Journal of Hospital Infection 131 (2023) 164–172

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin

Prevalence of healthcare-associated infections in public hospitals in New Zealand, 2021

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ARTICLE INFO

Article history:
Received 20 August 2022
Accepted 11 October 2022
Available online 19 October 2022

Keywords:
Hospital-associated infection
Point prevalence survey
Infection prevention and control
Epidemiology
Surgical site infection
Bloodstream infection

SUMMARY

Background: There are no contemporary data on healthcare-associated infections (HAIs) in New Zealand.

Aims: To determine the epidemiology of HAIs, prevalence of medical devices, and microbiology of HAIs in adults in public hospitals in New Zealand.

Methods: Point prevalence survey. Surveyors reviewed patients aged ≥18 years using the HAI definitions of the European Centres for Disease Prevention and Control. Device use and microbiology of HAIs were recorded.

Findings: In total, 5468 patients were surveyed; 361 patients (6.6%) had 423 HAIs (7.7 HAIs per 100 patients). The most common HAIs were: surgical site infections (*N*=104, 25%), urinary tract infections (*N*=80, 19%), pneumonia (*N*=75, 18%) and bloodstream infections (*N*=55, 13%). Overall, 3585 patients (66%) had at least one device, with 2922 (53%) patients having a peripheral intravenous catheter. Sixty-nine (16%) HAIs were device-associated. On multi-variable analysis, independent risk factors for HAIs included the presence of a peripheral [odds ratio (OR) 2.0] or central (OR 5.7) intravenous catheter and clinical service. HAI rates were higher in surgical patients (OR 1.8), intensive care unit patients (OR 2.6) and rehabilitation/older persons' health patients (OR 2.4) compared with general medicine patients ($P \leq 0.01$ for all groups). In total, 301 organisms were identified. *Clostridioides difficile* infection was uncommon, accounting for 1.7% of all HAIs. Forty-two isolates (14%) were drug-resistant, and most (*N*=33, 79%) were Enterobacterales.

Conclusion: This study established the most common HAIs and their risk factors in New Zealand. The high prevalence of device use underscores the need to ensure that proven multi-modal prevention interventions are in place. However, as less than half of HAIs are device- or surgery-associated, other intervention strategies will be required to reduce their burden.

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https://doi.org/10.1016/j.jhin.2022.10.002

Introduction

Healthcare-associated infections (HAIs) are a significant public health problem associated with increased morbidity, mortality, length of hospital stay and healthcare costs [1—8].

In New Zealand, there is limited information on the prevalence of HAIs. Previous point prevalence surveys (PPSs) in hospitals in Auckland District Health Board (DHB) in the late 1990s reported a cumulative incidence of HAI of 6.3% and prevalence of HAI of 9.5% [9,10]. The most common types of HAI, comprising more than 80% of all HAIs, were surgical site infections (SSIs), lower respiratory tract infections (LRTIs), skin/soft tissue infections (SSTIs), urinary tract infections (UTIs) and bloodstream infections (BSIs) [9,10]. In 1999, the estimated cost of HAIs for Auckland DHB was almost $19 million ($31m in 2021), and the estimated cost for New Zealand was $137 million ($226m in 2021) [5]. A 2013 PPS of medical and rehabilitation patients in another metropolitan Auckland DHB hospital, using a different methodology, found point prevalence of 5% and cumulative prevalence of 10.7% [11].

Medical care has changed over the past 20 years and with contemporary use of medical devices, immunosuppressive treatments and transplant programmes, older data, limited to larger, urban Auckland DHBs, may not represent the current rate or distribution of HAIs in the country. In addition, Health Quality and Safety Commission quality improvement (QI) programmes, such as Target CLAB Zero, Hand Hygiene New Zealand and Surgical Site Infection Improvement, have been in place for a decade with the aim of reducing HAIs [12—15].

This article reports the first national PPS of all DHB hospitals in New Zealand with the aim of obtaining information to inform the selection of QI initiatives to reduce HAIs. The current rate and spectrum of HAIs in New Zealand, prevalence of device use, device-associated HAIs, and microbiology of HAIs, including drug resistance, were determined.

Methods

Study design

A rolling PPS was performed across all DHB acute care public hospitals from 22nd February to 23rd June 2021 using the European Centre for Disease Prevention and Control (ECDC) methodology for PPSs on HAIs [16].

Data collection and surveyor training

Data were collected on mobile devices and entered into a secure web-based survey tool, Research Electronic Data Capture (REDCap) [17]. The collection tool included branching logics based on the ECDC HAI definitions used for this PPS [16]. On the survey day, a report of patients present on each defined ward at 08.00 h was generated from existing DHB data warehouses, and uploaded into REDCap to provide ward lists of patients. A census of the number and types of invasive devices present in these patients was undertaken by local DHB staff at 08.00 h on the survey day [i.e. peripheral intravenous catheters (PVCs), central intravenous catheters (CVCs), urethral or suprapubic catheters, and invasive ventilation (i.e. involving an endotracheal tube or tracheostomy)].

Trained surveyors (RB, BG, CW, SR, AM) collected all the data. Surveyor training was delivered by a contracted infection prevention and control (IPC) expert experienced in adult education (DJ), using an in-house 60-page training manual. Following 10 days of classroom training, all five surveyors had 2 days of practical experience capturing PPS data at Auckland City Hospital.

DHB engagement

To gain support for participating in the PPS, presentations to senior DHB management (i.e. Chief Executives, Chief Medical Officers and Directors of Nursing) occurred in November and December 2020. Once participation was confirmed, contact was made with the DHB IPC and/or QI teams to organize logistics, including scheduling, information systems support and local staff to support the surveyors to collect data. Key DHB staff participated in multiple PPS planning meetings, and other DHB stakeholders were invited to attend the exit meeting to review performance and provide feedback.

Patient inclusions and exclusions

Patients included in this study were adults aged $\geq$18 years present in designated wards at 08.00 h and not discharged at the time of the survey, patients temporarily off the ward before or at 08.00 h and not discharged from the ward at the time of the survey, and patients on short-term ward leave. Patients discharged before the surveyor arrived on the ward, day cases (including day surgery, patients in outpatient departments, and dialysis outpatients), and boarders were excluded from this study. Paediatric wards, mental health units (acute and non-acute), neonatal intensive care units, long-term rehabilitation wards, palliative care, and Accident and Emergency (A&E) departments (except for wards attached to A&E departments where patients are admitted and monitored for $>$24 h) were not included in this study.

Patient triggers and determining HAI

Two triggers were used to screen for the presence of HAIs: presence of fever ($>$38.0 °C in previous 24 h) and/or current antimicrobial therapy (excluding surgical or medical prophylaxis). If a trigger was met, a review of the clinical notes, and pathology and radiology results was undertaken to determine whether the patient met the ECDC definitions for HAI. Patient observation and medication charts were also reviewed. Categories of HAI included: BSIs; bone and joint infections; central nervous system infections; CVC- or PVC-related infections; *Clostridioides difficile* infection (CDI); pneumonia or other LRTIs (e.g. tracheitis or bronchitis without evidence of pneumonia); SSTIs; SSIs; sepsis (without a positive culture); ear, eye, nose, throat and mouth infections; and UTIs.

Susceptibility

Multi-drug-resistant organisms (MDROs) were defined as meticillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), carbapenem-resistant Gram-negative bacilli (CROs), and Enterobacterales resistant to third-generation cephalosporins but susceptible to carbapenems [mostly extended-spectrum beta-lactamase (ESBL)-positive; for analysis, called 'ESBL-positive organisms'].

Validation

To ensure that HAIs were defined and recorded correctly, at the end of each day, all proposed HAIs were presented by the surveyors and reviewed by at least one of the senior investigators (SR, AM). Additionally, a random sample of patients (with and without HAIs) was used to assess how consistently the PPS surveyors judged patient HAI status. It was presumed that inter-rater reliability (IRR) would be high, $\kappa \geq 0.8$, and the proportion of patients with HAIs in the overall survey sample would be ≥ 0.065. Based on these assumptions, the minimum required IRR group size was estimated to be 117 patients to yield a 95% confidence interval (CI) with lower bound ≥ 0.6. The agreement coefficient (AC_1), proposed by Gwet for use when there is high agreement for categorical data, was calculated [18]. Patients were assigned to the IRR group by daily random sampling from pre-determined wards. IRR was measured across the three main surveyors (BG, CW, RB). For large hospitals where all main surveyors were on site, the IRR group included six patients per day; fewer patients were included when only two main surveyors were on site. The clinical records of IRR patients were subjected to independently repeated data collection and entry by all surveyors on site.

Analysis and statistics

Univariate and multi-variable logistic regression were used to identify independent factors (demographic, hospital, clinical service and device features) associated with HAI status. All analyses were undertaken using R Version 4.1.1 (2021-08-10). A two tailed *P*-value of <0.05 was considered to indicate statistical significance. Factors were included in the multi-variable analysis if they were clinically plausible or significantly associated with HAI in the univariate analysis. Stepwise model selection with backward elimination was performed based on an Akaike information criterion algorithm. The combination of variables providing the best fit of the data was retained in the final model. A receiver operating characteristic (ROC) curve was used to test the accuracy of the model. A funnel plot was generated to detect variation in DHB HAI rates.

Privacy

A privacy impact assessment application was approved by the Northern Region DHB Regional Privacy Advisory Group in August 2020.

Ethics

As an audit and related activity, New Zealand's Health and Disability Ethics Committee (HDEC) deemed that this study did not require ethical committee review (T. Katz, personal communication to S.A. Roberts, 14th August 2020, HDEC).

Results

Study population and risk factors

The PPS was conducted from 22nd February until 23rd June 2021, and included 31 hospitals, and 313 wards and units. In total, 5468 patients were included; of these, 2189 (40%) were medical patients, 2012 (37%) were surgical patients, 755 (14%) were older persons' health/rehabilitation patients, 424 (8%) were obstetrics and gynaecology patients, and 87 (1.6%) were intensive care unit (ICU) patients. The clinical service of one patient was not recorded.

In total, 2007 patients (37%) had triggers for full record review; 1787 were receiving antimicrobial treatment, 42 had fever, and 178 had both. Overall, 1965 (36%) patients were receiving antimicrobial treatment.

Three hundred and sixty-one patients (6.6%; 95% CI 6.0–7.3) had 423 HAIs; of these, 308 patients had one HAI, 45 patients had two HAIs, seven patients had three HAIs, and one patient had four HAIs. There were 7.7 HAIs per 100 patients. One hundred and thirty-two HAIs were present on admission in 117 patients (2.1% of all patients, 32.4% of all patients with HAIs): 51 SSIs (39%), 22 BSIs (17%), 16 UTIs (12%), 12 cases of pneumonia (9%) and 31 (23%) other HAIs.

Patient characteristics and risk factors for HAI are presented in Tables I and II. Ethnicity was not associated with HAI rate, but HAI rate varied by clinical service. Regional referral DHBs did not have higher HAI rates compared with smaller DHBs (Table I). After multi-variable logistic regression analysis, the independent risk factors for HAIs were: clinical service type; presence of a PVC; presence of a CVC; and length of hospital stay. The ROC showed an area under the curve of 0.724, indicating an acceptable model.

Although HAI rates varied between DHBs, funnel plot analysis showed that all rates were within the 98.8% CI, with two DHBs outside the 95% CI (Figure S1, see online supplementary material).

Devices

Medical devices were common, with 3585 patients (66%) having at least one invasive device (Table II). Overall, 2922 (53%) patients had at least one PVC, 549 (10%) patients had at least one CVC, 967 (18%) patients had a urinary catheter, and 52 (1%) patients were ventilated. Two hundred and fifty patients had more than one PVC or CVC. The total number of devices was 4758. The most common device combinations were: PVC alone (*N*=2278, 42%), PVC and urinary catheter (*N*=519, 10%), CVC alone (*N*=280, 5%), and urinary catheter alone (*N*=238, 4%) (Figure S2, see online supplementary material). CVC use was common in several patient groups, including 89 of 191 (47%) haematology/oncology/transplant patients, 51 of 181 (28%) cardiovascular surgery patients, 98 of 809 (12%) general surgery patients, 49 of 609 (8%) orthopaedic patients, and 86 of 1558 (6%) general medicine patients.

Types of HAI

The distribution of HAIs is presented in Table III. The four most common HAIs were SSIs, UTIs, pneumonia and BSIs, comprising 74% of the total. Of the 104 SSIs, 34 (33%), 28 (27%) and 42 (40%) were superficial, deep and organ space, respectively. The most common sources of the 55 BSIs were intravenous (IV) catheters [*N*=14 (25%), of which 11 (20%) and 3 (5%) were CVCs and PVCs, respectively], UTIs (*N*=8, 15%) and SSIs (*N*=6, 11%). The source of 14 BSIs (25%) was not identified. There were seven (1.7%) cases of CDI.

Device-associated HAIs accounted for 69 (16%) of all HAIs; ventilator-associated pneumonia accounted for 13 (17%) cases of pneumonia, and urinary catheters were associated with 39

Table I
Patient characteristics and risk factors for healthcare-associated infections (HAIs)

Characteristics and risks	All patients *N*=5468 (%)	Without HAIs *N*=5107 (%)	With HAIs *N*=361 (%)	*N*[a]	Unadjusted OR	95% CI	*P*-value	Adjusted OR *N*=5464[b]	95% CI	*P*-value
Sex[c]				5467						
Female	2889 (53)	2715 (94)	174 (6)		Reference					
Male	2578 (47)	2391 (92.7)	187 (7.3)		1.22	0.99–1.51	0.068			
Age, years[c,d]				5468						
≥65	3212 (58.7)	2996 (93.3)	216 (6.7)		Reference			Reference		
<65	2256 (41.3)	2111 (93.6)	145 (6.4)		0.95	0.77–1.18	0.7	1.2	0.94–1.52	0.145
Median age (IQR)	70 (53–81)	70 (53–81)	70 (57–80)	5468	1.0	1.00–1.01	0.11			
Ethnicity				5454						
NZ European	3786 (69)	3527 (93.2)	259 (6.8)		Reference					
Māori	766 (14)	723 (94.4)	43 (5.6)		0.81	0.57–1.12	0.2			
Pacific peoples	410 (8)	378 (92.2)	32 (7.8)		1.15	0.77–1.66	0.5			
Asian	405 (7)	383 (94.6)	22 (5.4)		0.78	0.49–1.20	0.3			
Other	87 (2)	84 (96.6)	3 (3.4)		0.49	0.12–1.31	0.2			
Emergency admission[c,d]				5468						
Yes	3815 (70)	3582 (93.9)	233 (6.1)		Reference			Reference		
No	1653 (30)	1525 (92.3)	128 (7.7)		1.29	1.03–1.61	0.026	1.21	0.93–1.56	0.162
MDRO alert[c]				5467						
No	5047 (92)	4724 (93.6)	323 (6.4)		Reference					
Yes	420 (8)	382 (91)	38 (9)		1.45	1.01–2.04	0.037			
Regional referral DHB[e]				5468						
No	2615 (47.8)	2455 (94)	160 (6.1)		Reference					
Yes	2853 (52.2)	2652 (93)	201 (7)		1.16	0.94–1.44	0.2			
Clinical service type[c,d]				5467						
Medical	2189 (40)	2094 (95.7)	95 (4.3)		Reference			Reference		
Obstetrics & gynaecology	424 (8)	411 (96.9)	13 (3.1)		0.70	0.37–1.21	0.2	1.01	0.52–1.83	0.968
Rehabilitation/older persons' health	755 (14)	691 (91.5)	64 (8.5)		2.04	1.46–2.83	<0.001	2.41	1.62–3.56	<0.001
Surgical	2012 (37)	1843 (91.6)	169 (8.4)		2.02	1.56–2.63	<0.001	1.75	1.34–2.30	<0.001
ICU	87 (2)	67 (77)	20 (23)		6.58	3.75–11.1	<0.001	2.64	1.45–4.67	<0.002
Admission to survey date/infection date, days[c,d]	Median 4 (IQR 2–9)	Median 4 (IQR 2–8)	Median 9 (IQR 5–18)	5467	1.02	1.01–1.02	<0.001	1.01	1.008–1.019	<0.001

IQR, interquartile range; MDRO, multi-drug-resistant organism (e.g. meticillin-resistant *Staphylococcus aureus*, extended-spectrum beta-lactamase-positive); OR, odds ratio; CI, confidence interval; ICU, intensive care unit; NZ, New Zealand; DHB, district health board.

[a] Patients with missing values for the variable in question were omitted from univariate analysis.

[b] For multi-variable analysis, *N*=5464. Patients were omitted if they had missing values for any of the variables included in the initial model (marked '[c]').

[c] Variable included in initial multi-variable model.

[d] Variable included in final multi-variable model after stepwise variable selection.

[e] Auckland, Counties Manukau, Waikato, Capital & Coast, and Canterbury DHBs.

Table II
Surgery- and device-related risk factors for healthcare-associated infections (HAIs)

Characteristics and risks	All patients *N*=5468 (%)	Without HAIs *N*=5107 (%)	With HAIs *N*=361 (%)	*N*[a]	Unadjusted OR	95% CI	*P*-value	Adjusted OR *N*=5464[b]	95% CI	*P*-value
Surgery within 30 days				5420						
No	4294 (79)	4087 (95.2)	207 (4.8)		Reference					
Yes	1126 (21)	979 (86.9)	147 (13.1)		2.96	2.37–3.70	<0.001			
Devices										
Any device				5468						
No	1,883 (34.4)	1817 (96.5)	66 (3.5)		Reference					
Yes	3585 (65.6)	3290 (91.8)	295 (8.2)		2.47	1.89–3.27	<0.001			
Peripheral venous catheter[c,d]				5468						
No	2546 (47)	2381 (93.5)	165 (6.5)		Reference			Reference		
Yes	2922 (53)	2726 (93.3)	196 (6.7)		1.04	0.84–1.29	0.7	2.02	1.55–2.65	<0.001
Central venous catheter[c,d]				5468						
No	4919 (90)	4674 (95)	245 (5)		Reference			Reference		
Yes	549 (10)	433 (78.9)	116 (21.1)		5.11	4.0–6.5	<0.001	5.74	4.3–7.64	<0.001
Urinary catheter[c]				5468						
No	4501 (82)	4249 (94.4)	252 (5.6)		Reference					
Yes	967 (18)	858 (88.7)	109 (11.3)		2.14	1.69–2.7	<0.001			
Mechanical ventilation[c]				5468						
No	5416 (99)	5068 (93.6)	348 (6.4)		Reference					
Yes	52 (1.0)	39 (75)	13 (25)		4.85	2.47–8.94	<0.001			

IQR, interquartile range; OR, odds ratio.
[a] Patients with missing values for the variable in question were omitted from univariate analysis.
[b] For multi-variable analysis, *N*=5464. Patients were omitted if they had missing values for any of the variables included in the initial model (marked '[c]').
[c] Variable included in initial multi-variable model.
[d] Variable included in final multi-variable model after stepwise variable selection.

(49%) UTIs. There were 17 IV-catheter-related HAIs, three local insertion site infections, and 14 BSIs (Table II).

Microbiology

For the 423 HAIs, 301 pathogens were isolated in total; 208 patients had one isolate recovered from their HAI, 37 patients had two isolates, five patients had three isolates, and one patient had four isolates. One hundred and seventy-two (41%) HAIs did not have an organism identified (Table IV). *Staphylococcus aureus* was the most common pathogen identified (*N*=63, 21%), followed by *Escherichia coli* (*N*=61, 20%). Other Enterobacterales, mainly *Klebsiella* spp. (*N*=32), were the next most common group (*N*=59, 20%), with *Enterococcus* spp., other staphylococci, *Candida* spp. and *Pseudomonas aeruginosa* making up most of the other isolates (29%) (Table IV). *S. aureus* was the most common isolate in three of the four main HAI groups, and was responsible for three PVC BSIs and two CVC BSIs. Enterobacterales dominated UTIs (*N*=51, 64%), while no organism was identified for most of the patients with pneumonia (83%) and other HAIs (61%) (Table IV).

Pathogen susceptibility

There were 42 MDROs (14%) (Table IV). Eight (13%) of 63 *S. aureus* were MRSA. There were 120 Enterobacterales isolates, of which 28 (23%) were ESBL-positive and five (4%) were CROs, representing a combined MDRO prevalence of 33 (28%) for this group. MDROs accounted for 12 of 61 (20%) *E. coli*, 11 of 32 (34%) *Klebsiella* spp., and 10 of 27 (37%) other Enterobacterales. There were no VRE among the 36 enterococcus isolates, and only one of the 15 *P. aeruginosa* isolates was carbapenem resistant (Table IV).

Four hundred and twenty (8%) patients had an MDRO or *C. difficile* alert in their record; 243 (4.4%) for an ESBL-positive organism and 188 (3.4%) for MRSA. An MDRO alert was not an independent risk factor for HAI (Table I).

Validation results

IRR on the presence/absence of HAIs was measured from a sample of 316 patients (6% of cohort). For 113 patients in the sample, there were three replicates [i.e. an independent data collection was performed by each of the three main surveyors (RB, CG and BG)]. For the remaining 203 patients, there were two replicates. IRR was high [Fleiss κ 0.87 (95% CI 0.76–0.98); Gwet's AC_1 0.987 (95% CI 0.976–0.999)] [18].

Discussion

Recent PPS results from other countries [19–24] are summarized in Table S1 (see online supplementary material). Comparison with Singapore is difficult as that survey attributed a high proportion of HAIs to unspecified sepsis (26%) [20], which

Table III
Distribution of 423 healthcare-associated infections (HAIs)[a]

Type of HAI	Rank	Number of infections	% of all HAIs (95% CI)
Surgical site	1	104	24.6 (20.7–28.9)
Urinary tract[b]	2	80	18.9 (15.5–22.9)
Pneumonia[c]	3	75	17.7 (14.4–21.7)
Bloodstream[d]	4	55	13.0 (10.1–16.5)
Eye, ear, nose, throat, mouth[e]	5	38	9.0 (6.6–12.1)
Skin and soft tissue[f]	6=	16	3.8 (2.3–6.1)
Systemic[g]	6=	16	3.8 (2.3–6.1)
Gastrointestinal[h]	8	14	3.3 (2.0–5.5)
Cardiovascular	9	8	1.9 (1.0–3.7)
Reproductive tract	10	6	1.4 (0.7–3.1)
Bone and joint	11	5	1.2 (0.5–2.7)
Lower respiratory tract[i]	12	4	0.9 (0.4–2.4)
Central nervous system	13	2	0.5 (0.1–1.7)

CI, confidence interval.
[a] European Centre for Disease Prevention and Control definitions [16].
[b] Thirty-nine urinary tract infections (49%) were associated with a urinary catheter.
[c] Thirteen pneumonia events (17%) were associated with mechanical ventilation.
[d] Fourteen bloodstream infections (25%) were associated with an intravascular catheter (11 central, three peripheral), eight (15%) due to urinary tract infections and six (11%) due to surgical site infections.
[e] Includes 33 cases of oral candidiasis.
[f] Includes three local infections related to an intravascular catheter (one central, two peripheral).
[g] Treatment initiated for severe systemic infection where no isolate or site of infection identified.
[h] Includes seven cases of *Clostridioides difficile* infection.
[i] Infections (e.g. bronchitis, tracheitis) without evidence of pneumonia.

has not been reported by others [19,21–24]. The present results for New Zealand are very similar to those reported from Australia, the European Union (Europe), the USA, Switzerland and Wales, with the top four HAIs comprising 56–75% of all HAIs [19,21–24]. Direct comparison with the recent Australian report is difficult because those results were limited to principal referral and group A hospitals [24], rather than the wide range of service complexity provided by New Zealand DHBs.

The main differences in the PPS for New Zealand include a higher proportion of SSIs compared with the Europe and Wales [21,22], a higher proportion of UTIs compared with the USA [19], a lower proportion of systemic infections compared with Wales [21], a higher proportion of systemic infections compared with the USA [19], and fewer cases of CDI compared with Europe, the USA or Wales [19,21,22] (Table S1, see online supplementary material). Few reports described HAI rates for different clinical services, but the higher rate for ICU patients found in the present PPS is consistent with other reports [19–24]. The proportions of HAIs in this survey are very similar to those observed 20 years ago in Auckland DHB with the main difference being that SSIs currently comprise a higher proportion of HAIs (25% vs 18% previously) [10], and a lower proportion of BSIs were found to be linked to IV catheters in the present study (25% vs 40% previously) [25].

Multi-variable logistic regression analysis showed that certain clinical services had higher rates than general medicine, namely ICU, rehabilitation/older person's health and surgical specialties. The presence of either a CVC or PVC was an independent risk factor, as was length of hospital stay.

The organisms causing HAIs were dominated by *S. aureus* and Enterobacterales, of which *E. coli* and *Klebsiella* spp. were the most common. These proportions are very similar to those reported previously (Table S1, see online supplementary material) [19–24]. This study found a similar rate for MDROs as in Switzerland and Australia [23,24], but a lower proportion of MDROs compared with those encountered in Europe [22] (14% vs 32%). The highest proportion of MDROs was encountered among Enterobacterales, with almost one-quarter being MDROs, and was highest for *Klebsiella* spp. with one-third being MDROs (Table IV).

MDRO or *C. difficile* alerts were present for 8% of patients. In a recent Australian study, 12% of patients were being managed as MDRO-positive, and 11% of them had active HAIs [24]. While the present study did not specifically record if patients were under transmission-based precautions, many patients were and this represents a significant resource issue for hospitals. However, as the use of MDRO alerts differs among DHBs, the observed rate should be regarded only as an estimate for how commonly transmission-based precautions are in place.

Just over one-third of patients were receiving antibiotics for treatment. Several patients were on antibiotics without a statement in the chart to indicate the reason. While audit of antibiotic use was outwith the scope of this PPS, the frequency of antibiotic use, MDRO prevalence, and additional cost of managing MDRO infections [26,27] support the need for a national survey of antimicrobial prescribing to identify appropriate stewardship interventions [28].

This PPS was resource intensive in planning, training, execution and analysis. Communication was critical to PPS implementation, with initial high-level contact with DHB clinical and management teams seeking participation, followed by planning with the local PPS team and notifying ward staff about the survey and the need for the device census.

This study has several strengths. Comprehensive training was provided for surveyors on the HAI definitions and data entry. Data were collected by a limited number of surveyors, who had high interobserver agreement for recording HAIs, and cases were reviewed daily to decide on their inclusion. The hospitals were surveyed over a relatively short period of time that avoided the winter peak period.

However, this study has some limitations. Not all patients present on the survey day were assessed, and some HAIs would have been missed (e.g. a patient could have been discharged home on oral antibiotics for their HAI before the surveillance team arrived on the ward, or a patient may have been in the emergency department but not admitted by the 08.00 h cut-off for inclusion). Some patient triggers could have been missed, but this is considered to have been rare. The applied definitions did not include all possible HAIs; for example, some patients were receiving treatment for organ space SSIs, but the original operation was outside the 90-day inclusion period. Therefore, the observed prevalence of HAIs should be regarded as a minimum. Reasons for antibiotic treatment for those without HAIs (e.g. community infection) were not recorded. The susceptibility results of a small number of isolates were not known, and the MDRO rate should also be regarded as a minimum. DHBs

Table IV
Pathogens causing 423 healthcare-associated infections (HAIs), by infection type[a]

	423 HAIs		Surgical site (*N*=104)	Urinary tract (*N*=80)	Pneumonia (*N*=75)	Bloodstream (*N*=55)	Other HAIs (*N*=109)
Pathogen	301 isolates	Rank	87 isolates	80 isolates	17 isolates	65 isolates	52 isolates
	N (%)		*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Staphylococcus aureus[b]	63 (21)	1	27 (31)	3 (4)	3 (18)	16 (25)	14 (27)
Escherichia coli[c]	61 (20)	2	11 (13)	33 (41)	1 (6)	8 (12)	8 (15)
Enterococcus spp.[d]	36 (12)	3	9 (10)	11 (14)	1 (6)	8 (12)	7 (13)
Klebsiella spp.[e]	32 (11)	4	5 (6)	12 (15)	3 (18)	9 (14)	3 (6)
Other Enterobacterales[f]	27 (9)	5	12 (14)	6 (8)	1 (6)	6 (9)	2 (4)
Other staphylococci	20 (7)	6	9 (10)	2 (3)	-	6 (9)	3 (6)
Candida spp.[g]	17 (6)	7	3 (3)	7 (9)	1 (6)	3 (5)	3 (6)
Pseudomonas aeruginosa[h]	15 (5)	8	5 (6)	4 (5)	2 (12)	2 (3)	2 (4)
Other Gram-negatives[i]	8 (3)	9	1	-	4 (24)	3 (5)	-
Clostridioides difficile	7 (2)	10	-	-	-	-	7 (13)
Streptococcus spp.	5		1	2 (3)	-	2 (3)	-
Other Gram-positives	4		3 (3)	-	-	1 (2)	-
Other anaerobes	4		1	-	-	1 (2)	2 (4)
Aspergillus fumigatus	1		-	-	1 (6)	-	-
Herpes simplex virus	1		-	-	-	-	1 (2)
Multi-drug-resistant organisms[j]	42 (14)		14 (16)	15 (19)	2 (12)	7 (11)	4 (8)
No pathogen isolated[k]	172 (41)		35 (34)	9 (11)	62 (83)	0 (0)	66 (61)

[a] Total of 301 pathogens: one, two, three or four pathogens identified in 208, 37, five and one HAI, respectively.
[b] Eight (13%) meticillin-resistant *S. aureus*.
[c] Eleven (18%) extended-spectrum beta-lactamase (ESBL) positive, one (1.6%) carbapenem-resistant organism (CRO).
[d] No isolate was vancomycin resistant.
[e] Ten (31%) ESBL positive, one (3%) CRO.
[f] Seven (26%) ESBL positive, three (11%) CRO.
[g] *Candida albicans* (*N*=10), *C. glabrata* (*N*=3), *C. parapsilosis* (*N*=1), non-speciated (*N*=3).
[h] One (7%) CRO.
[i] None were drug resistant.
[j] Eight (19%) MRSA, 28 (67%) ESBL, six (14%) CRO.
[k] Number of HAIs used as the denominator.

have different processes for maintaining MDRO alerts in patient records, and the degree of variation is not known. In addition, the authors did not capture HAIs arising after discharge and managed in the community. As with all such surveillance, definitions may overcall some HAIs [29].

Although this PPS was conducted during the coronavirus disease 2019 pandemic, the operation of hospitals in New Zealand was relatively unaffected compared with many other countries. During the PPS period, elective and emergency clinical activity closely resembled the pre-pandemic clinical case load for these hospitals [30]. While there were no community lock downs during the surveillance period, entry into New Zealand was essentially restricted to citizens, and required 14 days of managed isolation and testing. The border restrictions resulted in a dramatic reduction in the expected seasonal respiratory virus activity, which can begin in June which was near the end of the PPS.

This PPS was conducted as the first step in a process to develop a national strategy to prevent HAIs in New Zealand. The observed prevalence will enable an estimate of incidence which, with national admission data, will enable calculation of the likely national burden of HAIs. The actions with the best-available evidence to inform national policy are multimodal interventions and surveillance, monitoring and feedback [31]. The most recent estimates for the preventable proportion of selected HAIs in high- and middle-income countries are of the order of 40—60% [32]. Well-described bundles of care to reduce a range of HAIs exist [33—37]. Choosing which interventions to promote will be challenging because the degree to which multi-modal interventions are currently in place within a hospital and between hospitals is unclear. For example, the national CLAB Zero improvement collaborative for ICUs resulted in 80% compliance with the insertion bundle [13], but CVCs are used across a wide spectrum of clinical services outside ICUs, and compliance, surveillance, monitoring and feedback in these settings are unknown.

While not a formal part of the surveillance methods, variation in recording of IV catheter use and their review was noted in this study. There was also inconsistent mention of urinary catheters in patient notes, and infrequent evidence of review for their continuing need. Device use and monitoring are items to consider for QI focus.

In conclusion, this study established the common HAIs and their risk factors in New Zealand. The high prevalence of device use underscores the need to ensure that proven multi-modal prevention interventions are in place. However, as less than half of HAIs are device- or surgery-associated, other intervention strategies will be required to reduce their burden.

Acknowledgements

The authors wish to thank Dr. Kalisvar Marimuthu from Singapore and Drs. Philip Russo, Andrew Stewardson, Allen Cheng and Brett Mitchell from Australia for the support provided during the development phase of the PPS, and for sharing the REDCap data collection tool. The authors also wish to thank Harini Srinivasan for performing the logistic regression and IRR analyses. The authors acknowledge the significant contribution of the local DHB IPC team members as well as the ward staff for assisting surveyors and performing the device census on the survey day. In addition, the authors wish to thank the ward and unit charge nurses who facilitated access to the hospital computer system and clinical records on the day. The authors also acknowledge the time and effort by the local DHB business intelligence units for data uploads. Finally, the authors wish to thank the senior management at all DHBs, including Chief Executive Officers, Directors of Nursing and Chief Medical Officers, for their support.

Author contributions

NG contributed to aspects of study design and contributed to the final manuscript. AF contributed to aspects of study design, logistical planning, and contributed to the final manuscript. AS contributed to study design, logistical planning, and contributed to the final manuscript. DJ developed the training materials, provided surveyor training, and contributed to study design and the final manuscript. EM contributed to study design, set up electronic data transfer, provided operational support for running the survey, performed data analysis, and contributed to the final manuscript. GC performed server provisioning and configuration for the electronic platform for data collection, and contributed to study design, design of data transfer processes, data analysis and the final manuscript. RB, BG and CW contributed to surveillance design, performed the surveillance, and contributed to the final manuscript. SR and AM are the principal investigators who conceived the study, contributed to study design, data collection, and manuscript preparation and review. All authors approved the final article.

Conflict of interest statement

None declared.

Funding sources

This work was supported by the Health Quality and Safety Commission.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2022.10.002.

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