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ORIGINAL ARTICLE

Can patient safety indicators monitor medical and surgical care at New Zealand public hospitals?

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Abstract

Introduction Increasing interest has focused on the safety of hospital care. The AusPSIs are a set of indicators developed from Australian administrative data to reliably identify inpatient adverse events in hospitals. The main aim of this study was to explore the application of the AHRQ/AusPSIs to New Zealand administrative hospital data related to medical and surgical care. Variation over time and across hospitals were also considered for a subset of the more common indicators.

Aim text.

Method AHRQ/AusPSIs were adapted for use with New Zealand National Minimum Dataset administrative data for the period 2001–9. Crude positive event rates for each of the 16 indicators were assessed across New Zealand public hospitals. Variation over time for six more common indicators is presented using statistical control charts. Variation between hospitals was explored using rates adjusted for differences in patient variables including age, sex, ethnicity, rurality of residence, NZDep score and comorbidities.

Results The AHRQ/AusPSIs were applied to New Zealand administrative hospital data and some 99,366 admissions were associated with a positive indicator event. However rates for some indicators were low (<1% of denominator admissions). Over the study period considerable variation in the rate of positive events was evident for the six most common indicators. Likewise there was substantial variation between hospitals in relation to risk adjusted positive event rates

Discussion Patient safety indicators can be applied to New Zealand administrative hospital data. While infrequent rates hinder the use of some of the indicators, several could now be readily employed as warning flags to help monitor rates of adverse events at particular hospitals. In conjunction with other established or emerging tools, such as audit and trigger tools, the PSIs are now available to promote ongoing quality improvement activities in New Zealand hospitals.

Since the publication of landmark studies detailing the prevalence of adverse events in hospitals,[1–3] worldwide attention has focused on the need to monitor the safety and quality of inpatient care. Four main methods have emerged to monitor hospital performance across aspects of structure, processes and outcomes: regulatory inspection, third party evaluations, internal investigations and statistical indicators.[4] Taking advantage of the availability of existing administrative data, indicators have become increasingly employed around the world[5,6] as objective measures of hospital performance with two main purposes: summative assessments for external accountability and formative measures for internal quality improvement.[7]

Leading this work, the United States-based Agency for Healthcare Research and Quality (AHRQ) has developed a series of quality and patient safety indicators.[8] The AHRQ patient safety indicators (PSIs) were formulated to target occurrences likely to represent adverse events, such as foreign bodies left after procedures. They were developed from a rigorous process that involved extensive literature review, detailed analysis of the International Classification of Diseases (ICD-9) codes, and assessments by clinical panels and empirical analyses.[9] The usefulness and validity of the indicators have now been well demonstrated in the United States.[10] International interest in the indicators has seen them extended for use in other countries including an adaption by an Australian team at Victoria Healthcare (AusPSIs) based on the same iteration of the ICD-10 coding system that is shared with New Zealand.[11]

The work undertaken for the AusPSIs involved electronic mapping of the AHRQ codes followed by detailed review by an expert coder with subsequent testing. The adaption of the AHRQ indicators to ICD10-AM coding provides an opportunity to explore their functionality in the New Zealand setting.

The availability of large datasets that comprehensively include all admissions to public hospitals in a country provides an undisputed advantage in efforts to readily and reliably monitor the quality of inpatient care.[12,13] Furthermore employing information coded to internationally agreed standards offers a potentially reliable basis for comparative assessment. The large resources needed to undertake internal investigations using medical record review such as were employed in the New Zealand Quality of Health Care Study[1] nullify any chance they could function as an ongoing monitoring tool, although targeted options like the Global Trigger Tool offer considerable promise.[14] Other alternatives such as using incident reporting data are plagued by uncertainties associated with the awareness and willingness of staff to volunteer information about their errors.[15,16]

New Zealand is well prepared to capitalize on previous PSI work with the availability of a national inpatient dataset, the National Minimum Dataset (NMDS). The NMDS uses the ICD-10-AM coding system and data are obtained from all District Health Boards and hospitals using a common unique national patient identifier (National Health Index, NHI). However, despite the availability of a comprehensive dataset that includes all publicly funded hospitalisations, New Zealand lags behind other countries particularly the United States and the United Kingdom in its monitoring and reporting of quality measures related to hospital performance.[17] Dr Foster in the United Kingdom[18] and Hospital Compare in the United States,[19] provide online up-to-date information about hospital performance using a range of indicators.

The primary objective of this study was to explore the feasibility of applying the AHRQ/AusPSIs to New Zealand administrative data over the period 2001–9 and describe rates of positive indicator events related to medical and surgical care across New Zealand hospitals. Secondary objectives were to explore variation over time in positive indicator event rates and variation between hospitals after risk adjustment.

Methods

All data in the NMDS between and including January 2001 and December 2009 were obtained and linked by NHI to mortality records. Admissions were recorded to 91 public hospitals over the study period although not all hospitals recorded admissions in all years. The data from a small number of facilities were combined to allow for the opening and closing of institutions. Admissions to private facilities were excluded.

Coding for the numerators and denominators for 16 indicators in ICD-10-AM (version 3) were developed in SAS (version 9.2) software,[20] modified from information provided by AHRQ[21,22] and AusPSI,[23] and then checked with clinical and coding staff to verify their relevance for the New Zealand setting.

PSIs were grouped into three categories: surgical (postoperative), medical, and general. Checks were undertaken of the PSI results to ensure there were no logical discrepancies, such as admissions flagged positive for a postoperative complication when a surgical procedure had not occurred. PSI rates were benchmarked against Australian and other international results and found to be generally consistent.

Approval for the study was obtained from the Multi Region Ethics Committee (MEC/08/59).

Statistical analyses and control charts—Descriptive statistics are presented for the population of all people discharged from New Zealand public hospitals from 2001 to 2009. Crude positive indicator rates are presented with 95% confidence intervals for the binomial estimates. In order to explore trends in the frequency of indicator positive events over time statistical process control charts are presented for the three most common indicators. Control charts present mean and upper and lower limits based on ±3 standard deviations and enable the identification of common or special causes of variation.[24]

Event rates are presented for each 3-month period. To explore variation in the same three PSIs between hospitals event rates were first risk adjusted using methodology employed by AHRQ.[21] The risk adjustment accounted for age, gender, ethnicity, rurality, deprivation and comorbidities and was undertaken with SAS[20] software. Deprivation was measured according to the New Zealand Deprivation Score (NZDep01 or NZDep06) based on the domicile of the patient.[25]

The NZDep scores were grouped into five quintiles with the most deprived areas being in quintile five. Rural or urban residence was based on the definition provided by Statistics New Zealand[26] for the census area unit related to the patient's domicile. Urban areas were identified (as 0), and rural locations with high (as 1), moderate (as 2) or low (as 3) urban influence were identified. Up to 30 comorbidities were listed for each admission based on the modified Elixhauser set.[27]

Results

Description of the patient safety indicators and population summary information—A description of the PSIs is included (Table 1). Over the study period there were 7,487,432 admissions to public hospitals. The people admitted to the facilities over the study period were predominantly female, European, and resided in urban locations and lower socio-economic areas (Table 2). Admission numbers rose steadily across the study period. Hypertension was the most frequent comorbidity (8.6%), while AIDS was rare (<0.1%).

Table 1. Definitions of the patient safety indicators

Indicator	Category	Cases	At-risk population
PSI 1 Complications of anaesthesia	General / anaesthesia	Episodes with anaesthesia complications	All adult surgical discharges
PSI 2 death in low mortality DRG	Medical	Patient death	Adults in low-mortality DRGs, (DRGs with a total mortality rate less than 0.5% over the previous three years or less than 0.5% in any of the previous 3 years.
PSI 3 Decubitus ulcer	Medical	Episodes with a decubitus ulcer	All adult medical and surgical episodes
PSI 4 Failure to rescue	Medical	Patient death	Episodes, adults, potential complication of care (i.e. acute renal failure, DVT/PE, pneumonia, sepsis, shock or cardiac arrest, and GI haemorrhage/acute renal failure)
PSI 5 Foreign body left during procedure	General	Episodes with foreign body left during procedure	All adult episodes
PSI 6 Iatrogenic pneumothorax	General	Episodes with pneumothorax.	All adult episodes
PSI 7 Selected infections due to medical care	Medical	Episodes with selected infection	All adult episodes
PSI 8 Postoperative hip fracture	Post-op	Episodes hip fracture	All adult surgical episodes
PSI 9 Postoperative haemorrhage or haematoma	Post-op	Episodes with postoperative haemorrhage or haematoma and postoperative control of haemorrhage or drainage of haematoma	All adult surgical episodes
PSI 10 Postoperative physiologic and metabolic derangement	Post-op	Episodes with physiologic and metabolic derangement	All elective adult surgical episodes
PSI 11 Postoperative respiratory failure	Post-op	Episodes with acute respiratory failure and a reintubation	All adult elective surgical episodes
PSI 12 Postoperative DVT or PE	Post-op	Episodes with pulmonary embolism or deep vein thrombosis	All adult surgical episodes
PSI 13 Postoperative sepsis	Post-op	Episodes of sepsis	All adult elective surgical episodes
PSI 14 Postoperative wound dehiscence	Post-op	Episodes with reclosure of postoperative disruption of abdominal wall	All adult abdominopelvic surgical episodes
PSI 15 Accidental puncture or laceration	General	Episodes with accidental puncture, laceration, cut or perforation	All adult episodes
PSI 16 Transfusion reaction	General	Episodes with a transfusion reaction	All episodes with a transfusion
PSI 17 Birth trauma – injury to neonate	Obstetric	Episodes with birth trauma	All newborn
PSI 18 Obstetric trauma – vaginal delivery with instrument	Obstetric	Episodes 3rd and 4th degree obstetric trauma.	All vaginal delivery episodes
PSI 19 Obstetric trauma – vaginal delivery without instrument	Obstetric	Episodes with 3rd and 4th degree obstetric	All vaginal delivery episodes

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Indicator	Category	Cases	At-risk population
PSI 20 Obstetric trauma – caesarean delivery	Obstetric	Episodes with 3rd and 4th degree obstetric trauma	All caesarean delivery episodes

Table 2. Summary descriptive data for admissions to New Zealand hospitals 2001–9

Variables	Mean (SD)	Range	Median	Interquartile range	
Age	42.8 (27.9)	0–119	42.0	48.0	
	Male	Female			
Gender[1] **N (%)**	3,319,063 (44.3)	4,168,362 (55.7)			
	European	Maori	Pacific	Asian	Other2
Ethnicity[2] **N (%)**	4,998,339 (66.8)	1,250,391 (16.7)	538,221 (7.2)	283,187 (3.8)	417,510 (5.6)
	NZDep 1+2	NZDep 3+4	NZDep 5+6	NZDep7+8	NZDep9+10
Deprivation N (%)	959,046 (12.9)	1,168,509 (15.7)	1,440,646 (19.4)	1,801,629 (24.2)	2,066,747 (27.8)
	0 Urban	1 Rural high urban influence	2 Rural moderate urban influence	3 Rural low urban influence	
Rurality[3] **N (%)**	4,910,377 (65.6)	705,740 (9.4)	1,473,591 (19.7)	383,063 (5.1)	
	2001 2002	2003 2004	2005 2006	2007 2008	2009
Event year N (%)	772,560 (10.3) 776,145 (10.4)	783,404 (10.5) 798,193 (10.7)	815.900 (10.9) 844,538 (11.3)	858,618 (11.5) 893,147 (11.9)	944,927 (12.6)
Comorbidities N (%)	'Congestive heart failure	Cardiac arrhythmia	Valvular disease	Pulmonary circulation disorder	Peripheral vascular disorder
	231,397 (3.1)	385,390 (5.2)	100,244 (1.3)	34,481 (0.5)	112,409 (1.5)
	Hypertension	Paralysis	Other neurological disorders	Chronic pulmonary disease	Diabetes uncomplicated
	644,491 (8.6)	129,876 (1.7)	185,176 (2.5)	320,321 (4.3)	233,739 (3.1)
	Complicated diabetes	Hypothyroidism	Renal failure	Liver disease	Peptic ulcer
	267,310 (3.6)	19,127 (0.3)	386,018 (5.2)	50,156 (0.7)	10,152 (0.1)
	AIDS	Lymphoma	Metastatic cancer	Solid tumour without metastasis	Rheumatoid arthritis
	1,966 (0.0)	72,235 (1)	166,847 (2.2)	198,056 (2.7)	53,172 (0.7)
	Coagulopathy	Obesity	Weight loss	Fluid/electrolyte disorders	Blood loss anaemia
	59,968 (0.8)	90,479 (1.2)	26,785 (0.4)	366,136 (4.9)	27,252 (0.4)
	Deficiency anaemias	Alcohol abuse	Drug abuse	Psychoses	Depression
	55,764 (0.7)	102,659 (1.4)	37,505 (0.5)	44,138 (0.6)	71,276 (1)

[1]Gender was not defined for 6 admissions. [2]Ethnicity was not defined for 121,921 admissions [3]Rurality was not defined for 14,661 admissions.

Table 3. Number of positive cases, denominators and rates for patient safety indicators across New Zealand hospitals 2001–9

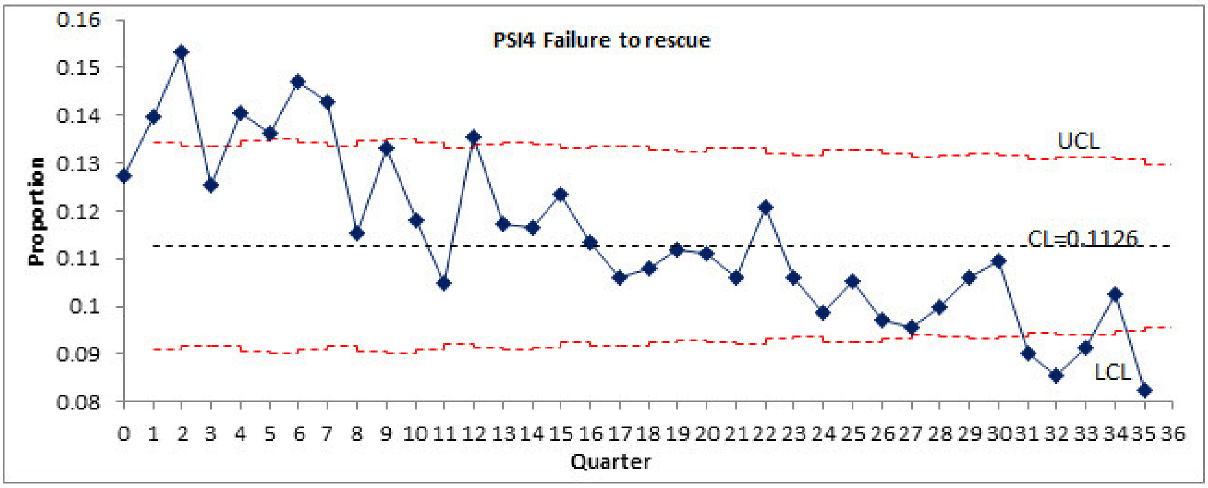
Variables	Positive cases	Admissions at risk	Rate per 10,000 admissions (95% confidence interval)	Range of rates per 10,000 admissions across NZ hospitals
Medical				
2 (death low mortality DRG)	2,157	2,024,136	11 (12–13)	0–20
3 (decubitus ulcer)	17,573	995,744	176 (174–179)	0–351
4 (failure to rescue)	10,240	90,920	1126.(1106–1147)	0–1622
7 (infections)	8,812	1,791,261	49 (48–50)	0–141
General				
5 (foreign body)	351	4,990,050	0.7 (0.6–0.8)	0–2
6 (pneumothorax)	1,637	4,814,105	3 (3–4)	0–8
15 (puncture)	10,156	4,979,685	20 (20–21)	0–130
16 (transfusion reaction)	25	294,442	0.8 (0.6–1)	0–7
Anaesthesia				
1 (complications)	25	1,663,890	0.15 (0.10–0.2)	0–1
Postoperative				
8 (hip fracture)	476	1,036,097	4.5 (4–5)	0–12
9 (haemorrhage)	26,745	1,400,503	191 (189–193)	0–311
10 (physiologic derangement)	230	127,989	18 (16–20)	0–44
11 (respiratory failure)	133	92,602	14 (12–17)	0–64
12 (DVT/PE)	4,557	1,426,837	32 (31–33)	0–125
13 (sepsis)	274	21,172	129 (114–146)	0–870
14 (wound dehiscence)	584	123,814	47 (43–51)	0–101

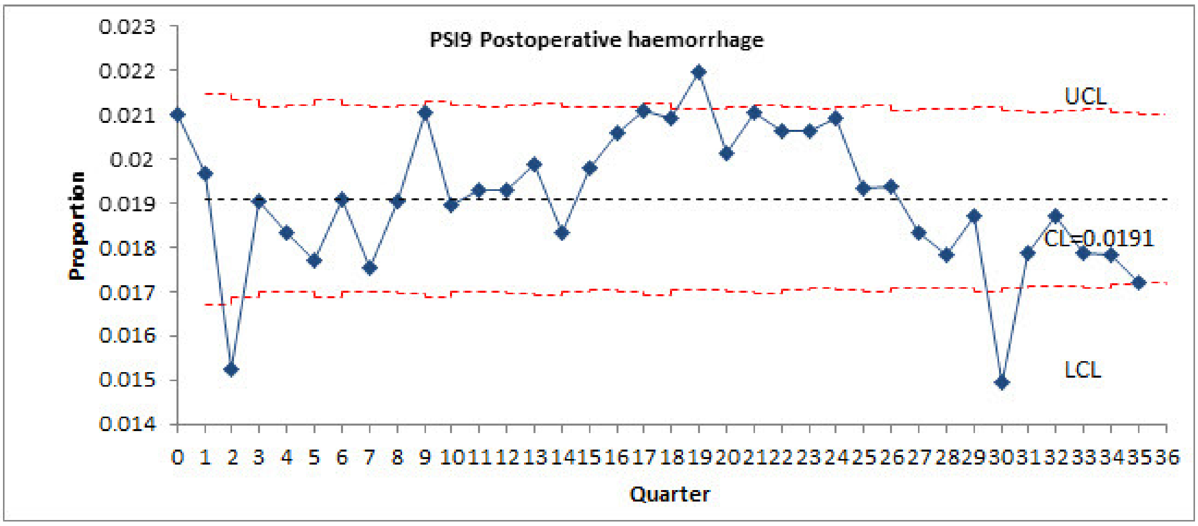
Results for crude PSIs across study period—Some 99,366 potential safety-related events were identified from a combined total denominator of over 26.8 million admissions at risk of at least one PSI (Table 3). Some 12,397 events represented deaths, either in low mortality Diagnostic Related Groups (DRGs) (i.e. PSI2) or related to major complications such as pneumonia, thromboembolism, sepsis, renal failure, shock, cardiac arrest or gastrointestinal haemorrhage (i.e. PSI4). Some indicators were uncommon with half having less than 600 positive numerator events over the study period.

By contrast, the denominators, numbers of admissions at risk of each PSI, were generally high (at least 21,172) such that event rates for 15 indicators were less than 0.2%. Positive event rates ranged between 0.15–1126 per 10,000 admissions and considerable variation was evident between hospitals. Inter-hospital variation was greatest for indicators with the highest event rates, particularly PSIs 4 and 13, such that rates ranged between 0–1622 and 0–870 per 10,000 admissions respectively.

Among the categories there was least variation exhibited for the general /anaesthesia indicators (PSIs 1, 5, 6, 15, 16) which were generally infrequent and recorded a maximum average rate of 26 per 10,000 admissions over the study period. Three indicators (PSIs 4, 9, 12) were selected based on both their higher number of positive events and their higher rate of positive events per 10,000 admissions to further explore variation over time and between hospitals.

Figure 1. Control charts for PSIs quarterly periods from Jan 2001 – Dec 2009





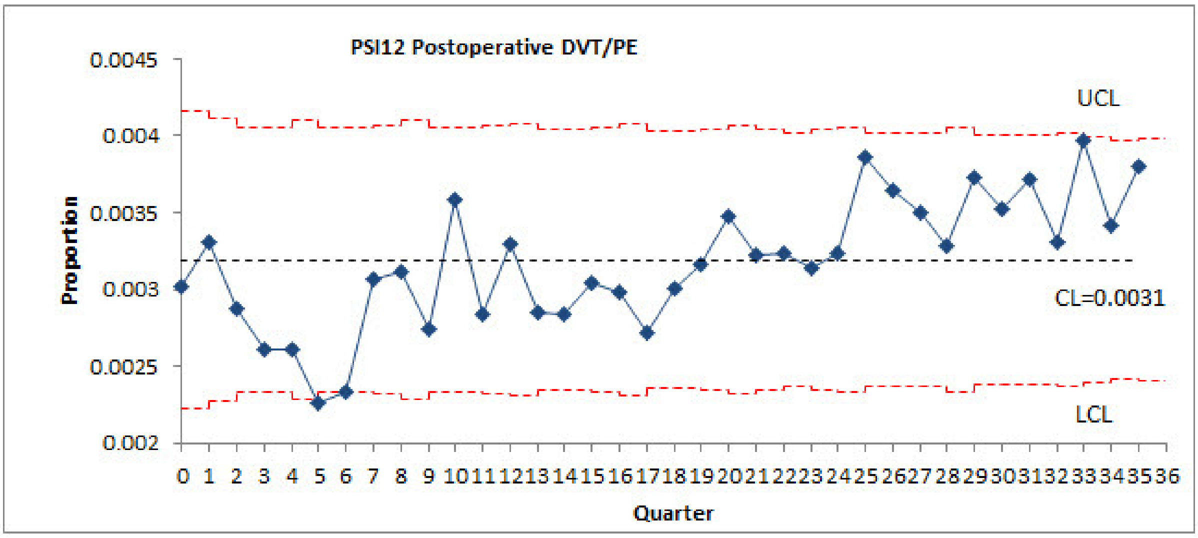
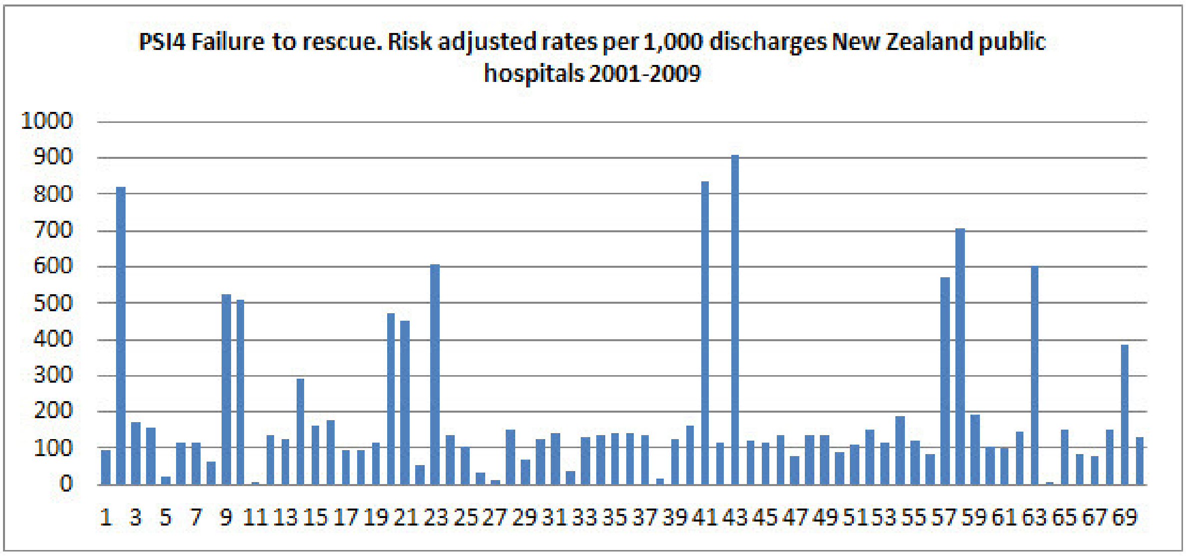
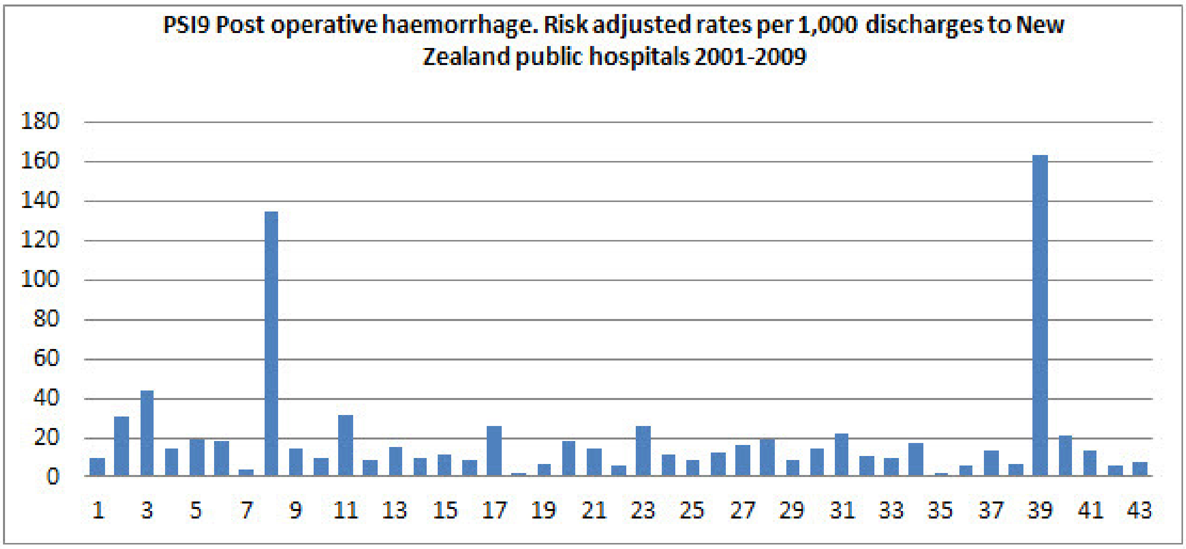
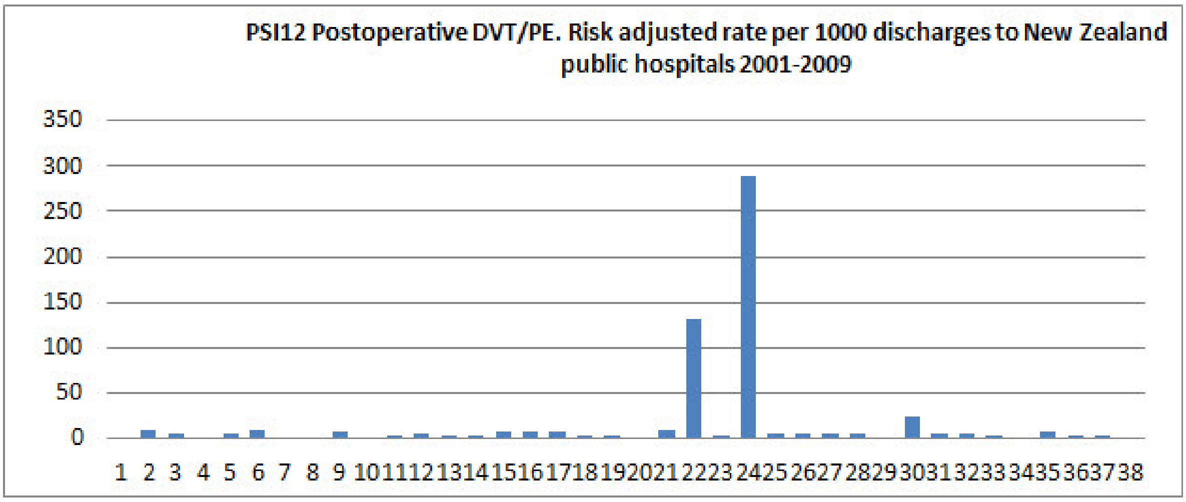


Figure 2: Risk adjusted PSI rates for New Zealand public hospitals 2001-2009







Variation in positive event rates over time—Control charts describe variation in crude positive event rates over time. Special cause variation is evident for three indicators where rates occur outside of the control limits. In the case of one indicators (PSI 4) this variation is evident for more recent data. Other guidelines, such as runs of eight points on one side of the centre line, suggest that PSI12 may also be exhibiting special cause variation in later years. Such variation may prompt further investigation to consider possible explanations beginning with changes in the coding or management of the data.

Variation in risk adjusted positive indicator event rates between hospitals—The three indicators also exhibit wide variation between hospitals for their risk-adjusted rates for the study period. Variation was highest for PSI4 where rates ranged between 0-907 per 1,000 discharges at 70 different hospitals. For all the PSIs most hospitals exhibited risk adjusted rates that were broadly similar however outliers were also evident. Many of these outliers related to the presence of small numerator and denominators. For example only 20 events were recorded at the hospital with PSI4 rate of 907 per 1,000 discharges, 4 events with the hospital with rate of 163 per 1,000 discharges for PSI 9 and 10 events for the hospital with a rate of 288 per 1,000 discharges for PSI12.

Discussion

The AHRQ/AusPSI indicators were designed to be used with computerised administrative data that have been already collected from hospitals. All publicly funded hospitals provide the data, and advantages for the indicators include comprehensiveness, unobtrusiveness and low cost (Table 6).[28] The PSIs do not rely upon the awareness or efforts of health professionals to recognize adverse events under their care.

The results from this study suggest that it is readily feasible to employ the AHRQ/AusPSIs in the New Zealand setting. However, it is noteworthy that event rates are relatively low for some of the indicators even over the combined nine years of the study (e.g., PSIs 1, 5, 6, 8 and 16) and their further utility appears limited. Among the three indicators presented in Figures 1 and 2, considerable variation is evident whether results are described across hospitals or over time. International use of the indicators has largely focused on their employment as part of a toolkit to improve patient care at a hospital,[29] track progress over time[30] and compare performance at the regional or national level.[31]

Potential limitations associated with administrative data and the AHRQ PSIs have been well described (Table 4).[32] The concerns need to be tempered by the realisation that indicators act as alerts or flags rather than definitive assessments of the quality of care. The usefulness of the indicators stems from their function as a screening tool and further efforts are usually required to interrogate the findings to ascertain whether patient safety problems actually exist when indicators suggest that patient care has been compromised.

The principal concern with the use of PSIs centres on whether administrative data collected for another purpose can be reliably applied to patient safety measurement. A concern is that the range of patient safety issues identified by the PSIs is limited; for example no information is generated about the presence of adverse drug events by the indicators, yet these events make a large contribution to iatrogenic harm.[1] Furthermore any identification of injury is further limited by the completeness and accuracy of the ICD-10 coding system. Although principal diagnoses are usually well recorded in most administrative databases doubts remain about the quality of recording for complications and comorbidities.[33]

Some concerns related to these issues are being addressed. Firstly, new indicators have emerged to describe medication related events using Australian administrative data.[34] In addition, the timing of any potential adverse event can now be better defined with New Zealand's adoption of the 'present on admission' flag which ensures that clinical coders record whether a condition was present at admission or alternatively may have occurred as a complication during the inpatient stay.[35] Finally,

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detailed work to validate the individual indicators by means of medical record review is now nearly complete and is producing some promising results.[36, 37] Some of the indicators appear to be associated with high positive predictive values underscoring their role as useful screening tools. Work has been undertaken to validate the indicators in New Zealand using similar record review methodology.

Table 4. Main advantages of using administrative data and indicators to measure patient safety

Comprehensive – all inpatient events and all publicly funded hospitals can be included.
The data are available and relatively inexpensive to use.
Indicators derived from administrative data can function as useful flags that an adverse event may have occurred.
They do not rely upon clinicians to identify and volunteer when an adverse event may have occurred.
A number of indicators have been associated with high levels of accuracy especially in relation to their specificity.
When indicator results are applied to data at a single hospital useful information can be generated about issues related to patient safety and the results from any interventions can be assessed.
Main limitations associated with the use of administrative data based indicators
Events can only be located when there are corresponding ICD-10 codes. The indicators focus on a relatively narrow range of adverse events.
Limitations associated with the type of information provided in the medical record, the legibility and accuracy of the medical notes and the ability of medical coders to accurately identify adverse events that may have occurred and reliably code these events. Administrative data lack clinical information – in particular there is limited information about the severity of any condition or complication.
Different hospitals or coders may vary in the accuracy and completeness of their inclusion of secondary diagnosis codes.
The validity of the various indicators to accurately identify adverse events is variable. Some are associated with relatively high sensitivity and/or specificity. Specificity of the indicators can be high and results are best when they are applied to specific populations.

Preliminary results suggest that the same PSIs are consistently associated with similarly high positive predictive values in the local setting. These findings are reassuring as, unlike some other countries, New Zealand administrative data only includes secondary diagnoses that were materially relevant to patient care during an inpatient stay.[38] As the PSIs rely heavily on secondary diagnosis codes it was possible that some indicator events may either not have been identified or some exclusions could not be applied, so indicators may have been less accurate locally. The final results from the validation exercise will be important to further determine the applicability of the indicators in New Zealand.

Limitations aside, the application of the PSIs to New Zealand data raises interesting questions about the local epidemiology of adverse events and the impact of quality improvement initiatives. For example, further work is needed to explore whether the decline in rates of PSI 4 (failure to rescue) can reliably be attributed to the increasing adoption of early warning scoring systems and outreach teams in hospitals.[39] Further impetus for the use of PSIs to explore the epidemiology of adverse events comes from the suggestion that the indicators may detect different events from those identified by other methods.[40]

The PSIs could be readily adopted by key organisations in New Zealand, such as the Health Quality and Safety Commission (HQSC) and the Health Roundtable, that are already involved with DHBs in the measurement, analysis and reporting of hospital performance information in New Zealand. The PSIs could augment their existing measures and contribute to their provision of customized dashboards that enable each DHB to assess their progress over time, and with suitably adjusted measures, help them compare themselves against others. Ideally these dashboards should monitor data with as close to real time information as possible. Employing the Variable Life Adjusted Display methodology that has been successfully deployed in Australia,[41] they could be used to generate case-by case warnings about any significant differences between observed and expected outcomes in conjunction with a guided response that begins with the judicious scrutiny for any changes in coding and escalates when appropriate to the investigation of service delivery.

Whilst their most important function would be to foster internal quality improvement by hospitals, on confirmation of their validity some of them could later be considered for an accountability function and incorporated into the Integrated Performance and Incentive Framework[42] with the aim of supporting clinical governance and fostering continuous quality improvement for hospitals alongside primary care. Creating incentives for continuous improvement avoids some of the potential constraints associated with health targets that are limited to determining whether a finite level has been achieved rather than charting progress over time and encouraging, ongoing, iterative cycles of improvement.

Considerable interest exists in the public reporting of performance information. In New Zealand, hospital performance data are mainly used internally and between DHBs. This contrasts with the United states where The Department of Health and Human Services in the United States now provides patient safety indicator results for named hospitals on the internet for public scrutiny.[43] Proponents argue that such reporting generates opportunities for public accountability, scrutiny and competitive improvement between hospitals.

Detractors have counseled about the pitfalls inherent in comparative public reporting, citing limitations of using inadequately validated indicators, insufficient adjustments for case mix, spurious findings occurring when hospitals are ranked even though considerable random variation may be present and the potential for gaming that can occur when attention is focused solely on specific measures.[44] Limited evidence exists for the premise that public reporting of indicator data sponsors quality improvement[45] and until confirmation is provided from rigorous evaluation in the local setting most attention should be given to promoting the use of PSIs by hospitals and DHBs for internal improvement processes possibly as part of a broader scorecard with metrics related to access, effectiveness and efficiency.[46]

In conclusion, the PSIs can be readily applied to New Zealand's administrative data. Used judiciously, in conjunction with other established and emerging forms of quality assessment and monitoring, such as clinical audit, trigger tools and incident reporting, the PSIs offer another valuable tool for hospitals to assist them with their efforts to enhance patient safety.

The advantages of New Zealand's rich administrative dataset combined with its small size suggest that promoting the use of PSIs to enhance patient safety should be readily achievable. Furthermore, New Zealand is well placed to take advantage of the work of existing organisations such as the HQSC and new developments in real time monitoring to sponsor their introduction.[47]

With confirmation of validity, the PSIs could be extended to an accountability framework that encourages continuous improvement and perhaps comprises public reporting as long as it includes appropriate evaluation to ensure that undesired outcomes are not fostered.

Competing interests: Nil.

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