Sub-category	Benefit Sub-Area
Productivity: Care Coordination	Patient-provider communication and overall experience
Productivity: Efficiency/costs	Avoidable admissions
Productivity: Net Cost	Test costs and duplicate diagnostic tests
Productivity: Net Cost	Net cost savings – return on investment

Appendix C: Detailed Assumptions and Limitations

This appendix outlines the assumptions and limitations specific to each benefit area and its quantitative estimate.

EMR use reduces staff time spent on specific paper-based administrative tasks

Time savings resulting from improved administrative efficiency vary widely across practices as demonstrated by the range of estimates provided by the literature. Although the estimates presented here are based on averages, time savings will strongly depend on the sophistication of the EMR and network, the familiarity of staff with computers, the size of the practice and other factors. A majority of estimates are based on American literature where EMR systems are often better integrated into the health care system network and where efficiencies may be greater. Also, different EMR products may deliver these benefits in varying degrees based upon available functionality and scope of use.

Due to the limited evidence on the extent of chart pull reductions in primary care, some estimates derived outside of a primary care environment were used. For example, Babbitt et al. (2003) focused on paediatric care and MedicaLogic (no date) reported reductions in a neurology practice. However, estimates were consistent with those reported in primary care practices and including these did not change the overall reduction estimate by more than two percentage points.

There is limited data available related to changes in laboratory results time management resulting from EMRs. The estimate presented here therefore relies on one study conducted in Canada, where the number of practices was not large enough to generate statistical confidence in the estimates, although practices from multiple provinces participated (BC, Ontario, Quebec, New Brunswick and Nova Scotia). A range was provided based on bottom and top performers; however, all of these estimates should be extrapolated with caution.

EMR use reduces the number of duplicate diagnostic tests ordered

A majority of the studies available on test duplication and potential reductions were conducted in hospital settings in the U.S. The Tierney research was the only available evidence in a primary care setting but dates from the mid-1980s and its applicability in today's health care environment is uncertain. Given that the estimates include findings from both the primary care and hospital settings, it is assumed that ordering behaviour is the same in both environments. The validity of this assumption is uncertain and further research is necessary in determining the impact of the EMR on duplicate testing in community-based practices.

Most studies did not judge the appropriateness of the decrease in utilization, which assumes that any reduction in duplicate testing is positive. For example, some studies defined duplicate tests as the occurrence of the same test within a specified time period from the original test, including both unnecessary and clinically warranted duplicate examinations. However, it is reasonable to assume that the frequency of necessary duplicate tests remains stable over time and that any changes observed are due to changes in unnecessary duplicate tests (You, 2008).

The model relied on maturity of use estimated from the CWF 2012 which surveyed physicians regarding their ability to generate laboratory results. This was used as a proxy for the ability to generate results for diagnostic tests. Also, specific maturity of use for community-based specialists was not available and was estimated based on overall EMR use of community-based specialists relative to primary care physicians.

EMR use increases the appropriateness of diagnostic tests

The benefits estimated are based on one study (Blackmore et al., 2011), and participants were not randomized; rather, their diagnostic imaging ordering patterns were examined retrospectively. The study was also conducted in a top-performing health care network, hence findings may not be generalizable.

The Tierney studies related to reductions in lab tests were not included in order not to duplicate cost savings estimated in the previous section (i.e. EMRs reduce the number of duplicate diagnostic tests ordered). Indeed, although the EMR features targeted appropriateness, part of the impact may have been a result of reduced duplicate testing.

Finally, the appropriateness of imaging was not evaluated. The studies focused on estimating the impact of EMR features aimed at increasing appropriateness (e.g. decision support) on the number of tests ordered and not the impact on appropriateness itself. Therefore, the authors could not determine whether inappropriate utilization continued to exist and whether the decrease in utilization was appropriate.

EMR use improves immunization rates

It should be noted that models present in the international literature vary in terms of whether they find certain immunizations to be cost-effective (additional costs but large improvements in health outcomes) or cost-saving (improved health outcomes and fewer costs), depending on assumptions and which costs are included or excluded. This model focused on current evidence available for Canada. A comparison to other studies and why findings may vary was not conducted as part of this Study.

The literature to this date has focused on a narrow list of immunizations. Further research is recommended in order to estimate the benefit of other immunizations and for other at risk population groups (for example young children).

EMR use leads to faster responses to changes in care and treatment guidelines

Although the ability to generate patient registries and review patient records was often cited by stakeholders as a large benefit of EMRs, there are few studies that estimate the size of that benefit.

The number of medication recalls and/or guideline changes that occur in one year and that would require pulling a full list of patients is uncertain and unpredictable. Based on Health Canada's recall listing[15], five Type 1 priority medication recalls occurred in 2012. However, one of these recalls applied to private clinics only and one recall applied to medical clinics in select jurisdictions. For the modeling, it was assumed that 1 recall or guideline change occurred in a year, which is a conservative estimate.

The model relies on one study which, although it did find significant benefits, was based on only four paper-based practices. Also, it is unclear as to the extent time savings in responding to a medication recall would lead to reduced adverse drug events. The latter benefits are not included in the estimates above.

[15] Health Canada drug recall listing. Accessed November 28, 2012 at: http://www.hc-sc.gc.ca/dhp-mps/compli-conform/recall-retrait/_list/index-eng.php

Appendix D: Technical Appendix

This appendix outlines the inputs and calculations for each of the benefit estimates. For each benefit, four tables present the following:

1) Relative benefit estimates from the literature and supporting evidence;

2) Canadian context data and data sources;

3) Maturity of use estimates and sources; and

4) Benefit estimates and underlying calculations (numbers may not add up due to rounding).

EMR use reduces staff time spent on specific paper based administrative tasks

1) Chart Pulls

RELATIVE BENEFIT FROM LITERATURE

Benefit	Estimate and Sources
Reduction in chart pulls	Baseline: 72% Low: 48% High: 96%
	Literature: Grieger et al. (2007): 96% reduction after 2 years MedicaLogic (2004): 54% in an 8-physician staffed clinic and 84% in a 6-physician staffed clinic Keshavjee et al. (2001): 64.4% reduction in minutes used after 18 months of implementation to pull charts for day visits Kalata et al. (1998): 48.4% reduction in paper chart pull requests in 13 ambulatory care facilities and two emergency departments in Cleveland Babbitt et al. (2003): 85% reduction in charts pulled in a paediatric setting (3-5 minutes allotted for each chart pulled)

CANADIAN CONTEXT DATA

Model Parameter	Estimate	Data Source
Number of services, Family Medicine, 2009/10	143,204,385	CIHI National Physician Database 2009/10, Table B.5.1 (2011)
Number of services, Total Physicians, 2009/10	243,156,469	CIHI National Physician Database 2009/10, Table B.5.5 (2011)

Model Parameter	Estimate	Data Source
Time spent per chart pull (min)	4 minutes	Girosi et al. (2005)
Number of medical secretaries	21,465	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-563-XCB2006069 (Canada, Code01)
Number of nurses working in primary care offices	5,473	Canadian Institute for Health Information, *Regulated Nurses: Canadian Trends, 2006 to 2010* (Ottawa, Ont.: CIHI, 2011).
Average medical secretary salary ($ 2012)	$30,835	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-563-XCB2006069 (Canada, Code01)
Average RN salary ($ 2012)	$55,537	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-563-XCB2006069 (Canada, Code01)
Number of primary care physicians	42,910	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Number of specialists	33,010	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Share of community-based specialists	30%	PwC estimation from National Physician Survey 2010

MATURITY OF USE

Estimate	Source	Question	Response
Baseline: 56%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)?	Yes
Specialist ratio: 81%	National Physician Survey 2010	Thinking about your MAIN patient care setting, which of these describes your record keeping system?	I use a combination of paper and electronic charts **Or** I use electronic records instead of paper charts

CALCULATION

Benefit Lever	Physician Type	Estimate	Calculation
Benefit of reduced staff time spent on paper based administrative tasks, hours a year	Primary care physician	Baseline: 3,845,170 Low: 2,580,971 High: 5,132,445	(Minutes spent pulling charts pre EMR – minutes spent pulling charts post EMR) * Maturity of use / 60 = (4* 143,204,385* 0.72)*0.56/60
	Community-based specialist	Baseline: 652,622 Low: 438,055 High: 871,105	(Minutes spent pulling charts pre EMR – minutes spent pulling charts post EMR) * Maturity of use / 60 = (4* 0.3* (243,156,469-143,204,385)* 0.72) *0.45/60
Benefit of reduced staff time spent on paper based administrative tasks, hours per week per physician	Primary care physician	Baseline: 1.9 Low: 1.3 High: 2.5	(Annual redeployed hours / 48)/ number of primary care physicians = 3,845,170 /48 /42,910
	Community-based specialist	Baseline: 1.4 Low: 0.9 High: 1.8	(Annual redeployed hours / 48)/ number of primary care physicians = 652,622 /48 /(33,010*0.3)
Benefit of reduced staff time spent on paper based administrative tasks, dollars	Primary care physician	Baseline: $71,803,368 Low: $48,196,162 High: $95,841,510	Annual redeployed hours * cost per hour = 3,845,170 * [(21,465/(21,465+5,473)*30,835/115,200 + 5,473/(21,465+5,473)*55,537/115,200] * 60
	Community-based specialist	Baseline: $12,186,832 Low: $8,180,097 High: $16,266,707	Annual redeployed hours * cost per hour = 652,622 * [(21,465/(21,465+5,473)*30,835/115,200 + 5,473/(21,465+5,473)*55,537/115,200] * 60

2) Diagnostic Test Results Management

RELATIVE BENEFIT FROM LITERATURE

Benefit	Estimate and Sources
Reduction in time to manage lab reports	15.6 min (range 12.6 – 17.3 min)

Benefit	Estimate and Sources
	Literature: CRHE: Average time (min) is 17.9 with paper, 4.5 with scanned, and 2.3 with electronic

CANADIAN CONTEXT DATA

Model Parameter	Estimate	Data Source
Number of laboratory and diagnostic imaging orders annually in Canada by primary care physicians	54,933,202	See calculation at end of Appendix
Number of laboratory and diagnostic imaging orders annually in Canada by community-based specialists	11,502,486	See calculation at end of Appendix
Number of medical secretaries (2006)	21,465	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Number of nurses working in primary care offices	5,473	Canadian Institute for Health Information, *Regulated Nurses: Canadian Trends, 2006 to 2010* (Ottawa, Ont.: CIHI, 2011).
Average medical secretary salary ($ 2012)	$30,835	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-563-XCB2006069 (Canada, Code01)
Average RN salary ($ 2012)	$55,537	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-563-XCB2006069 (Canada, Code01)
Number of primary care physicians	42,910	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Number of specialists	33,010	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Share of community-based specialists	30%	PwC estimation from National Physician Survey 2010

MATURITY OF USE

Estimate	Source	Question	Response
Baseline: 31%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)? **And** Do you use any of the following technologies in your practice? - Electronic ordering of laboratory tests.	Yes Yes, routinely or Yes, occasionally
Low: 17%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)? **And** With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following information about your patients: - List of patients by laboratory result. - List of all laboratory results for an individual patient.	Yes Easy and Computerized Easy and Computerized
Specialist ratio: 59%	National Physician Survey 2010	Please indicate which of the following you use in the care of your patients?	Electronic interface to external laboratory/diagnostic imaging **And** Use on PC

CALCULATION

Benefit Lever	Physician Type	Estimate	Calculation
Benefit of reduced staff time spent on managing diagnostic tests, hours a year	Primary care physician	Baseline: 4,427,616 Low: 1,961,115 High: 4,910,113	Time saved per year /60 * Maturity of use = 54,933,202*(17.9-2.3)/60 *0.31

Benefit Lever	Physician Type	Estimate	Calculation
	Community-based specialist	Baseline: 549,942 Low: 243,585 High: 609,871	Time saved per year /60 * Maturity of use = 11,502,486*(17.9-2.3)/60 *0.18
Benefit of reduced staff time spent on managing diagnostic tests, hours per week per physician	Primary care physician	Baseline: 2.1 Low: 1.0 High: 2.4	(Annual redeployed hours / 48)/ number of primary care physicians = 4,427,616 /48 /42,910
	Community-based specialist	Baseline: 1.2 Low: 0.5 High: 1.3	(Annual redeployed hours / 48)/ number of primary care physicians = 549,942 /48 /(33,010*0.3)
Benefit of reduced staff time spent on managing diagnostic tests, dollars	Primary care physician	Baseline: $82,679,775 Low: $36,621,191 High: $91,689,750	Annual redeployed hours * cost per hour = 4,427,616 * [(21,465/(21,465+5,473)*30,835/115,200 + 5,473/(21,465+5,473)*55,537/115,200] * 60
	Community-based specialist	Baseline: $10,269,424 Low: $4,548,616 High: $11,388,528	Annual redeployed hours * cost per hour = 549,942 * [(21,465/(21,465+5,473)*30,835/115,200 + 5,473/(21,465+5,473)*55,537/115,200] * 60

EMR use reduces the number of duplicate diagnostic tests ordered

RELATIVE BENEFIT FROM LITERATURE

Benefit	Estimate and Sources
Reduction in number of duplicate lab tests	Baseline: 6.2% Low: 5.9% High: 8.5%
Reduction in number of duplicate DI tests	Baseline: 4.7% Low: .08% High: 8.5%
	Literature: Tierney (1987): 8.5% reduction in duplicate tests through displaying past test

Benefit	Estimate and Sources
	results Bates (1998): 8.6% reduction in redundant tests Bates (1999): 69% of redundant tests cancelled when informed Daurio (2009): 48% reduction in duplicate tests You (2008): 0.9% reduction in duplicate x-rays

CANADIAN CONTEXT DATA

Model Parameter	Estimate	Data Source
Number of lab tests ordered by primary care physicians in Canada each year	366,830,791	See calculation below
Number of lab tests ordered by community-based specialists in Canada each year	76,810,850	See calculation below
Number of potentially duplicated DI tests ordered by primary care physicians in Canada each year	23,390,394	See calculation below
Number of potentially duplicated DI tests ordered by community-based specialists in Canada each year	5,398,161	See calculation below
Average cost per laboratory test	$13	CIHI National Physician Database 2009/10 Table B.9.3
Average cost per radiology test	$59	CIHI National Physician Database 2009/10 Table B.9.3

MATURITY

Estimate	Source	Question	Response
Baseline: 23.5%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)? **And** With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following information about your	Yes

Estimate	Source	Question	Response
		patients:	
		- List of all laboratory results for an individual patient.	Easy and Computerized
Low: 9.3%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)?	Yes
		And	
		With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following information about your patients:	
		- List of all laboratory results for an individual patient.	Easy and Computerized
		- List of patients who are due or overdue for tests or preventive care	Easy and Computerized
Specialist ratio: 81%	National Physician Survey 2010	Thinking about your MAIN patient care setting, which of these describes your record keeping system?	I use a combination of paper and electronic charts
			Or
			I use electronic records instead of paper charts

CALCULATION

Benefit Lever	Physician Type	Estimate	Calculation
Benefit of reduced number of duplicate diagnostic tests	Primary care physician	Baseline: $84,752,735 Low: $26,261,703 High: $123,472,166	(Reduction in annual lab tests * cost per lab test)*Maturity of use + (reduction in annual DI tests * cost per DI test)*Maturity of use = 366,830,791*0.062*13*0.235 + 23,390,394*0.047*59*0.235
	Community-based specialist	Baseline: $14,655,819	(Reduction in annual lab tests * cost per lab test)*Maturity of use

Benefit Lever	Physician Type	Estimate	Calculation
		Low: $2,932,693 High: $21,450,933	+ (reduction in annual DI tests * cost per DI test)*Maturity of use = 76,810,850*0.062*13*0.19 + 5,398,161*0.047*59*0.19

EMR use increases the appropriateness of diagnostic tests

RELATIVE BENEFIT FROM LITERATURE

Benefit	Estimate and Sources
Reduction in number of diagnostic tests from functionalities aimed at appropriateness	Sinus CT: 26.8% Lumbar MRI: 23.4% Head MRI: 23.2%
	Literature: Blackmore (2011): Decision Support reduced number of Sinus CT by 26.8%, number of Lumbar MRI by 23.4%, and number of Head MRI by 23.2%

CANADIAN CONTEXT DATA

Model Parameter	Estimate	Data Source
Head CT without IV contrast, physician fee	$43.25	Ontario Ministry of Health and Long Term Care; Schedule of Benefits for Physician Services under the Health Insurance Act. Retrieved from http://www.health.gov.on.ca/english/providers/program/ohip/sob/physserv/physserv_mn.html
MRI spine (one segment), physician fee	$59.50	Ontario Ministry of Health and Long Term Care; Schedule of Benefits for Physician Services under the Health Insurance Act. Retrieved from http://www.health.gov.on.ca/english/providers/program/ohip/sob/physserv/physserv_mn.html
MRI head, physician fee	$73.35	Ontario Ministry of Health and Long Term Care; Schedule of Benefits for Physician Services under the Health Insurance Act. Retrieved from http://www.health.gov.on.ca/english/providers/program/ohip/sob/physserv/physserv_mn.html
MRI technical fee (CT technical fee assumed identical)	$875	WSIB Magnetic Resonance Imaging Fee Schedule Retrieved from http://www.wsib.on.ca/files/Content/Fee%20Sch

Model Parameter	Estimate	Data Source
		edulesFeesMRI/MRIFeeSch.pdf
Tests per 100,000 Population, CT-Other	398	You (2007)
Tests per 100,000 Population, MRI-Spine	747	You (2007)
Tests per 100,000 Population, MRI-Brain	817	You (2007)
Canadian population	34,880,500	Statistics Canada, CANSIM, Table 051
Share of primary care physicians to all physicians	57%	PwC estimation from Statistics Canada 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Share of community-based specialists to all physicians	13%	PwC estimation from Statistics Canada 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)

MATURITY OF USE

Estimate	Source	Question	Response
Baseline: 5.5%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)?	Yes
		And	
		With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following information about your patients:	
		- List of all laboratory results for an individual patient.	Easy and Computerized
		- List of patients who are due or overdue for tests or preventive care	Easy and Computerized
		And	
		Are the following tasks *routinely* performed in your practice?	
		- You receive a reminder for guideline-based interventions and/or screening tests	Yes, Using a Computerized

Estimate	Source	Question	Response
			System
Specialist ratio: 81%	National Physician Survey 2010	Thinking about your MAIN patient care setting, which of these describes your record keeping system?	I use a combination of paper and electronic charts **Or** I use electronic records instead of paper charts

CALCULATION

Benefit Lever	Physician Type	Estimate	Calculation
Total Reduction	Primary care physician	$4,764,076	Reduction in Sinus CT test costs + reduction in Lumbar MRI test costs + reduction in Brain MRI test costs
	Community-based specialist	$894,602	Reduction in Sinus CT test costs + reduction in Lumbar MRI test costs + reduction in Brain MRI test costs
Reduction in Sinus CT test costs	Primary care physician	$1,057,968	Reduction in Sinus CT tests * cost of test * Maturity of use = 0.268* (398*34,880,500*0.57 /100,000) * (43.25+875) * 0.055
	Community-based specialist	$198,666	Reduction in Sinus CT tests * cost of test * Maturity of use = 0.268* (398*34,880,500*0.13 /100,000) * (43.25+875) * 0.04
Reduction in Lumbar MRI test costs	Primary care physician	$1,764,451	Reduction in Lumbar MRI tests * cost of test * Maturity of use = 0.234* (747*34,880,500*0.57 /100,000) * (59.50+875) * 0.055
	Community-based specialist	$331,330	Reduction in Lumbar MRI tests * cost of test * Maturity of use = 0.234* (747*34,880,500*0.13 /100,000) * (59.50+875) * 0.04
Reduction in Brain MRI test costs	Primary care physician	$1,941,657	Reduction in Brain MRI tests * cost of test * Maturity of use

Benefit Lever	Physician Type	Estimate	Calculation
			= 0.232* (817*34,880,500*0.57 /100,000) * (73.35+875) * 0.055
	Community-based specialist	$364,606	Reduction in Brain MRI tests * cost of test * Maturity of use = 0.232* (817*34,880,500*0.13 /100,000) * (73.35+875) * 0.04

EMR use improves immunization rates

1) Pneumococcal Immunization

RELATIVE BENEFIT FROM LITERATURE

Benefit	Estimate and Sources
Increase in pneumococcal vaccination rate	49%
	Literature: Loo et al. (2011): 49% increase in pneumococcal vaccination (19.5% EMR vs. 13.1% control) Chaudhry et al. (2006): 33% increase in pneumococcal vaccination Johnston et al. (2003): 3x as likely to have patients up to date (influenza, pneumococcal, tetanus)

CANADIAN CONTEXT DATA

Model Parameter	Estimate	Data Source
Cost of vaccine (one time)	$20	Assumption based on conversion from Akin et al. (2011)
Canadian population over age 65	4,973,438	Statistics Canada, CANSIM, Table 051
Vaccination rate (Pre-EMR)	60%	Akin et al. (2011)
Hospitalization rate, BPP	95.5%	Akin et al. (2011)
Hospitalization rate, NBPP	19.4%	Akin et al. (2011)
Incidence of BPP	1,136 per 100,000	Akin et al. (2011)
Incidence of NBPP	51.5 per 100,000	Akin et al. (2011)

Model Parameter	Estimate	Data Source
Vaccine effectiveness against BPP	60%	Akin et al. (2011)
Vaccine effectiveness against NBPP	21%	Akin et al. (2011)
Cost of hospitalized BPP	$15,548	Ontario Case Costing Initiative (OCCI), 2010/2011. Average total cost per acute inpatient case over age 70 for: J13-Pneumonia due to Streptococcus pneumonia J153-Pneumonia due to Streptococcus, group B J154-Pneumonia due to other streptococci
Cost of un-hospitalized BPP and NBPP	$504	Ontario Case Costing Initiative (OCCI), 2010/2011. Average total cost per ambulatory care case for all pneumonia cases over age 70 (diagnosis codes *J13, J153, J154, A403, B012, B052, B953, B960, B961, J100, J120, J121, J122, J123, J128, J129, J14, J150, J151, J152, J155, J156, J157, J158, J159, J160, J168, J170, J171, J172, J173, J178, J180, J181, J182, J188, J189, J200, J20*)
Cost of hospitalized NBPP	55% of BPP inpatient costs + 66% of NBPP outpatient costs	Based on relative costs in Akin et al. (2011)

MATURITY OF USE

Estimate	Source	Question	Response
Baseline: 3%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)? **And** With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following information about your patients:	Yes

Estimate	Source	Question	Response
		- List of patients who are due or overdue for tests or preventive care	Easy and Computerized
		And	
		Are the following tasks *routinely* performed in your practice?	
		- Patients are sent reminder notices when it is time for regular preventive or follow-up care	Yes, Using a Computerized System
		- You receive a reminder for guideline-based interventions and/or screening tests	Yes, Using a Computerized System
High: 10%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)?	Yes
		And	
		With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following information about your patients:	
		- List of patients who are due or overdue for tests or preventive care	Easy and Computerized or Manual
		And	
		Are the following tasks *routinely* performed in your practice?	
		- Patients are sent reminder notices when it is time for regular preventive or follow-up care	Yes, Using a Computerized System

CALCULATION

Benefit Lever	Estimate	Calculation
Pneumococcal vaccination annual savings	Baseline: $0.3 – 0.4 million High: $1.1 – 1.4 million	(Vaccinated population post EMR – Vaccinated population pre EMR) * (Cost of vaccinated population) + (Unvaccinated population post EMR – Unvaccinated population pre EMR) * (Cost of unvaccinated population)

Benefit Lever	Estimate	Calculation
		Where Vaccinated population pre EMR = 4,973,438*0.6 Unvaccinated population pre EMR = 1 – vaccinated population pre EMR Vaccinated population post EMR = 4,973,438*0.6*(1+0.49*0.03) Unvaccinated population post EMR = 4,973,438 – vaccinated population post EMR Cost of vaccinated population (1st year) = 20+15,548* 51.5/100,000* 0.4*0.955 + 504* 51.5/100,000* 0.4*0.045 + (0.55*15,548+0.66*504) *0.194* 1136/100000*0.79 + 504*1136/100000* 0.79*0.806) Cost of unvaccinated population (1st year) = 15,548* 51.5/100000*0.955 + 504* 51.5/100000*0.045 + (0.55*15,548+0.66*504) *0.194* 1,136/100000 + 504*1,136/100000*0.806

2) Influenza Immunization

RELATIVE BENEFIT FROM LITERATURE

Benefit	Estimate and Sources
Increase in influenza vaccination rate	20% *Literature:* Loo (2011): 20.7% increase (56.5% EMR vs. 46.8% control) in influenza vaccination Chaudhry (2006): 12% - 18% increase in influenza vaccination Johnston (2003): 3x as likely to have patients up to date (influenza, pneumococcal, tetanus)

CANADIAN CONTEXT DATA

Model Parameter	Estimate	Data Source
Canadian population over age 65	4,973,438	Statistics Canada, CANSIM, Table 051
Vaccination rate (Pre-EMR)	64%	Dahrouge (2012) & Statistics Canada CANSIM Table 105-4045
Rate of GP visits, Vaccinated	5.509%	Dahrouge (2012)
Rate of ED visits, Vaccinated	2.497%	Dahrouge (2012)
Rate of Hospital visits, Vaccinated	1.915%	Dahrouge (2012)
Rate of GP visits, Un-vaccinated	11.018%	Dahrouge (2012)
Rate of ED visits, Un-vaccinated	4.994%	Dahrouge (2012)
Rate of Hospital visits, Un-vaccinated	3.83%	Dahrouge (2012)
Cost of GP visit	$35	Dahrouge (2012)
Cost of ED visit	$220	Dahrouge (2012)
Cost of Hospital visit	$6,417	Dahrouge (2012)
Cost of vaccine	As part of routine visit (25% of population): $8.15 + $7.5 As standalone visit (75% of population): $17.85 + $7.5	Dahrouge (2012)

MATURITY OF USE

Estimate	Source	Question	Response
Baseline: 3%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)? **And** With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following	Yes

Estimate	Source	Question	Response
		information about your patients: - List of patients who are due or overdue for tests or preventive care **And** Are the following tasks *routinely* performed in your practice? - Patients are sent reminder notices when it is time for regular preventive or follow-up care - You receive a reminder for guideline-based interventions and/or screening tests	Easy and Computerized Yes, Using a Computerized System Yes, Using a Computerized System
High: 10%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)? **And** With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following information about your patients: - List of patients who are due or overdue for tests or preventive care **And** Are the following tasks *routinely* performed in your practice? - Patients are sent reminder notices when it is time for regular preventive or follow-up care	Yes Easy and Computerized or Manual Yes, Using a Computerized System

CALCULATION

Benefit Lever	Estimate	Calculation
Influenza vaccination annual savings	Baseline: $2.1 million High: $6.8 million	(Vaccinated population post EMR – Vaccinated population pre EMR) * (Cost of vaccinated population) + (Unvaccinated population post EMR – Unvaccinated population pre EMR) * (Cost of unvaccinated population)

Benefit Lever	Estimate	Calculation
		Where Vaccinated population pre EMR = 4,973,438*0.64 Unvaccinated population pre EMR = 4,973,438 – vaccinated population pre EMR Vaccinated population post EMR = 4,973,438*0.64*(1+0.2*0.03) Unvaccinated population post EMR = 4,973,438 – vaccinated population post EMR Cost of vaccinated population = 0.25*(8.15+7.5)+ 0.75*(17.85+7.5) + 0.05509*35 + 0.02497*220 + 0.01915*6,417 Cost of unvaccinated population = cost of vaccinated population – 0.25*(8.15+7.5) – 0.75*(17.85+7.5)

EMR use may lead to faster responses to changes in care and treatment guidelines

RELATIVE BENEFIT FROM LITERATURE

Benefit	Estimate and Sources
Hours saved in responding to medication recall / guideline change	38.63 hours per recall per physician
	Literature: Lapointe et al., 2012: The hours required for a full review all active patient records for paper records is estimated at 40 and for EMR, is estimated at 1.37.

CANADIAN CONTEXT DATA

Model Parameter	Estimate	Data Source
Number of Primary Care Physicians	42,910	Statistics Canada, 2006 Census of

Model Parameter	Estimate	Data Source
		Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Number of medical secretaries	21,465	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-563-XCB2006069 (Canada, Code01)
Number of nurses working in primary care offices	5,473	Canadian Institute for Health Information, *Regulated Nurses: Canadian Trends, 2006 to 2010* (Ottawa, Ont.: CIHI, 2011).
Average medical secretary salary ($ 2012)	$30,835	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-563-XCB2006069 (Canada, Code01)
Average RN salary ($ 2012)	$55,537	Statistics Canada, 2006 Census of Population, Statistics Canada catalogue no. 97-563-XCB2006069 (Canada, Code01)

MATURITY OF USE

Estimate	Source	Question	Response
Baseline: 12%	Commonwealth Fund Survey 2012	Do you use electronic patient medical records in your practice (not including billing systems)?	Yes
		And	
		With the patient medical records system you currently have, how easy would it be for you (or staff in your practice) to generate the following information about your patients:	
		- List of all patients taking a particular medication	Easy and Computerized

CALCULATION

Benefit Lever	Estimate	Calculation
Benefit from faster response to medication recalls / guideline changes, in hours	1 recall: 198,914 hours	Time required per physician to do full review in paper environment – time required per physician to do a full review electronically [(40 min * 42,910 physicians) – (1.37 min * 42,910 physicians)] *0.12

Benefit Lever	Estimate	Calculation
Benefit from faster response to medication recalls / guideline changes, in dollars	1 recall: $3,714,444	Annual redeployed hours per recall * cost per hour = 198,914 * [(21,465/(21,465+5,473)*30,835/115,200 + 5,473/(21,465+5,473)*55,537/115,200] * 60

Estimated number of diagnostic tests in Canada

Diagnostic tests	Estimate	Source / calculation
Number of annual family physician consultations	143,204,385	CIHI National Physician Database 2009/10, Table B.5.1 (2011)
Number of annual physician consultations	243,156,469	CIHI National Physician Database 2009/10, Table B.5.5 (2011)
Share of community-based specialists to total specialists	30%	PwC estimation from National Physician Survey 2010
Number of laboratory tests per visit	2.56	Bunting et al. (2004)
Number of diagnostic imaging tests annually in Canada	46,000,000	Canada Health Infoway (2008) Diagnostic Imaging Benefits Evaluation Report
Share of primary care physicians and community-based specialists to total physicians	70%	PwC estimation from Statistics Canada 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Total number of diagnostic tests ordered annually by primary care physicians and community-based specialists	475,641,088	(Number of family physician visits + Number of community-based specialist visits) * laboratory tests per visit + number of diagnostic imaging tests * share of primary care physicians and community-based specialists = (143,204,385 + (243,156,469 – 143,204,385)*0.3) * 2.56 + 46,000,000 *0.7
Number of potentially duplicated DI tests in Canada annually	**Estimate**	**Source / calculation**
Number of MRIs per 100,000 population	2,546	You et al. (2007)

Number of CT scans per 100,000 population	**10,687**	**You et al. (2007)**
Canadian population	34,880,500	Statistics Canada CANSIM Table 051-0001.
Total number of MRI and CT scans	4,615,737	Number of MRIs and CT scans per 100,000 population * population =(2,546 + 10,687) * 34,880,500 / 100,000
Number of diagnostic imaging tests annually in Canada	46,000,000	Canada Health Infoway (2008) Diagnostic Imaging Benefits Evaluation Report
Share of primary care physicians and community-based specialists to total physicians	70%	PwC estimation from Statistics Canada 2006 Census of Population, Statistics Canada catalogue no. 97-559-XCB2006011 (Canada, Code01)
Number of potentially duplicated DI tests in Canada annually	28,788,555	Number of diagnostic imaging tests annually in Canada – total number of MRI and CT scans = (46,000,000 – 4,615,737) *0.7
Diagnostic orders	**Estimate**	**Source / calculation**
Number of annual family physician consultations	143,204,385	CIHI National Physician Database 2009/10, Table B.5.1 (2011)
Number of annual physician consultations	243,156,469	CIHI National Physician Database 2009/10, Table B.5.5 (2011)
Share of community-based specialists to total specialists	30%	PwC estimation from National Physician Survey 2010
Percentage of visits where any lab test is ordered	23.1%	Furukawa et al. (2011)
Percentage of visits where any radiology procedure is ordered	15.26%	Furukawa et al. (2011)
Estimated number of diagnostic orders by primary care physicians and community-based specialists	66,435,688	(Number of consultations * percentage of visits where any lab test is ordered) + (Number of consultations * percentage of visits where any radiology test is ordered) = 23.1% * 173,190,010 + 15.25% * 173,190,010