The Case for Investing in Patient Safety in Canada

August 2017

RiskAnalytica
SCIENCE OF APPLIED RISK & REWARD MANAGEMENT

An independent study conducted on behalf of:

About RiskAnalytica

RiskAnalytica is a health economics research and technology firm that periodically provides objective, independent, and evidence-based analysis. The goal is to provide a quantitative understanding of the short- and long-term risks and returns behind policy decisions and health and economic outcomes.

As a brand of the Canadian Centre for Economic Analysis, at the centre of RiskAnalytica's analysis is the *Prosperity at Risk* (PaR) simulation platform. PaR is a sophisticated agent-based socio-economic computer platform that simulates the interactions of more than 40 million virtual agents (individuals, households, corporations, governments, and non-profit organizations) to realistically understand the consequences of market and policy developments for our clients.

RiskAnalytica does not accept any research funding or client engagements that require a predetermined result or policy stance or otherwise inhibits its independence.

About This Report

In keeping with RiskAnalytica's guidelines for funded research, the design and method of research, as well as the content of this study, were determined solely by RiskAnalytica.

The interpretation and reporting of the results of the mathematical modelling contained within this report do not necessarily represent the policy position or the opinion of the Canadian Patient Safety Institute. Forecasts and research often involve numerous assumptions and data sources, and are subject to inherent risks and uncertainties. This information is not intended as specific investment, accounting, legal, or tax advice.

This study was commissioned by the Canadian Patient Safety Institute, who would like to acknowledge the funding support from Health Canada. The results and interpretation contained within this report do not necessary represent the policy positions of CPSI or the views of Health Canada.

Citation:

RiskAnalytica. *The Case for Investing in Patient Safety in Canada.* August 2017.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

KEY TAKEAWAYS

Over the next 30 years in Canada, within acute and home care settings, there could be roughly 400,000 average annual cases of patient safety incidents (PSIs), costing around $6,800 per patient and generating an additional $2.75 billion (2017$) in healthcare treatment costs per year. The PSIs considered, and the costs incurred, are all preventable.

In terms of mortality, PSIs in total (acute/home care combined) rank third behind cancer and heart disease with just under 28,000 deaths across Canada (in 2013).

This is equivalent to such events occurring in Canada every 1 minute and 18 seconds, and a resulting death every 13 minutes and 14 seconds.

In the acute care setting, infections will be the biggest driver of PSIs, accounting for roughly 70,000 PSIs per year on average – generating an additional $480 million per year on average in healthcare costs.

Traumas (e.g., falls) will be the biggest driver of PSIs in the home care setting, accounting for roughly 115,000 PSIs per year on average. The emergency room and hospital costs associated with these trauma events amounts to approximately $860 million per year on average.

There are success stories from around the world (including Canada) in improving patient safety.

Given CPSI's 2016-17 operating budget of $7.7 million, its programs would only have to help reduce just over 1,100 PSIs per year – approximately one quarter of one percent of the average annual number expected over the next 30 years of total PSIs in Canada – in order to offset the costs of its operations.

1 THE SCALE OF PATIENT HARM IN CANADA

Nearly 20 years ago, the Institute of Medicine (IOM) released a report, "*To Err is Human",* which brought into full view the impact of patient harm in American hospitals (Institute of Medicine, 2000). In 2004, Dr. G. Ross Baker and his colleagues estimated that one in fourteen patients in Canadian hospitals suffer from some form of harm, with a third of such cases being preventable (Baker, et al., 2004). More recently, a joint effort between the Canadian Patient Safety Institute (CPSI) and the Canadian Institute for Health Information (CIHI) produced a new measure for hospital harm in Canada and estimated that one of every eighteen patients in Canadian hospitals experience a preventable incidence of harm (CIHI;CPSI, 2016). Furthermore, given a growing emphasis on decentralizing healthcare to home care facilities, patient harm in other settings is becoming more evident (Doran, et al., 2013). Here, incidence has been estimated to be slightly higher, with roughly one in ten clients experiencing preventable harm (CPSI, 2013).

1.1 Patient Safety Incidents in Canada

In order to understand the impact of patient safety in Canada over the next 30 years, RiskAnalytica used *Prosperity at Risk* (PaR), an integrated socio-economic computer platform that incorporates social, health, and financial factors in a networked modeling system. PaR is capable of tracking over 40 different conditions and risk factors and mapping them to healthcare utilization data.

Over the next 30 years, it is expected that a PSI will occur in Canada nearly every minute, and a resulting death nearly every 13 minutes

RiskAnalytica linked patient safety incident rates from the latest Canadian research sources to the PaR platform to derive the costs of patient safety incidents. For the purpose of this study, the definition of Patient Safety Incidents (PSIs) is based on a preventable unintended outcome of care caused by medical management or complication rather than by the underlying disease itself, resulting in prolonged healthcare, disability or death. Appendix B contains a full description of the

definitions used. It is important to note that the definition specifically focuses on preventable incidents. (For more information on the PaR platform and methodology used in this analysis, please refer to Appendix B.1).

Based on this analysis, over the next 30 years in Canada, within acute and home care settings, RiskAnalytica estimates there could be roughly 400,000 average annual cases of patient safety incidents (PSIs), generating an additional $2.75 billion (2017$) in healthcare costs per year, or around $6,800 per patient. These PSIs are preventable unintended outcomes of care that could be avoided given evidence-based practices.

This is equivalent to such events occurring in Canada every 1 minute and 18 seconds. Further, deaths due to PSIs occur every 13 minutes and 14 seconds. PSIs have the potential to cause serious illness and even death, with patients who experience harm having a higher mortality than those who do not. There could be roughly 40,000 average annual deaths due to PSI in Canada over the next 30 years.

The average annual and cumulative total results for the incidence, mortality, and healthcare costs caused by PSIs in acute care and home care are provided in Table 1.

Table 1 Impact of harm over 30 years from PSIs across Canada

	Annual Averages			30-Year Totals		
Setting	Incidence	Mortality	Healthcare Costs (2017$)	Incidence	Mortality	Healthcare Costs (2017$)
Acute Care	190,000	24,000	$1.30B	5.7M	713,000	$39B
Home Care	210,000	16,000	$1.45B	6.4M	478,000	$43B
	400,000	**40,000**	**$2.75B**	**12.1M**	**1.2M**	**$82B**

In the acute care setting, infections will be the biggest driver of harm events, accounting for 37% of the PSIs – or roughly 70,000 PSIs per year on average – generating an additional $480 million per year on average in healthcare costs associated with an added length of stay in a hospital. Traumas (e.g., falls) are the biggest driver of harm events in the home care setting, accounting for an estimated 54% of events – or roughly 115,000 PSIs per year on average. The emergency room and hospital costs associated with these trauma events amounts to approximately $860 million per year on average.

Part of this simply stems from a quickly growing population in both care settings, from 11% of the total Canadian population in 2018 to 15% by 2047. This itself is mostly due to the aging of Canada's population (and the associated comorbidities), though PSIs readily occur across all patient ages, including children. It is estimated that nearly one in eleven hospitalized children experience a harm event (Matlow, et al., 2012). The most common patient harm for older children (5-18 years old) involved surgery, while drug-related patient harms were common among younger children (1-5 years old) (Matlow, et al., 2012). It should be noted that some possible reasons for patient harm among children overlap with those that occur in home care, such as complexity of care, high number of caregivers, and documentation standards (Matlow, et al., 2012; CPSI, 2013; Masotti, McColl, & Green, 2010).

1.2 Sensitivity Analysis

Although literature consistently supports the fact that PSIs have a substantial impact, it is important to note that there is large variability in the published rates and estimations in the literature and publicly available data regarding the incidence of PSIs. This can be caused by methodology differences, the definition of harm, or the setting (i.e., large acute care settings or small intensive care units within a hospital). For example, in literature, the rate of medication events can range from 0.02% to 2.27%, infections can range from 2.04% to 11.70%, and trauma can range from 0.19% to 5.2% (Baker, et al., 2004; CPSI, 2013; CIHI;CPSI, 2016; PHAC, 2013). When attempting to make cost effectiveness calculations, conclusions can vary considerably depending on which incidence rates are used.

As exhibited in Table 2, the impact (average annual incidence, mortality, and healthcare costs) of medication events within the acute care setting can vary

substantially. This is due to the fact that the incidence rate from the Canadian adverse event study (0.9%) is almost 45 times as large as the rate used by RiskAnalytica (0.02%) which is based off of the Hospital Harm study done by CIHI and CPSI.

The lower incidence rate used by RiskAnalytica likely reflects that medication errors are often under-represented for methodological reasons – for example, because they contribute to other events that are affected by medication practices and thus captured under other incident categories (CIHI;CPSI, 2016). However, studies commonly agree that medication errors are among the most common and harmful of patient safety incidents (CIHI;CPSI, 2016; Slawomirksi, Auraaen, & Klazinga, 2017) .

Table 2 Sensitivity Analysis: Acute Care Medication Events

Study	Incidence Rate	Avg. Annual Incidence	Avg. Annual Mortality	Avg. Annual Healthcare Costs (2017$)
RiskAnalytica Estimates	0.02%[1]	700	40	$2.6M
Canadian Adverse Event Study (Preventable)	0.9%[2]	30,000	1,900	$125M

Using the Canadian Adverse Event Study rates of *preventable* medication events, the average annual healthcare costs, for example, increases from $2.6 million (current estimates) to $125 million. For this study, the CIHI/CPSI source for the rate (0.02%) was chosen because it is the more recent and more conservative estimate. The result of this is that the estimated impact of PSIs in Canada, although still substantial, is more conservative than would be estimated using the higher rate.

In addition, because this analysis only considers additional treatment costs rather than broader social costs, the cost estimates represent only a portion of the full

[1] Incidence rate used in the analysis from the Hospital Harm Indicator from CIHI and CPSI (CIHI;CPSI, 2016).

[2] Incidence rate of preventable drug- and fluid-related events from the Canadian Adverse Event Study (Baker, et al., 2004).

costs of patient safety incidents in Canada. The additional costs imposed by these incidents are described later in this report.

2 CANADIAN EXPERIENCE IN AN INTERNATIONAL CONTEXT

Canada is not the only country for which patient harm is a significant problem. Patient harm is a global disease burden estimated to be the 14th leading cause of morbidity and mortality in the world (Slawomirksi, Auraaen, & Klazinga, 2017). This would place it on par with diseases like tuberculosis and malaria (Slawomirksi, Auraaen, & Klazinga, 2017). Furthermore, as this section will highlight, the estimates of the incidence of patient harm and its impact on the healthcare systems of other countries cluster around the estimates found in Canada and reinforce the impact of harmful events.

Across developed nations, the incidence rates of patient harm among hospitalizations are estimated to be between 6% and 17%

2.1 Overall Incidence, Preventability, and Mortality

As was discussed in the previous section, the estimates of the incidence of patient safety incidents vary based on methodological approaches and definitions. This is most obvious when looking at the history of patient harm in the United States. Looking at the measurement of harm from 1978 to the present day, incidence in the U.S. has ranged from 3.7% of hospitalizations to 10-12% of hospitalizations, with 27%-50% being considered preventable (AHRQ, 2016; Brennan, et al., 1991; Levinson, D.R., 2010).

Such a range in not uncommon and falls in line with estimates from Canada and other countries, as exhibited in Table 3 . Canadian incidence rates were originally estimated by the Baker Norton study to be about 7%, with one third of these preventable. More recently, the Hospital Harm Measure put the rate of preventable PSIs in the acute care sector at 5.6%.

Table 3 International comparison of estimated preventable PSI incidence rates

Country	Estimated Preventable PSI Incidence Rate	Source
Canada	5.6%	(CIHI;CPSI, 2016)
Australia	5.3-8.3%	(Wilson, Runciman, Gibber, Newby, & Hamilton, 1995; Thomas, et al., 2000)
United Kingdom	5.9%	(Vincent, Neale, & Woloshynowych, 2001)
Denmark	3.6%	(Schioler, et al., 2001)
Netherlands	2.3%	(Zegers, et al., 2009)
New Zealand	6.3%	(Davis, et al., 2002; Davis, et al., 2003)

A recent report by the Organization for Economic Co-Operation and Development (OECD) further supports this range of incidence of PSIs, concluding based on a broad survey of studies from developed and developing countries that up to 17% of all hospitalizations are affected by one or more adverse events, with 30-70% of these being preventable ((Slawomirksi, Auraaen, & Klazinga, 2017), p.11 and p.20). This study notes that approximately one in ten patients are harmed in the acute care setting ((Slawomirksi, Auraaen, & Klazinga, 2017), p.10). While other settings such as primary care, home care and long-term care are less studied, patient safety incidents are common in these settings as well. Studies in the primary care setting have identified medication error and diagnostic errors as key issues, with one U.S. study estimating that about 5% of adult patients experience diagnostic errors ((Slawomirksi, Auraaen, & Klazinga, 2017), p.10).

As noted in the analysis in Section 1, approximately 10% of preventable Canadian PSIs result in death. The recent Hospital Harm Measure developed in Canada estimated the mortality rate to be 12.5%. The OECD study reports that studies in developed countries suggest a mortality rate between 2% and 16% (Baker, et al., 2004; Soop, Fryksmark, Koster, & Haglung, 2009). Furthermore, the OECD report found that although developed and developing nations have similar incidence rates, they tend to vary in the severity of the cases. That is, it appears that in developing countries one in three patients suffering patient harm die as a result

(Baker, et al., 2004; Soop, Fryksmark, Koster, & Haglung, 2009). What's more is that a substantial portion of patient harm in developing countries could be prevented through simple measures such as better training, increased awareness among providers, and implementation and compliance with relevant patient safety protocols.

2.2 Overall Cost

From the few studies looking into the direct healthcare costs of patient harm around the world, it is evident that other countries pay a large price for such events[i], on par with the healthcare costs of harm in Canada, estimated in our analysis to be about $6,800 per patient. Studies done in the U.S. and Australia have estimated the economic cost of PSIs to be $6,124 and $12,648 per case[3] respectively (Kaushal, Bates, Franz, Soukoup, & Rothschild, 2007; Ehsani, Jackson, & Duckett, 2006).

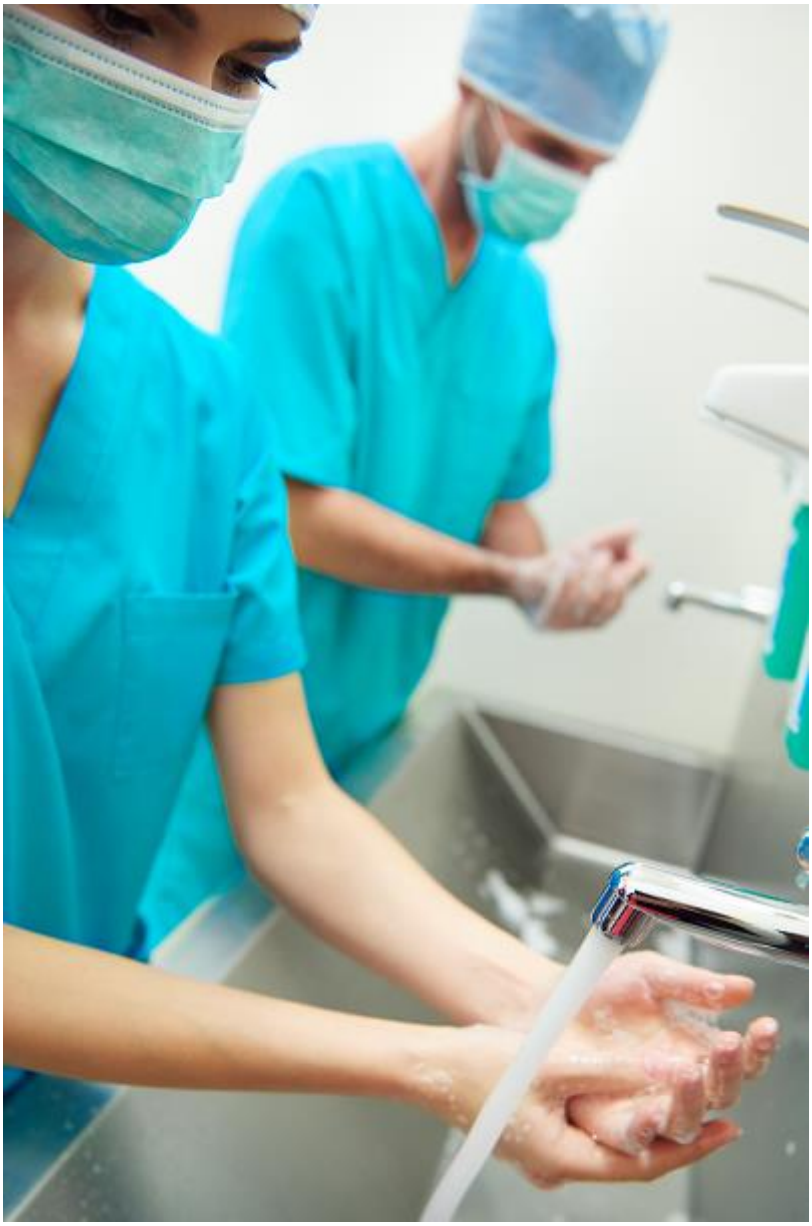
Of course, these averages can be deceiving as the costs for PSIs can vary depending upon the type of event. For example, medication errors have been shown to cost $400-$600 per event, while surgical site infections have been estimated, in some cases, to cost as much as $26,000 per case (Etchells, et al., 2012). Even within a given event type, for example nosocomial infections[4], international studies in the U.S., Europe, and Australia have provided cost estimates between $2,265 and $29,950 per event (Etchells, et al., 2012).

The cumulative total of these treatment costs impose a significant financial burden. When expressed as a percentage of public hospital spending, the burden of PSIs varies from 1.3% to 32%, with this variation partly explained by methodological differences between studies[5]. Overall, the OECD study concluded that, in developed countries, patient harm in hospitals consume approximately 15% of acute care expenditure in a healthcare system (Slawomirksi, Auraaen, & Klazinga, 2017). Our analysis estimates costs of $2.75 billion per year, $1.3 billion in the acute care setting and $1.45 billion in the home care setting. In other studies, acute care spending attributable to adverse events has been estimated to be over $1.1 billion

[3] Values were converted to 2010 CAD dollars
[4] Infections acquired in a hospital setting (e.g., C. Difficile or Methicillin resistant Staphylococcus aureus (MRSA))
[5] Note that some variation may be due to costing methodologies.

in 2009 ((Slawomirksi, Auraaen, & Klazinga, 2017), p.18). The economic cost of medical error in the U.K. was estimated to be 2% to 10% of hospital spending, and the cost of medical error in the U.S. was estimated at $19.5 billion ((Slawomirksi, Auraaen, & Klazinga, 2017), p.21).

Broader social and system costs are discussed later in this report. As will be shown, patient safety events are costing countries trillions of dollars across the world. Given that a high proportion of these incidents are preventable, they represent a true opportunity cost to the healthcare system ((Slawomirksi, Auraaen, & Klazinga, 2017), p. 10).



3 BEYOND THE DIRECT IMPACT OF PATIENT HARM

The estimated health and healthcare impact of patient harm in Canada over the next 30 years is staggering. However, these costs do not represent the total economic burden of patient harm, which extends beyond healthcare resources to include disability, lost productivity, and impact on friends and family.

3.1 Disability

Directly, patient harm in the acute care setting lead to increased lengths of stay, which take up additional resources that could go to other patients. In home care, over 90% of patient harm events were associated with increased use of healthcare resources (CIHI;CPSI, 2016; CPSI, 2013). But they can also result in longer-term disability. Within the home care setting it has been estimated that over two-thirds of patient harm events result in disability, while over one-third of them in acute care resulted in disability of some form[6], and around 5% of patient harm events resulted in permanent disability[7] (CPSI, 2013; Baker, et al., 2004).

Such disabilities reach beyond the individual directly affected by these events. Disability often involves informal caregiving: when individuals, aged 15 or older, provide unpaid care to a family member or friend with a long-term health condition, a physical or mental disability, or problems related to aging (Employer Panel for Caregivers, 2015). In 2012, 8.1 million, or 28% of Canadians, were providing such care. Three quarters of this group (roughly 6.1 million) were in the workforce, representing 35% of employed Canadians. Employee caregivers experience work interruptions, lower productivity and absences, and are less able to provide overtime, travel for work, or take career-advancing opportunities. In 2012, 1.6 million caregivers took leave from work and 600,000 reduced their work hours; 160,000 turned down paid employment; and 390,000 quit their jobs to provide care. Furthermore, caregivers are more likely to experience mental health issues (between one-sixth and one-third will experience depression) or other

[6] Disability ranging from minimal impairment, recovery in 1 month, to permanent impairment, recovery over a year.
[7] Defined as disability lasting more than 1 year.

impacts due to the added stress of caregiving (Employer Panel for Caregivers, 2015). Therefore, PSIs have the potential to result in additional informal caregiving due to disability causing an increased reliance on support. This has the potential to reverberate throughout the socio-economic system as informal caregivers, especially those who provide care for an extended period, experience their own mental or other health issues.

Taking this further, individuals becoming more reliant on informal caregiving may actually lead to *more* PSIs. Substantial variance in levels of training and education between informal and formal care-givers can significant impact quality of care and safety. This is especially true as it relates to home care (Miller, 2012), in which one study found that informal caregivers contributed to 42.3% of PSIs (Johnson K. , 2006).

3.2 Lost Productivity

Patient harm also leads to lost productivity. One study looked into preventable medication hospitalizations in Netherlands to determine the direct and indirect costs of such events[ii]. When extrapolated to the entire Dutch healthcare system, preventable medication hospitalizations cost over $140 million CAD (€94 million) in direct and indirect healthcare expenditures, with lost productivity, including time off work, adding $12 million CAD (€8 million) in costs[8](Leendertse, et al., 2011).

Another study evaluated the direct costs due to adverse drug events (ADEs), including costs for dispensed drugs, primary care, other outpatient care, and inpatient care.[iii] The study found that an ADE resulted in an additional $2,357 CAD ($US 1,719) in lost productivity when compared to regular patients. This represented 45% of the total costs (direct + indirect) (Gyllensten, et al., 2014).

Studies done in the U.S.[iv] have investigated the cost of injury, including lost wages and lost household productivity. When extrapolated to the entire US and brought up to 2008 dollars, lost wages amount to $21.25 billion CAD ($US 15.5 billion) and lost household productivity amounted to $34 billion CAD ($US 25 billion). (Johnson, Brennan, & Newhouse, 1992; Van Den Bos, et al., 2011). Another study done in Utah and Colorado[v] found that, when extrapolated to the entire U.S., patient harms

[8] Productivity costs included cost estimates for time off work and reduced productivity on the job.

resulted in a total of $23 billion ($US 17 billion) in total healthcare costs, roughly $700 per hospital admission, which includes lost wages amounting to $4.67 billion ($US 3.4 billion), or $141 per hospital admission, and lost household productivity amounting to $6.5 billion ($US 4.8 billion), or $200 per hospital admission (Thomas, et al., 1999). Most recently, the OECD estimated that the economic cost of medical error in 2008 in the U.S. to be almost $1.34 trillion CAD ($US 1 trillion) (Slawomirksi, Auraaen, & Klazinga, 2017).

Comparatively, mental health, another condition for which productivity costs tend to be a substantial contributor to overall cost, produces indirect impact, such as absenteeism, presenteeism, and the foregone wages due to the presence of mental illness, representing 13% of the total cost (Smetanin, et al., 2011). The studies mentioned above place the indirect impact of patient harm at between 9% and 50% of the total cost.

4 DISEASE COMPARATORS

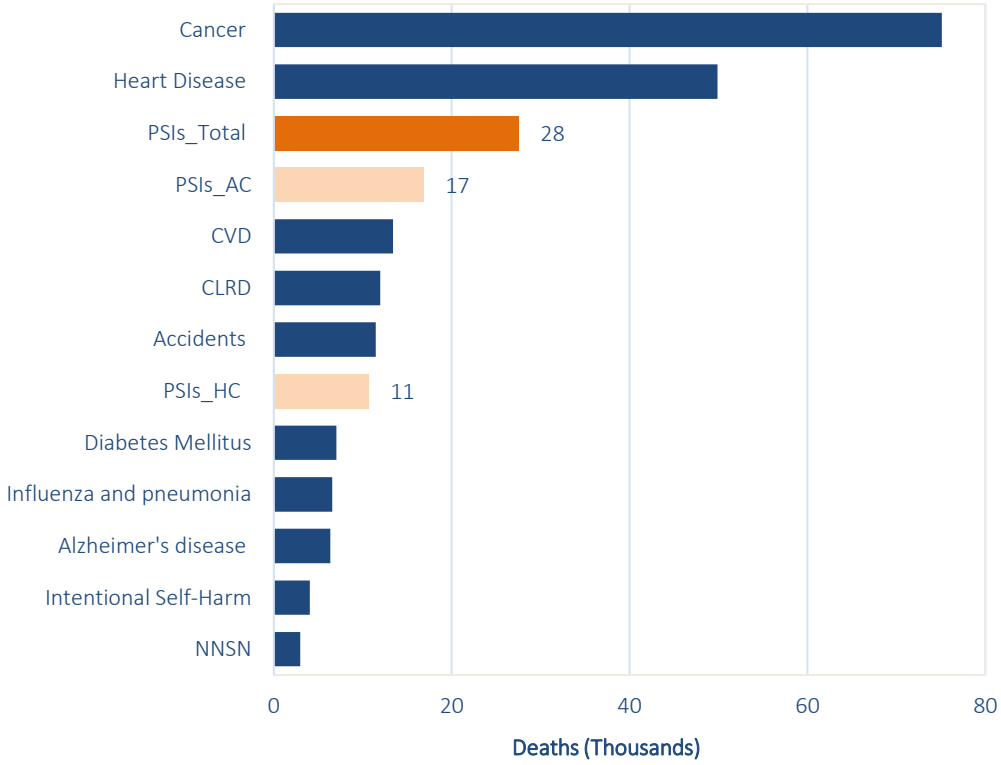
One of the biggest shocks coming from the release of the IOM's seminal report on patient safety in the U.S., "*To Err is Human",* was the realization that more people die each year from medical errors in U.S. hospitals alone (between 44,000 and 98,000) than from traffic accidents, breast cancer, or AIDS (Institute of Medicine, 2000). Subsequent studies estimate that the IOM estimation of the deaths caused by patient harm in the U.S. was an underestimation, and a serious one at that. Such researchers believe that the actual number of deaths caused by preventable patient harm in the U.S. is closer to 250,000 annually[vi] (Makaray & Daniel, 2016). It is also important to note that this refers to only preventable deaths due to medical error that occur in hospitals and ignores, due to data insufficiency, deaths in other settings, such as home care, resulting from patient harm. Given this mortality rate, preventable medical errors would be the third leading cause of death in the U.S., behind heart disease and cancer (Makaray & Daniel, 2016). From a global perspective, patient harm is estimated to be the 14th leading cause of morbidity and mortality in the world (Slawomirksi, Auraaen, & Klazinga, 2017). This would place patient harm on par with diseases like tuberculosis and malaria (Slawomirksi, Auraaen, & Klazinga, 2017).

Using a similar approach, RiskAnalytica's estimates for the mortality associated with PSIs in the acute and home care settings were compared with Statistics Canada estimates for leading causes of death in 2013[vii,viii], as evident in Figure 1 (Statistics Canada). In total (acute and home care combined), PSIs rank third behind cancer and heart disease with just under 28,000 deaths across Canada (in 2013). PSIs in acute care alone are the fourth leading cause of cause of death with approximately 17,000 deaths in 2013. And with just under 11,000 deaths, PSIs in home care rank 6th, falling just behind chronic lower respiratory disease (12,000 deaths) and accidental injury (11,500 deaths), but still well above Diabetes Mellitus, Influenza/ Pneumonia, and Alzheimer's disease. RiskAnalytica's estimates of the ranking of

With an estimated mortality of 28,000 in 2013, patient safety incidents were the third leading cause of death in Canada, behind cancer and heart disease

acute care PSIs is consistent with those found in other studies in the U.S. (Makaray & Daniel, 2016). As with all estimates that rely on the incidence of PSIs, it should be noted that these numbers probably underestimate the actual number of deaths caused by patient harm, especially in the home care setting.

Figure 1 Leading causes of death in Canada, 2013[9]



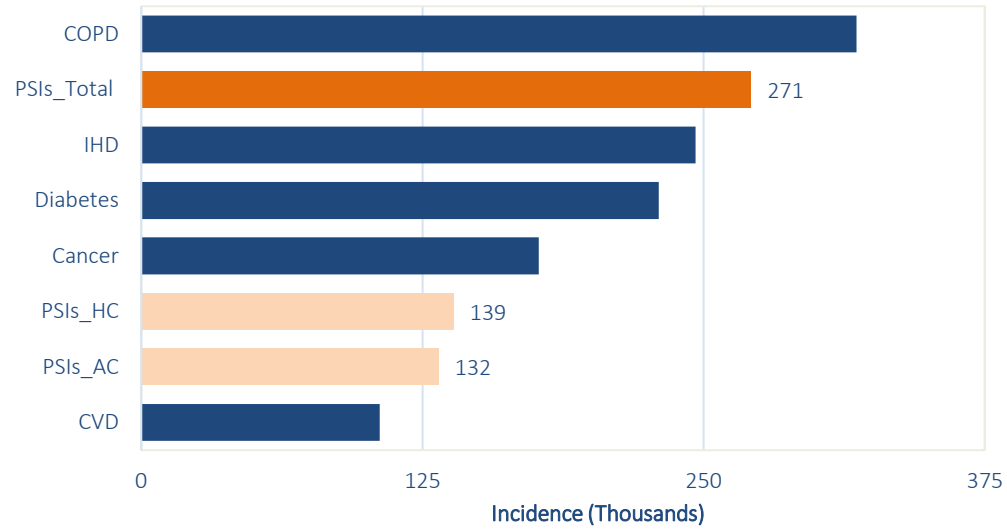
Source: Statistics Canada (Table 102-0561); RiskAnalytica

Using PHAC data, it was possible to further highlight the impact of PSIs by showing how their incidence and possible associated healthcare costs rank among other diseases. Using 2012 data from the Public Health Agency of Canada (PHAC) (2016), the incidence of PSIs[ix] ranks among the incidence of some of the most heavily discussed and researched diseases, including: chronic obstructive pulmonary disease (COPD), diabetes, cancer, ischaemic heart disease (IHD), and cerebrovascular disease (CVD).[x]. Hospital costs in 2008 for these diseases were estimated PHAC's Economic Burden of Illness in Canada cost generator[xi] (Public

[9] PSIs = Patient Safety Incidents, AC = Acute Care, HC = Home Care, Total = Acute Care and Home Care, CVD = Cerebrovascular Disease (i.e., Stroke), CLRD = Chronic Lower Respiratory Disease, and NNSN = Nephritis, nephrotic syndrome, and nephrosis.

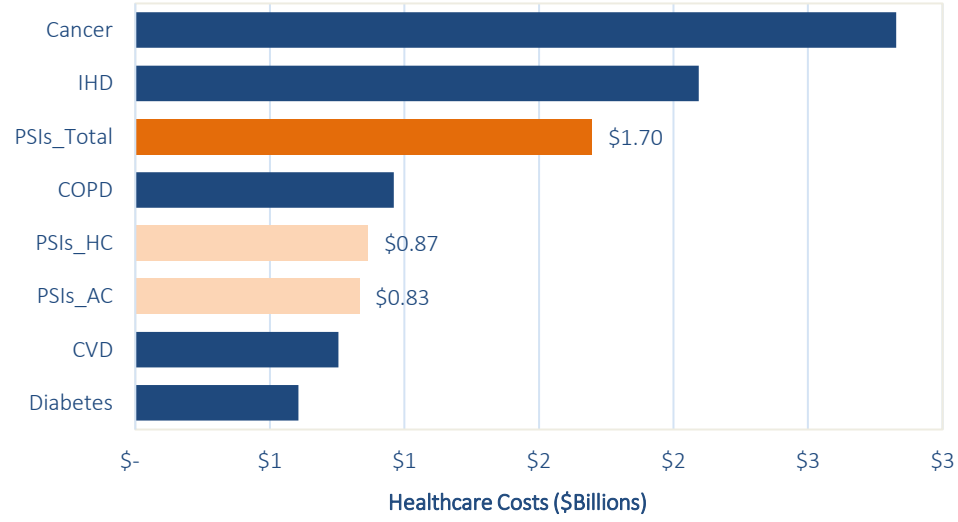
Health Agency of Canada, 2017). Comparisons between PSIs and other diseases as it relates to incidence and hospital costs are shown in Figure 2 and Figure 3.

Figure 2 Disease Incidence (2012) Rankings in Canada[10]



Source: (Public Health Agency of Canada, 2016); (Public Health Infobase, 2017); RiskAnalytica

Figure 3 Disease Healthcare Costs ($2017) Rankings in Canada



Source: (Public Health Agency of Canada, 2016); (Public Health Infobase, 2017); RiskAnalytica

[10] COPD = Chronic Obstructive Pulmonary Disease, PSIs = Patient Safety Incidents, AC = Acute Care, HC = Home Care, Total = Acute Care and Home Care IHD = Ischaemic Heart Disease, and CVD = Cerebrovascular Disease (i.e., stroke).

Individually, the number of PSIs ranks fifth (home care) and sixth (acute care), among the diseases tracked, falling behind some high-profiled diseases like Ischemic heart disease (IHD), diabetes, and cancer. However, when combined, incidence of PSIs in both settings ranks second in Canada, behind only COPD. A similar story exists when comparing healthcare costs (Figure 3). Although individually PSIs rank fourth (home care) and fifth (acute care), combined, they rank third behind cancer and IHD.

5 REGARDED PATIENT SAFETY INITIATIVES ACROSS THE GLOBE

It is no surprise that "*To Err is Human*" – which highlighted the human and economic toll that patient harm has placed on healthcare systems around the world – was a wakeup call credited for launching modern patient safety initiatives (Shekelle, et al., 2013). The good news is that a large proportion of the incidence and costs of patient safety events are preventable. The OECD study notes that many patient safety events can be systematically prevented through better policy and practice, with the cost of prevention typically much lower than the cost of harm (Slawomirksi, Auraaen, & Klazinga, 2017).

Focusing on improving such a complex system, many patient safety initiatives have turned to the "Swiss Cheese Model", which is an apt description of how harm occurs, wherein multiple barriers are set up to prevent errors yet each barrier has flaws (or "holes", similar to Swiss cheese). When the "holes" on multiple barriers align, the harm makes it through to the patient (AHRQ, 2015).

This analogy provides two powerful insights into patient harm prevention: it is important to: a) encourage individuals to identify "holes" at all levels to reduce the likelihood that they occur; and b) accept that human error is inevitable. This latter point ensures that we do not expect perfect performances from healthcare practitioners working in complicated and stressful environments, and that effort should instead be focused on preventing errors resulting from process and system design (AHRQ, 2015). This is especially true considering that unsafe care and resulting patient harm are principally the result of system failures in the way care is organized and coordinated, with typical causal factors related to communication failures, absence of relevant information, insufficient education, knowledge and skills, and inadequate organizational culture (Slawomirksi, Auraaen, & Klazinga, 2017). Organizations and programs – such as the Scottish Patient Safety Program (SPSP) in Scotland, Dutch safety programs, Agency for Health Research & Quality (AHRQ) in the U.S., and the Canadian Patient Safety Institute (CPSI) – take such multiply disciplinary approaches to improving patient safety.

Although a limited number of studies have attempted to estimate the cost of PSIs, even fewer have tried estimating the potential savings associated with patient safety initiatives. Of those that have, only a small proportion are based on empirical data (Slawomirksi, Auraaen, & Klazinga, 2017). However, some of the evidence from these studies appears promising. For example, a study in the U.S. on venous thromboembolism (VTE) found that the costs associated with preventable hospital-acquired VTEs in the U.S. ranged from $9.2 to $36 billion while the costs related to preventing such events was estimated to be less than $808 million (Slawomirksi, Auraaen, & Klazinga, 2017).

The following provides an overview of some of the more highly regarded patient safety initiatives around the world.

5.1 Scotland

The Scottish Government's *Healthcare Quality Strategy* has specified three "Quality Ambitions", the first of which is "There will be no avoidable injury or harm to people from healthcare, and an appropriate, clean and safe environment will be provided for the delivery of healthcare services at all times" (Quality Strategy, 2016).

To help achieve this ambitious goal, Healthcare Improvement Scotland co-ordinates the Scottish Patient Safety Programme (SPSP) on behalf of the Government, with the goal of reducing mortality in Scottish hospitals. The SPSP began in the acute care setting, but has since expanded into other care areas including a maternity and children quality improvement collaborative, mental health collaborative, and primary care program (SPSP - About Us, 2017).

After being launched in 2008, the Acute Adult program concluded its current phase of work in March 2016. In the last year, the program was able to demonstrate a:

- 16.5% reduction in Hospital Standardised Mortality Ratio (HSMR) of from the 2007 baseline;
- 21% reduction in 30-day mortality sepsis, using ICD-10 A40/41 sepsis codes; and
- 19% reduction in cardiac arrest rate for 11 hospitals that have reported consistently from February 2012 to December 2015.

In addition, eight out of 15 reporting NHS boards reporting between March 2014 and February 2015 show the percentage of patients discharged from hospital without any of the Scottish Patient Safety Indicator (SPSI) types of harm exceeds the original aim of 95% (SPSP, 2016).

Within the primary care setting, the SPSP tackles safety from three different levels. At the healthcare provider level, individuals are required to anonymously fill out surveys to provide a snapshot of the safety environment. This is a way of identifying the holes in the "blocks of cheese". At the leadership level, leaders get involved with general practices to improve safety and demonstrate to frontline staff their support for safety improvement. Last, structural changes that can be made to improve safety are identified by reviewing previous incidents of harm. These

changes are then implemented through educational sessions, protocol development, and practice (SPSP, 2014). Although quantitative statistics on the rates of PSIs are not available for primary care, the program has shown significant uptake among healthcare providers. Since its launch in 2013, 93% of all general practitioners (GPs) participate in the safety climate survey, 74% of GPs are carrying out structured case-note reviews (with NHS reporting that safety changes have been made at an organizational level), and 83% of GP practices have introduced safer medicine bundles, which are a new system of medication reconciliation for the prescribing of high-risk drugs (SPSP, 2016).

A unique aspect of SPSP has been an emphasis on mental health safety. Since 2012, the organization has worked to change the culture around mental health as it relates to medicines, risk assessments and safety planning, violence, restraint and seclusion reduction, and communication at transitions (SPSP, 2016). Recently, wards and units utilizing their safety principles and programs have demonstrated reductions in restraint use of up to 57%, reduction in the percentage of patients who self-harm by up to 70%, and reduction in the rates of violence of up to 78% (SPSP, 2016). Similar to other SPSP and patient safety programs, mental health safety is addressed at multiple levels. This includes admission/discharge follow-up procedures to ensure adequate communication, patient safety climate tools to collect data on safety, risk assessment training for education, medication reconciliation, and restraint monitoring and management (SPSP, 2016).

5.2 Netherlands

As evident in Table 3, the Netherlands has one of the lowest patient harm rates in the world, with just under 6% of hospitalizations resulting in harm, and just over 2% of hospitalizations resulting in preventable harm (Zegers, et al., 2009). The Dutch have been regarded as one of the global leaders in the patient safety movement with many countries turning to their strategies in hopes of achieving similar results.

The Netherlands conducted two major programs: the "Better Faster" program (2003-2008) and the "Prevent Harm, Work Safely" program (2008-2012). (Baines, Langelaan, Bruijne, Spreeuwenberg, & Wagner, 2015). The first program had limited enrollment with 24 out of 93 hospitals taking part. The program focused on improving safety management systems, increasing hospital board accountability, and engaging government (Prins, 2010). During this period, the rate of PSIs actually increased in the Netherlands (from 4% to 6%, though the rate of *preventable* harm did not change), a change that may be due to the reduced stigma associated with reporting on patient harm and a growing openness in the healthcare environment, an area where the Netherlands has been shown to be a leader (Baines, Langelaan, Bruijne, Spreeuwenberg, & Wagner, 2015; Wagner, Smits, Sorra, & Huang, 2013).

The second, more ambition program - "Prevent Harm, Work Safely" - was introduced throughout all Dutch hospitals with the goal of a 50% reduction in avoidable unintended harm. This program involved the implementation of a safety management system within all hospitals that was a combination of policy and strategy, proactive culture change, risk inventory, incident reporting and analysis, and continuing improvement (Prins, 2010; Baines, Langelaan, Bruijne, Spreeuwenberg, & Wagner, 2015). Furthermore, the program focused on ten practical themes[11] to address and introduce a surgical checklist on a large scale (Baines, Langelaan, Bruijne, Spreeuwenberg, & Wagner, 2015). Over four years the program, the program observed an uncorrected crude reduction of 45% and a corrected reduction of 30%in the rate of PSIs, though researchers were unable to

[11] The ten themes were: prevention of postoperative wound infections, early detection and treatment of critically ill patients, early detection and treatment of pain, verification of medicines upon admission and discharge, prevention of renal failure from the use of iodinated contrast agents, high risk medications, optimised care for acute coronary syndrome, prevention of line sepsis and the treatment of severe sepsis, vulnerable elderly, and safe patient transfer.

conclude that the improvement was due solely to the new protocols (Baines, Langelaan, Bruijne, Spreeuwenberg, & Wagner, 2015).

5.3 United States

The Agency for Healthcare Research and Quality (AHRQ) works to improve safety and quality of healthcare in the U.S. (About AHRQ, 2017). One of their initiatives is the Patient Safety Organization (PSO) that provides a legally secure environment for clinicians and healthcare providers to report, aggregate, and analyze data that allows for the development of insights into patient safety (Patient Safety Organizations Program, 2016).

AHRQ is a member of the Partnerships for Patients (PfP) campaign, launched in 2011 with the goal of reducing preventable hospital-acquired conditions (HACs) by 40% and 30-day hospital re-admissions by 20%. The campaign targeted ten areas for which there was strong evidence that improvement was possible, such as adverse drug events (ADEs), hospital acquired infections (HAIs), falls, pressure ulcers, and surgical site infections (SSIs). Reporting on preliminary results from

baseline data in 2010, this program saw a 21% decline in HACs by 2015, which translates to 3.1 million fewer HACs that would have occurred if 2010 rates had been maintained (Slawomirksi, Auraaen, & Klazinga, 2017). The greatest aggregate reductions were seen for adverse drug events (42%), pressure ulcers (23%), and catheter-associated urinary tract infections (15%). Some possible explanation for these improvements could be transparency and public reporting of hospital-level results, financial incentives, investment in knowledge development, or implementation and improved use of electronic health records (Slawomirksi, Auraaen, & Klazinga, 2017).

Some of the processes that the PfP campaign implemented traversed all levels of healthcare providers from hospital leadership to hospital staff. Examples includes removing the negative consequences associated with reporting a PSI or near misses, which allowed there to be a focus on safety and learning from others' mistakes (AHRQ, 2015). They also began integrating other caregivers and families of patients into education about potential events, such as pressure ulcers or venous thromboembolisms (AHRQ, 2015).

5.4 Canada

The establishment of the Canadian Patient Safety Institute (CPSI) in 2003 highlighted a commitment to patient safety in Canada. CPSI's mission is to work with governments, healthcare organizations, leaders, and providers to achieve improvements in patient safety and quality (About CPSI, 2016). The organization was established following a report from the National Steering Committee on Patient Safety (National Steering Committee on Patient Safety, 2002). The Institute was mandated to be a multidisciplinary organization that consists of clinical, academic, and administrative experts in the fields of safety and healthcare from across Canada with the purpose of recommending best practices, technologies, and programs (National Steering Committee on Patient Safety, 2002). Since being established, CPSI has gone on to develop programs to ensure the safety of patients through the dissemination of tools, resources, and knowledge that can be applied in any healthcare organization.

Many of CPSI's programs focus on delivery behaviour, aiming to impact cultural enablers (e.g., learning and reporting culture, teamwork and communications,

patient safety education, and engagement) across many care pathways and settings[12]. For example, *Safe Healthcare Now* (SHN) was a set of customizable and evidence-based interventions across many clinical areas (e.g., acute myocardial infarction, infection prevention and control, falls, sepsis, and medication reconciliation) utilized to prevent patient safety events (CPSI - Intervention, 2016). However, this program was eventually retired (though the evidence-based recommendations and guidelines are still available) in favor of a cross-clinical program called *SHIFT to Safety* (CPSI - SHIFT to Safety, 2016). In collaboration with the Canadian Institute for Health Information (CIHI), CPSI has created a hospital harm measure, which monitors the variation in patient safety in acute care facilities across the country, and combined it with improvement resources to provide many of the evidence-based guidelines and resources in order to drive change in these facilities. Moreover, CPSI is actively involved in the growing home care setting with initiatives to support patient safety improvements for home care clients. Their home care initiative grew out of their *Safety at Home: A Pan-Canadian Home Care Study* that highlighted the incidence of PSIs in home care clients (CPSI, 2013). Since the release of *Safety at Home*, CPSI has provided resources to home care providers, family caregivers, and policy makers to ensure that patient safety in all settings is achieved (CPSI - Home Care Safety, 2016).

Although impact data on CPSI's programs are limited, they have shown some promising, preliminary data on some PSIs. Over the course of the SHN program, the mean rate of catheter line infections (CLIs) decreased from 2.4 per 1,000 catheter days to 1.5, which - had the status quo continued over the five year period - would have cost the healthcare system approximately $20 million (Centre for Disease Control and Prevention, 2011). Moreover, another SHN collaborative team focusing on ventilator associated pneumonias (VAPs) saw the rate of VAPs decrease by just over 50%, which would have potential cost avoidance of $1.6 million per year over a three-year period (Muscedere, Martin, & Heyland, 2008).

Furthermore, CPSI's work in home care safety included an evaluation of their home care collaborative. Although the collaborative is still in its infancy and is currently only being carried out in a handful of healthcare organizations, a reduction in falls was seen, including a 5% decrease in the fall rate at the Winnipeg Regional Health

[12] For more information on CPSI programs, please see http://www.patientsafetyinstitute.ca/en/Pages/default.aspx

Authority, and a 25% reduction in the fall rate at the Saint Elizabeth home and the VHA Home Health care center (Dainty, 2016).

5.4.1 CPSI PROGRAM TARGETS

CPSI's 2015-16 statement of operations in showed expenses of nearly $7.7 million (CPSI, 2016). Given the estimated healthcare costs associated with Canadian patient harm, CPSI's programs would have to help reduce just over 1,100 PSIs per year[xii] – approximately one quarter of one percent of the average annual number of PSIs expected over the next 30 years in Canada – in order to offset the organization's operating budget.

RiskAnalytica analysis shows that, given the differences between program effectiveness, incidence rates, and healthcare costs per PSIs, acute care infections and home care falls and medication events appear to be promising focus areas for efforts targeting patient safety. This is because such targeted program efforts would be more cost effective, given what is known about their costs and the benefits achieved through various interventions available in literature[13].

As an example of potential success in this area, and using data from CPSI's March 2016 *Falls Prevention Audit Tool* for acute and home care, RiskAnalytica evaluated the potential impact of CPSI's fall prevention program. The Tool was developed to allow organizations to assess the quality of their falls prevention and injury reduction practices and identify areas of improvement. The audit provided the severity of harm that occurred to fallers and the number of CPSI recommended preventative measures carried out for those fallers in the acute and home care settings. Therefore, using data from this audit, organizations across acute care and home care were split into two groups: those that performed the 0-3 appropriate CPSI recommendations and those that performed 4-5 appropriate recommendations. Once divided, it was possible to determine the difference in the proportion of falls that resulted in major or moderate harm between the two groups of organizations.

[13] It is important to note that as mentioned before, the incidence rates for various patient safety incidents vary substantially in literature (e.g., medication events can range from 0.02% to 2.27%). Therefore estimates on cost effectiveness may vary.

As shown in Table 4 and Table 5, fewer falls resulted in major harm in both settings when organizations completed all or most of CPSI's fall assessment recommendations. While severity was reduced in acute care, severity and incidence of harm were reduced significantly in home care. Similarly, in both settings, the average healthcare costs per fall were reduced by at least $310 per patient. If rolled out across all healthcare organizations, this could amount to $1.8 million (acute) and $85 million (home) in healthcare costs prevented each year, on average, based on the estimated average annual number of such events in Canada over the next 30 years. The difference in the costs is largely due to the difference in incidence between the two settings (despite a larger acute care population).

Table 4 CPSI Falls Prevention Impact, Acute Care

# of CPSI fall assessment recommendations completed	Proportion of falls resulting in major harm	Proportion of falls resulting in moderate harm	Avg. healthcare costs per fall
0-3	5%	4%	$818
4-5	3%	4%	$508
Difference	**-2%**	**-**	**-$310**

Table 5 CPSI Falls Prevention Impact, Home Care

# of CPSI fall assessment recommendations completed	Proportion of falls resulting in major harm	Proportion of falls resulting in moderate harm	Avg. healthcare costs per fall
0-3	7%	11%	$1,331
4-5	3%	5%	$592
Difference	**-4%**	**-6%**	**-$739**

6 CONCLUSION

The impact of patient harm in Canada is significant, leading to noticeably higher healthcare costs. RiskAnalytica estimates that, over the next 30 years, patient safety incidents could average 400,000 cases annually, generating an additional $2.75 billion (2017$) in healthcare costs per year - around $6,800 per patient.

But there are costs beyond the healthcare system, too. Mortality from PSIs rank third behind cancer and heart disease with just under 28,000 deaths across Canada (2013). This is in addition to the impacts of disability and economic productivity loss, both in terms of the directly affected patient, as well as those friends or family members who end up caring for those patients informally.

There are success stories from around the world (including Canada) in improving patient safety. As far as they can, such efforts should be emulated (or expanded) in Canada. The cost of not investing in patient safety is simply too great.

A. BIBLIOGRAPHY

About AHRQ. (2017, February). Retrieved February 16, 2017, from Agency for Healthcare Research and Quality: https://www.ahrq.gov/cpi/about/profile/index.html

About CPSI. (2016). Retrieved February 20, 2017, from CPSI: http://www.patientsafetyinstitute.ca/en/about/Pages/default.aspx

AC; CIHI; CPSI. (2014). *Preventing Falls: From Evidence to Improvement in Canadian Health Care.* Ottawa, ON: Canadian Institute for Health Information.

AHRQ. (2015). *Project Evaluation Activity in Support of Partnership for Patients. Interim Evaluation Report, Final.* Agency for Healthcare Research and Quality. Retrieved February 12, 2017, from https://downloads.cms.gov/files/cmmi/pfp-interimevalrpt.pdf

AHRQ. (2015, March). *Systems Approach*. Retrieved from Patient Safety Primer: https://psnet.ahrq.gov/primers/primer/21/systems-approach

AHRQ. (2016, July). *Adverse Events, Near Misses, and Errors*. Retrieved from Patient Safety Primer: https://psnet.ahrq.gov/primers/primer/34/adverse-events-near-misses-and-errors

Baines, R., Langelaan, M., Bruijne, M., Spreeuwenberg, P., & Wagner, C. (2015). How effective are patient safety initiatives? A retrospective patient record review study of changes to patient safety over time. *BMJ Quality and Safety, 24*(9), 1-12.

Baker, G., Norton, P., Flintoft, V., Blais, R., Brown, A., Cox, J., . . . Tamblyn, R. (2004). The Canadian Adverse Events Study: The incidence of adverse events among hospital patients in Canada. *Canadian Medical Association Journal, 170*(11), 1678-1686.

Bouvy, J., De Bruin, M., & Koopmanschap, M. (2015). Epidemiology of Adverse Drug Reactions in Europe: A Review of Recent Observational Studies. *Drug Safety, 38*(5), 437-453.

Brennan, T., Leape, L., Laird, N., Herbert, L., Localio, A., Lawthers, A., . . . Hiatt, H. (1991). Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *New England Journal of Medicine, 324*(6), 370-376.

Cadario, B. (2005). New appreciation of serious adverse drug reactions. *BCMJ, 47*(1), 1.

Centre for Disease Control and Prevention. (2011, March 1). Vital Signs: Central Line-Associated Blood Stream Infections - United States, 2001,2008, and 2009. *Morbidity and Mortality Weekly Report*, pp. 1-6.

CIHI. (2016). *Measuring Patient Harm in Canadian Hospitals: Technical Report.* Ottawa, ON: Canadian Institute for Health Information.

CIHI. (2017). *Patient Cost Estimator*. Retrieved February 17, 2017, from Canadian Institute for Health Information: https://www.cihi.ca/en/spending-and-health-workforce/spending/patient-cost-estimator

CIHI;CPSI. (2016). *Measuring Patient Harm In Canadian Hospital. With What can be done to improve patient safety? Authored by Chan B, Cochrane D.* Ottawa: Canadian Institute for Health Information.

CPSI - Home Care Safety. (2016). Retrieved February 26, 2017, from Canadian Patient Safety Institute: http://www.patientsafetyinstitute.ca/en/toolsresources/homecaresafety/pages/default.aspx

CPSI - Intervention. (2016). Retrieved February 25, 2017, from Canadian Patient Safety Institute: http://www.patientsafetyinstitute.ca/en/toolsResources/Pages/Interventions-default.aspx

CPSI - SHIFT to Safety. (2016). Retrieved February 26, 2017, from Canadian Patient Safety Institute: http://www.patientsafetyinstitute.ca/en/About/Programs/shift-to-safety/Pages/default.aspx

CPSI. (2013). *Safety at Home Care.* Canadian Patient Safety Institute.

CPSI. (2016). *2015-16 Annual Report.* Canadian Patient Safety Institute. Retrieved February 26, 2017, from http://www.patientsafetyinstitute.ca/en/About/Annual-Report/pages/default.aspx

Dainty, K. (2016). *Final Evaluation Report: CPSI Virtual Quality Improvement Collaborative in the Home Care Sector.* KD Consulting.

Davis, P., Lay-Yee, R., Briant, R., Ali, W., Scott, A., & Schug, S. (2002). Adverse events in New Zealand public hospitals I: occurence and impact. *The New Zealand Medical Journal, 115*(1167), U271.

Davis, P., Lay-Yee, R., Briant, R., Ali, W., Scott, A., & Schug, S. (2003). Adverse events in New Zealand public hospitals I: occurence and impact. *The New Zealand Medical Journal, 116*(1183), U624.

Doran, D., Hirdes, J., Blais, R., Baker, G., Poss, J., Li, X., . . . McIsaac, C. (2013). Adverse Events Associated Hospitalization or Detected through the RAI-HC Assessment among Canadian Home Care Clients. *Healthcare Policy, 9*(1), 80-96.

Ehsani, J., Jackson, T., & Duckett, S. (2006). The incidence and cost of adverse events in Victorian hospitals 2003-04. *The Medical Journal of Australia, 184*(11), 551-555.

Employer Panel for Caregivers. (2015). *When Work and Caregiving Collide: How Employers Can Support Their Employees Who Are Caregivers.* Government of Canada.

Etchells, E., Mittmann, N., Koo, M., Baker, M., Krahn, M., Shojania, K., . . . Daneman, N. (2012). *The Economics of Patient Safety in Acute Care: Technical Report.* Canadian Patient Safety Institute.

Etchells, E., Mittmann, N., Koo, M., Baker, M., Krahn, M., Shojania, K., . . . Daneman, N. (2012). *The Economics of Patient Safety in Acute Care: Technical Report.* Canadian Patient Safety Institute. Retrieved February 11, 2017, from http://www.patientsafetyinstitute.ca/en/toolsResources/Research/commissionedResearch/EconomicsofPatientSafety/Documents/Economics%20of%20Patient%20Safety%20-%20Acute%20Care%20-%20Final%20Report.pdf

Gyllensten, H., Hakkarainen, K., Hagg, S., Carlsten, A., Petzold, M., Rehnberg, C., & Jonsson, A. (2014). Economic Impact of Adverse Drug Events - A Restrospective Population-Based Cohort Study of 4970 Adults. *PLOS ONE, 9*(3), e92061: 1-9.

Hohl, C., Nosyk, B., Kuramoto, L., Zed, P., Brubacher, J., Abu0laban, R., . . . Sobolev, B. (2011). Outcomes of Emergency Department Patients Presenting With Adverse Drug Events. *Annals of Emergency Medicine, 58*(3), 270-279.

Institute of Medicine. (2000). *To Err is Human: Building a Safer Health System.* Washington, D.C.: The National Academies Press.

Jha, A., Larizongoitia, I., Audera-Lopez, C., Prasopa-Plaizier, N., Waters, H., & Bates, D. (2013). The global burden of unsafe medical care: analytical modelling of observational studies. *BMJ Quality and Safety, 22*(10), 809-815.

Johnson, K. (2006). Adverse Events Among Winnipeg Home Care Clients. *Healthcare Quarterly, 9*, 127-134.

Johnson, W., Brennan, T., & Newhouse, J. (1992). The Economic Consequences of Medical Injuries: Implications for a No-fault Insurance Plan. *JAMA, 267*(18), 2487-2492.

Kaushal, R., Bates, D., Franz, C., Soukoup, J., & Rothschild, J. (2007). Costs of adverse events in intensive care units. *Critical Care Medicine, 35*(11), 2479-2483.

Leendertse, A., Van Den Bemt, P., Poolman, J., Stoker, L., Egberts, A., & Postma, M. (2011). Preventable hospital admissions related to medication (HARM): Cost analysis of the HARM Study. *Value in Health, 11*, 34-40.

Levinson, D.R. (2010). *Adverse Events in Hospitals: National Incidence Among Medicare Beneficiaries.* Department of Health and Human Services: Office of Inspector General.

Makaray, M., & Daniel, M. (2016). Medical error - the third leading cause of death in the US. *BMJ, 353*, 1-5.

Masotti, P., McColl, M., & Green, M. (2010). Adverse events experienced by homecare patients: a scoping review of literature. *International Journal for Quality in Health Care, 22*(2), 115-125.

Matlow, A., Baker, R., Flintoft, V., Cochrane, D., Coffey, M., Cohen, E., . . . Nijssen-Jordan, C. (2012). Adverse events among children in Canadian hospitals: the Canadian Paediatric Adverse Events Study. *CMAJ, 184*(13), E709-E718.

Miller, K. (2012). *Understanding hte relation between adverse events, patient characteristics, and risk factors among home care patients.* Kimberly A. Miller.

Moser, R. (1956). Disease of Medical Progress. *New Englad Journal of Medicine, 255*(13), 606-614.

Muscedere, J., Martin, C., & Heyland, D. (2008). The impact of ventilator-associated pneumonia on the Canadian health care system. *Journal of Critical Care, 23*(1), 5-10.

National Steering Committee on Patient Safety. (2002). *BUilding a Safer System: A National Integrated Strategy for Improving Patient Safety in Canadian Health Care.*

Patient Cost Estimator. (n.d.). Retrieved February 17, 2017, from Canadian Institute for Health Information: https://www.cihi.ca/en/spending-and-health-workforce/spending/patient-cost-estimator

Patient Safety Organizations Program. (2016, September). Retrieved March 7, 2017, from Agency for Healthcare Research and Quality: https://www.ahrq.gov/cpi/about/otherwebsites/pso.ahrq.gov/index.html

PHAC. (2013). *Healthcare-Associated Infections – Due Diligence. The Chief Public Health Officer's Report on the State of Public Health in Canada.* Public Health Agency of Canada.

Prins, M. (2010). *The Dutch Patient Safety Strategy.* Ministry of Health, Welfare, and Sport.

Public Health Agency of Canada. (2016). *How Healthy Are Canadians? A Trend Analysis Of The Health Of Canadians From A Healthy Living And Chronic Disease Perspective.*

Public Health Agency of Canada. (2017, May 01). *Economic Burden of Illness in Canada*. Retrieved from Government of Canada: http://ebic-femc.phac-aspc.gc.ca/index.php

Public Health Infobase. (2017, May 01). Retrieved from Public Health Agency of Canada: http://infobase.phac-aspc.gc.ca:9600/PHAC/dimensionMembers.jsp?l=en-US,en;q=0.8&rep=iA20B53C4B9ED444D947E251092175D16

Quality Strategy. (2016, Jul 06). Retrieved from Scottish Government: http://www.gov.scot/Topics/Health/Policy/Quality-Strategy

RiskAnalytica. (2017). *Evaluation of Patient Harm in Canada.*

Schioler, T., Lipczak, H., Pedersen, B., Mogensen, T., Bech, K., Stockmarr, A., . . . Frolick, A. (2001). Incidence of adverse events in hospitals. A restrospective study of medical records. *Ugeskr Laeger, 163*(39), 5370-5378.

Shekelle, P., Wachter, R., Pronovost, P., Schoelles, K., McDonald, K., Dy, S., . . . Winters, B. D. (2013). *Making Health Care Safer II: An Updated Critical Analysis of the Evidence for Patient Safety Practices. Comparative Effectiveness Review No. 211.* Rockville, MD: Agency for Healthcare Research and Quality. Retrieved from www.ahrq.gov/research/findings/evidence-based-reports/ptsafetyuptp.html

Slawomirksi, L., Auraaen, A., & Klazinga, N. (2017). *The Economics of Patient Safety: Strengthening a value-based approach to reducing patient harm at national level.* OECD.

Smetanin, P., Stiff, D., Briante, C., Adair, C., Ahmad, S., & Khan, M. (2011). *The life and economic impact of major mental illnesses in Canada: 2011 to 2041.* RiskAnalytica on behalf of the Mental Health Commission of Canada.

Soop, M., Fryksmark, U., Koster, M., & Haglung, B. (2009). The incidence of adverse events in Swedish hospitals: a restrospective medical record review study. *International Journal for Quality in Health Care, 21*(4), 285-291.

SPSP - About Us. (2017). Retrieved February 17, 2017, from Scottish Patient Safety Program: http://www.scottishpatientsafetyprogramme.scot.nhs.uk/about-us

SPSP. (2014). *Executive Report: a short update on the implementation of the Scottish Patient Safety Programme in Primary Care.* Healthcare Improvement Scotland.

SPSP. (2016). *Mental Health: End of phase report.* Healthcare Improvement Scotland.

SPSP. (2016). *SPSP ACute Adult: End of phase report August 2016.* Healthcare Improvement Scotland.

SPSP. (2016). *SPSP Primary Care: End of phase report.* Healthcare Improvement Scotland.

Statistics Canada. (n.d.). *Table 102-0561.* Retrieved April 28, 2017, from Leading causes of death, total population, by age group and sex, Canada, annual: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1020561&paSer=&pattern=&stByVal=1&p1=1&p2=49&tabMode=dataTable&csid=

Thomas, E., Studdert, D., Newhouse, J., Zbar, B., Howard, K., Williams, E., & Brennan, T. (1999). Costs of medical injuries in Utah and Colorado. *Inquiry, 36*(3), 255-264.

Thomas, E., Studdert, D., Runchiman, W. W., Sexton, E., Wilson, R., Gibbert, R., . . . Brennan, T. (2000). A comparison of iatrogenic injury studies in Australia and the USA. I: Context, methods, casemix, populationl, patient and hospital characteristics. *International Journal For Quality in Healthcare, 12*(5), 371-378.

Van Den Bos, J., Rustagi, K., Gray, T., Halford, M., Ziemkiewicz, E., & Shreve, J. (2011). The $17.1 Billion Problem: THe Annual Cost of Measurable Medical Errors. *Health Affairs, 30*(4), 596-603.

Vincent, C., Neale, G., & Woloshynowych, M. (2001). Adverse events in British hospitals: preliminary restrospective record review. *BMJ, 322*(7285), 517-519.

Wagner, C., Smits, M., Sorra, J., & Huang, C. (2013). Assessing patient safety culture in hospitals across countries. *International Journal for Quality in Health Care, 25*(3), 213-221.

WHO. (2000). *World Health Report 2000: Health Systems: Improving Performance.* The World Health Organization.

WHO. (2009). *Conceptual Framework for the International Classification for Patient Safety Version 1.1 Technical Report.* World Health Organization. Retrieved February 20, 2017, from http://www.who.int/patientsafety/taxonomy/icps_full_report.pdf

Wilson, R., Runciman, W., Gibber, R., Newby, L., & Hamilton, J. (1995). The Quality in Australian Health Care Study. *Medical Journal of Australia, 163*(9), 458-471.

Woolcott, J., Khan, K., Mitrovic, S., Anis, A., & Marra, C. (2012). The cost of fall related presentations to the ED: A prospective, in-person, patient-tracking analysis of health resource utilization. *Osteoporosis International, 23*(5), 1513-1519.

Wu, C., Bell, C., & Wodchis, W. (2012). Incidence and Economic Burden of Adverse Drug Reactions among Elderly Patients in Ontario Emergency Departments. *Drug Safety, 35*(9), 769-781.

Zegers, M., de Brujne, M., Wagner, C., Hoonhout, L., Waaijman, R., Smits, M., . . . van de Wal, G. (2009). Adverse events and potentially preventable deaths in Dutch hospitals: results of a retrospective patient record review study. *Quality and Safety in Health Care, 18*(4), 297-302.

B. APPENDIX

B.1. Prosperity at Risk (PaR)

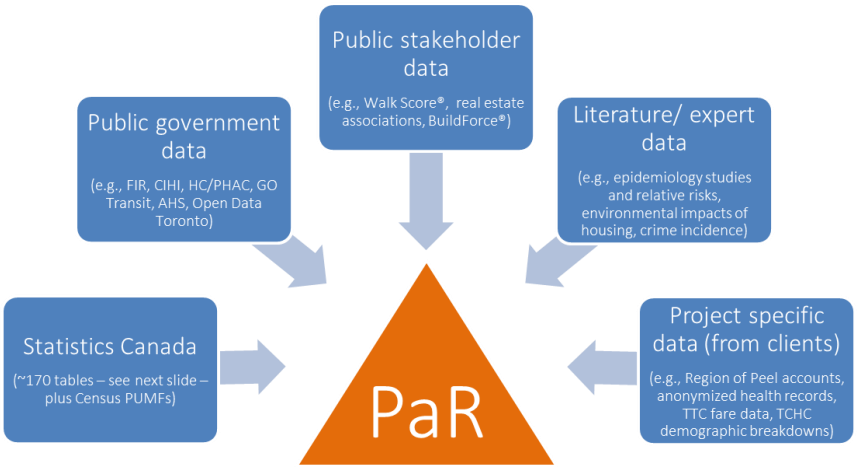
This analysis was done using *Prosperity at Risk* (PaR), an integrated socio-economic computer platform that has been used in over 150 studies. *Prosperity at Risk* (PaR) is an award-winning "big data" computer simulation platform that incorporates social, health, economic, financial, and infrastructure factors in a networked system. This platform models agents as:

- Individuals, with individual budget constraints (e.g., income, expenses, assets, and liabilities) and production/consumption activities (dependent upon economic input/output tables), thereby recognizing the independence of their motivations and decisions; and as
- Part of a spatial socio-economic network, thereby recognizing the dependence of their economic decisions upon other agents (via, for example, policy, investment decisions, and land use).

As such, PaR simulates the interactions of more than 40 million agents that are each encoded with behavioural rules to guide their decisions, act based on those rules, and be influenced by the actions of others. This is enabled by an enormous "linked-path" database that links hundreds of disparate (and typically cross-sectional) data sources back to the very objects that created them[14]. This allows for varied constraints and behaviours over time.

[14] For example, PaR imbues in agents hundreds of data sources (e.g., Statistics Canada tables, many down to detailed geographic areas) on demographics, income statements and balance sheets, consumption patterns, labour force statistics, and commuting choices, among many others.

Figure 4 PaR Linked Data



Within the PaR platform is the *Life at Risk* module, which is the health module that contains information on over 40 different conditions, including illnesses and external events impacting health, such as injuries. The module also contains different risk factors that change an agent's chance of developing one or more of the conditions tracked. The population is modeled as being in one of several states relative to each condition, ranging from never having been exposed to having died from that condition. Each health condition is modeled relative to its idiosyncrasies. For instance, infectious diseases are mapped through models that follow a stochastic spread, while injury related to vehicular collisions are probabilistic. PaR is able to recover the incidence and prevalence of various conditions, calibrated to existing literature on the behaviour of each condition relative to individual agent risk factors and characteristics.

Once the incidence and prevalence of the conditions are computed in PaR, these are then mapped to healthcare utilization data for each respective condition, which was obtained from sources including the Canadian Institute for Health Information. Thus health states, utilization rates, and associated costs can be calculated for the entire population of Canada through time, or can be analyzed for a particular subgroup of the population, with appropriate data.

B.2. Definitions

This analysis discusses the impact of patient safety incidents (PSIs) in the acute care and home care settings. Within these two settings, different terminology and definitions are often used to describe the unintentional harm experienced by patients. Although the majority of studies base their definition of patient safety and harm on the World Health Organization's (WHO) framework (2009), most studies adapt the definition and therefore may create slight yet important differences in what is tracked (e.g., preventability).

Therefore, in this analysis, a combined definition was adopted for a "patient safety incident", which is defined as:

> "A preventable unintended outcome of care or a preventable injury caused by medical management or complication rather than by the underlying disease itself that may be prevented with evidence-informed practices, that is identified and treated in the same hospital stay, or one that results in an adverse outcome, and generally includes prolonged healthcare, a resulting disability, or death."

This definition encompasses both the definition of a patient harm event from the *Measuring Patient Harm in Canadian Hospitals* report by CPSI and CIHI (CIHI;CPSI, 2016) and an adverse event from the WHO framework (WHO, 2009). This was done in order to ensure consistent reporting throughout analysis. More details on each of the individual definitions for adverse events and patient harm events are provided below.

This combined definition that encompasses both patient harm events and preventable adverse events was used because literature readily switches between the two, using them synonymously, which can create confusion. For example, in literature referring to PSIs in the acute care setting, a "patient harm event" terminology was used and was defined as outlined in the *Measuring Patient Harm in Canadian Hospitals* report by CPSI and CIHI (CIHI;CPSI, 2016). This report also took definitions from the WHO (2009) and adapted it to their study. As mentioned in the report, a "patient harm event" is defined as:

> "…an unintended outcome of care that may be prevented with evidence-informed practices and that is identified and treated in the same hospital stay."

Alternatively, in literature studying the home care setting, a similar terminology and definition of "Patient Harm" was not available, but the term and definition of "adverse event" was used (CPSI, 2013). Similar to "patient harm" in the acute care setting, the definition of "adverse event" was taken from the WHO framework (WHO, 2009) and adapted to the home care study. It was defined as:

> "….an injury caused by medical management or complication rather than by the underlying disease itself, and one that results in an adverse outcome….defined as a consequence of an AE and generally includes prolonged healthcare, a resulting disability, or death…"

It is also important to mention that the definition of "adverse event" does not mention "preventability"[15]. Our definition of "patient safety incident" includes only those events that are preventable and the rates, further discussed below, represent that. .

Furthermore, at certain points in this report, there is reference made to specific PSIs, such as infection, trauma, and medication events. Within the given settings, the definitions of these PSIs are outlined below.

Aligned with CPSI's *Measuring Patient Harm in Canadian Hospitals* report, in the acute care setting:

- Medication events are defined as an error in dosage or administration;
- Infections were defined as the entire Healthcare Associated Infections category, which includes infections such as UTIs, pneumonia, sepsis, post-procedural infections; and
- Trauma (e.g., falls) were defined as the Patient Accidents category

Aligned with CPSI's *Safety at Home Care* report, in the home care setting:

[15] In the *Safety at Home* report, this was estimated to be 56% of the AEs (CPSI, 2013).

- Medication events are defined as medication-related ED or hospitalizations;
- Infections were defined as sepsis/bacteraemia as they represented the majority of the infections reported; and
- Trauma (e.g., falls) were defined as injurious falls and other injuries

Where these reports lacked data on patient safety incident, such as healthcare utilization rates, mortality, and healthcare costs, a literature review was conducted in order to supplement these reports. Attempts were made to ensure that all supplemental data found through literature review matched the definitions outlined above as best as possible.

B.3. Data Sources

Table 6 and 0 provide the incidence rate and mortality rate assumption used in this analysis. The incidence rate is the rate of all acute care patients and all home care clients. While the mortality rates are the rate of all the cases that result in a death. The incident rates come from CPSI and CIHI's collaboration report on patient harm in Canadian acute care facilities, "*Measuring Patient Harm in Canadian Hospitals*" (CIHI;CPSI, 2016). The incidence rate for home care events are based on CPSI and CHCA report on safety in home care (CPSI, 2013).

Table 6 PSI Incidence and Mortality Rate Assumptions, Acute Care

PSI	Incidence Rate	Incidence Source	Mortality Rate	Mortality Source
Overall	5.6%	(CIHI;CPSI, 2016)	12.5%	(CIHI;CPSI, 2016)
Medication Event	0.02%	(CIHI;CPSI, 2016)	6.10%	(Cadario, 2005; Baines, Langelaan, Bruijne, Spreeuwenberg, & Wagner, 2015)
Infections	2.07%	(CIHI;CPSI, 2016)	3.86%	(PHAC, 2013)
Trauma (e.g., falls)	0.17%	(CIHI;CPSI, 2016)	8.00%	(AC; CIHI; CPSI, 2014)

Table 7 PSI Incidence and Mortality Rate Assumptions, Home Care

PSI	Incidence Rate	Incidence Source	Mortality Rate	Mortality Source
Overall	9.65%	(CPSI, 2013)	7.5%	(CPSI, 2013)
Medication Event	1.75%	(CPSI, 2013)	0.07%	(Wu, Bell, & Wodchis, 2012)
Infections	0.8%	(CPSI, 2013)	3.86%	(PHAC, 2013)
Trauma (e.g., falls)	5.24%	(CPSI, 2013)	8.00%	(AC; CIHI; CPSI, 2014)

The healthcare length of stay and associated costs are based on CIHI's *Patient Cost Estimator* (CIHI, 2017). It provides the average cost of various services provided in hospitals across Canada by jurisdiction and by patient age group. These costs include costs incurred by the hospital in providing services and exclude physician fees (CIHI, 2017). The healthcare utilization and cost per day for each event is shown in Table 8.

Table 8 PSI Utilization and Cost (2017$)

PSI	Length of Stay (LOS)	Cost/day (2017$)	Source
Overall	4.9	$1,380	(CIHI, 2017)
Medication Event	2.3	$1,785	(CIHI, 2017)
Infections	5.7	$1,214	(CIHI, 2017)
Trauma (e.g., falls)	7.0	$1,062	(CIHI, 2017)

Using the included conditions in the *Measuring Patient Harm in Canadian Hospitals* technical report (CIHI, 2016), it was possible to determine the range of conditions and their associated utilization and cost from the *Patient Cost Estimator*. A weighted average based on the number of discharges was taken in order to determine the length of stay and cost for each patient harm category. This process allowed cost data to be consistent across all harm events, as opposed to introducing multiple sources, which could include different cost aspects into their

calculations (e.g., including or not including physician fees). It should be noted that the cost determined through this process were consistent with (though more conservative than) those found in literature (Wu, Bell, & Wodchis, 2012; Etchells, et al., The Economics of Patient Safety in Acute Care: Technical Report, 2012; Hohl, et al., 2011; Woolcott, Khan, Mitrovic, Anis, & Marra, 2012).

ENDNOTES

[i] Comparing costing methods is difficult process as case details, clear definitions of cost components, quantity, prices, and time horizon are missing. Furthermore, studies may use different methods to estimate costs (Slawomirksi, Auraaen, & Klazinga, 2017).

[ii] After evaluating 331 admissions and then extrapolating to the entire Dutch healthcare system, they found that for someone under the age of 65 , the average productivity loss for one admission was $2,564 CAD (€1,712) (Leendertse, et al., 2011).

[iii] The study was interested in determining the societal cost of injury (COI) as it relates to ADEs. The indirect costs were determined by extracting data from the Swedish Social Insurance Agency and were calculated using an individuals' lost productivity due to sick-leave or disability pension using an the human capital approach, based on the age-specific national wages statistics and compulsory social security contributions (Gyllensten, et al., 2014).

[iv] Such studies were done at the beginning of the patient safety initiative evaluated a random sample of 794 individuals who had suffered medical PSIs in New York hospitals in 1984. They found that lost wages amounted to $378 million CAD ($US 276 million, 31% of total) and lost household productivity amounted to $604 million CAD ($US 441 million, 50% of total), in 1989 dollars.

[v] The study evaluated the patient harm injuries in a sample of 14,732 hospital records in 1992 from 28 hospitals, and found that for preventable AEs, there were $87 million ($US 63 million) in lost wages (20%) and $118 million ($US 86 million) in lost household production (28% of the total) in 1996 dollars.

[vi] This is based on hospital discharge data in the U.S. from 2013 (Makaray & Daniel, 2016)

[vii] Causes of death in Canada in 2013 come from Statistics Canada table 102-0561. For more information on the definitions of the causes of death, please refer to: http://www5.statcan.gc.ca/cansim/a47.

[viii] The simulation was run back in time in order to determine the estimated number of deaths due to preventable AEs in Canada in 2013 in order to keep estimates of death consistent with Statistics Canada's most recent data on all-cause mortality.

[ix] The PSI incidence cases in acute and home care was estimated for 2012 using the simulation model used in evaluating the impact of patient harm in Canada (RiskAnalytica, 2017).

[x] Note that these diseases were selected because incidence data were available from a single and reputable government source (PHAC) for a given year, allowing for consistent estimates between the diseases.

[xi] For similar reasons to the incidence data, hospital costs for the aforementioned diseases are from 2008 (though brought up to 2017 dollars) for consistency among all the diseases listed. It is important to note that the PSI cost data come from CIHI's hospital cost estimator, so there may be some differences.

[xii] This takes the annual operating expenses of $7,677,182 for 2015-16 (available here: http://www.patientsafetyinstitute.ca/en/about/annual-report/pages/default.aspx) and divide by the estimated per patient cost (over the next 30 years) of $6,806, yielding 1,128 patient-equivalents.