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Published in:
Journal of Hospital Infection

DOI:
10.1016/j.jhin.2020.12.026

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

Journal of Hospital Infection 114 (2021) 51–58

Available online at www.sciencedirect.com

Journal of Hospital Infection

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

Evaluating the post-discharge cost of healthcare-associated infection in NHS Scotland

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ARTICLE INFO

Article history:
Received 5 October 2020
Accepted 23 December 2020

Keywords:
Healthcare-associated infection
Hospital
Acute
Community
Post-discharge
Patient outcomes

SUMMARY

Background: Whereas the cost burden of healthcare-associated infection (HAI) extends beyond the inpatient stay into the post-discharge period, few studies have focused on post-discharge costs.
Aim: To investigate the impact of all types of HAI on the magnitude and distribution of post-discharge costs observed in acute and community services for patients who developed HAI during their inpatient stay.
Methods: Using data from the Evaluation of Cost of Nosocomial Infection (ECONI) study and regression methods, this study identifies the marginal effect of HAI on the 90-daypost-discharge resource use and costs. To calculate monetary values, unit costs were applied to estimates of excess resource use per case of HAI.
Findings: Post-discharge costs increase inpatient HAI costs by 36%, with an annual national cost of £10,832,437. The total extra cost per patient with HAI was £1,457 (95% confidence interval: 1,004–4,244) in the 90 days post discharge. Patients with HAI had longer LOS if they were readmitted and were prescribed more antibiotics in the community. The results suggest that HAI did not have an impact on the number of readmissions or repeat surgeries within 90 days of discharge. The majority (95%) of the excess costs was on acute care services after readmission. Bloodstream infection, gastrointestinal infection, and pneumonia had the biggest impact on post-discharge cost.
Conclusion: HAI increases costs and antibiotic consumption in the post-discharge period. Economic evaluations of IPC studies should incorporate post-discharge costs. These

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https://doi.org/10.1016/j.jhin.2020.12.026

findings can be used nationally and internationally to support decision-making on the impact of IPC interventions.

Introduction

Healthcare-associated infections (HAIs) increase the cost of healthcare and impose additional morbidity and risk of mortality [1]. The cost burden extends beyond the inpatient stay into the post-discharge period, yet a 2005 review showed that most published studies focus on inpatient costs only, particularly additional length of stay (LOS), and ignore the post-discharge period [2]. Previous research has mostly focused on the post-discharge incidence of surgical site infection (SSI) and associated costs [3–5]. Reporting post-discharge impact of HAI requires long-term follow-up of patients with, and without, HAI once they have left hospital. Recording healthcare utilization by these patients, which can be resource intensive to collate, is further complicated by the requirement to adjust for comorbidities seen within this patient population. The challenges and variability of estimates have been well described [6]. Plowman *et al*. reported similar post-discharge resource use between HAI and non-HAI groups [7,8]. Other studies have shown an increase in hospital readmissions in HAI patients when compared to patients without HAI [9–13]. One review in the USA estimated that between 9% and 13% of the total health cost of HAI occurs post discharge and highlighted the wide range of methodologies, different HAI types, settings and differences in reporting [14]. These create challenges when interpreting the findings of the few studies that include a perspective broader than acute hospitals.

Reliable estimates on the total burden of HAI are critical for assessing the cost-effectiveness of infection prevention and control (IPC) programmes [15]. This requires estimates of resource use incurred during both the inpatient and post-discharge phases. With a growing focus on minimizing the duration of hospital stays there is an increasing requirement for acute and community services to be involved in patient care after a patient has been discharged from hospital. However, little is known about the impact of all types of HAI on the level and distribution of post-discharge resource use among acute and community services. The aim of this study was to investigate the impact of all types of HAI on the magnitude and distribution of post-discharge costs observed in acute and community services for patients who developed HAI during their inpatient stay. As such, the study provides information that can be used in the economic evaluation of IPC measures, as the financial benefits of preventing HAI in hospital may extend after the inpatient stay.

Methods

The analysis focuses on resource use and resulting costs that fall directly on the health service in the 90 days after patients are discharged from hospital. A 90-daypost-discharge period was chosen to fully capture the impact on resource use that can be attributed to the preceding hospital stay.

Incidence of HAI

The Evaluation of Cost of Nosocomial Infection (ECONI) study was a two-centre, prospective observational HAI incidence study with record linkage. The study was undertaken in one Scottish NHS teaching hospital and one general hospital, which were selected as being broadly representative of other acute hospitals of their type in Scotland in terms of patient specialties, HAI prevalence, and patient mix [16]. Data collection began in April 2018 and continued for one calendar year. All adult inpatients admitted overnight were included within an incidence cohort. HAI cases were defined using the ECDC epidemiological case definitions [17,18]. National estimates of incidence are reported elsewhere within each specialty group and hospital type in 2018/19 [19].

Identification of excess post-discharge resource use

All adult overnight admissions to the study hospitals, including HAI cases and non-cases, were linked to NHS Scotland administrative electronic databases that contain information on discharge specialty, reason for admission, post-discharge episodes of care, post-discharge healthcare contacts, surgical interventions, and post-admission prescribing [20–23].

During the study there were 99,018 admissions to the hospitals. This analysis includes 664 patients who developed HAI and 43,841 patients with no HAI (see Appendix Figure A1). Patients who did not have a complete 90 days follow-up were excluded from the analysis. Patients who died within 90 days post discharge were excluded (2604 people died in hospital including 158 with HAI and 2374 people died post discharge including 57 with HAI). Patients were also excluded if they did not have any post-discharge follow-up information available (in total 2631 people 161 of which had HAI), plus a small number of patients who had been discharged from hospital for less than 90 days (31 people all non-HAI).

Regression analysis at the patient level was employed to identify the marginal effect of HAI on post-discharge resource use also referred to as patient outcomes. Patient outcomes in this study included readmissions to acute care hospitals, outpatient visits, community prescribing and general practitioner (GP) prescribing costs. In the regression analysis, one admission or index inpatient stay per patient was selected for the analysis of events during the 90 days post discharge. In this study, reported excess LOS due to readmission included stay in any facility such as intensive care unit (ICU) or other ward; the excess LOS spent in ICUs was also estimated separately [21]. For patients with multiple HAIs within a single admission, the first identified infection type was used in the analysis by HAI type. As a robustness check the analysis was repeated to include patients who did not survive in the 90 days post discharge (see Appendix Table A4).

Table I
Costs (£) for each NHS service

Resource	Mean unit cost	SD: plausible range	Distribution for sensitivity analysis	Source
Acute care				
Bed-day ward[a]	486.40	307.08	Log–normal	ISD [26]
Bed-day ICU[a]	1800.41	310.48	Log–normal	ISD [26]
Theatre cost per case[a]	616.41	676.68	Normal	ISD [26]
Outpatient visit	134.00	96.00–160.00	Normal	PSSRU [27]
Community care				
GP appointment	28.00	22.40–33.60	Normal	PSSRU [29]

NHS, National Health Service; SD, standard deviation; ISD, Information Services Division (ISD) Scotland; ICU, intensive care unit; GP, general practitioner; PSSRU, Personal Social Services Research Unit.
[a] Unit costs are based on NHS reference (accounting) costs.

The regression model controlled for other covariates likely to explain variation in the outcomes. Covariates were selected by reviewing the Scottish Patients at Risk of Readmission and Admission (SPARRA) tool which predicts an individual's risk of being admitted to hospital as an emergency inpatient within the next year [24,25]. The covariates included were: type of hospital, sex, age, specialty of admission, type of admission (elective or emergency), Scottish Index of Multiple Deprivation (SIMD) as an indicator of deprivation, time since last inpatient procedure, LOS in the two years before admission, and comorbidities: cancer, cardiovascular disease, chronic renal failure, and diabetes.

Valuation of HAI excess post-discharge resource use

The second step of the analysis was to build a cost model with parameters that capture events representing extra use of services. Estimates of the regression model were multiplied by the unit costs of services to calculate post-discharge costs for the average individual affected by HAI. Publicly available unit costs were used as shown in Table I for each patient outcome. Costs are reported in pounds sterling using 2018 data [26,27].

Bed-day unit costs were based on reference costs that included permanent staff and other direct costs excluding capital and overhead costs [26]. The bed-day costs considered in this study are a proxy for the direct cost of providing healthcare services in the NHS. The cost of repeat surgeries is the weighted average of theatre costs across teaching and large general hospitals in NHS Scotland [26]. Outpatient visits were costed using the Personal Social Services Research Unit (PSSRU) [27]. The PSSRU also provides estimates for lower and upper quartiles of the outpatient visit costs and these were used as a plausible range.

The cost of prescriptions for antibiotic treatment within the first 90 days after the index admission episode was calculated from linkage to the Prescribing Information System dataset [23]. Community prescribing has been reported in terms of cost, number of items, number of prescriptions and defined daily dose (DDD) [28]. Since there is currently no routinely available data set that collects GP visits, the number of prescriptions for an antibiotic was used as a proxy for GP visits.

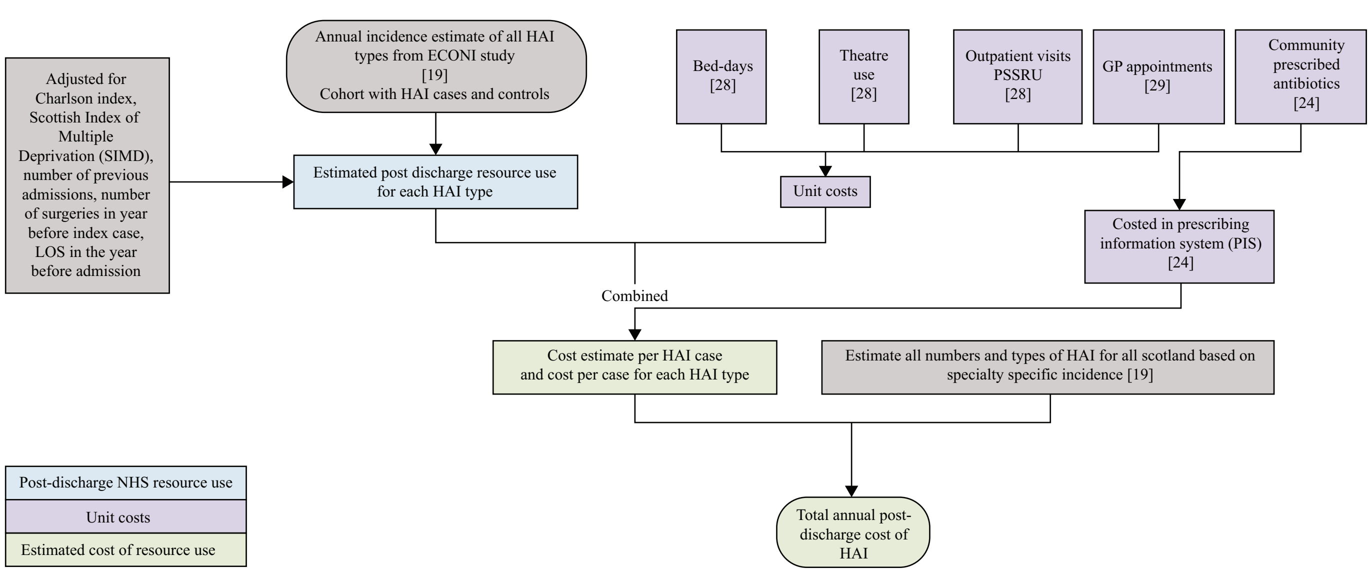

Figure 1. How information was calculated and combined in order to estimate cost per case and total cost of HAI within 90 days post discharge. HAI, healthcare-associated infection; LOS, length of stay; ECONI, Evaluation of Cost of Nosocomial Infection; PSSRU, Personal Social Services Research Unit; GP, general practitioner; NHS, National Health Service.

Table II
Descriptive characteristics of sample

Variable	HAI patients ($N = 664$)		Non-HAI patients ($N = 43,841$)	
Age (years)				
<40	49	(7.4%)	7199	(16.4%)
40–49	55	(8.3%)	4493	(10.3%)
50–59	114	(17.2%)	7082	(16.2%)
60–69	111	(16.7%)	8022	(18.3%)
70–79	165	(24.9%)	8808	(20.1%)
>80	170	(25.6%)	8237	(18.8%)
Sex				
Female (Yes)	352	(53.0%)	23,338	(53.2%)
SIMD				
1 (most deprived)	133	(20.0%)	8449	(19.3%)
2	204	(30.7%)	11,271	(25.7%)
3	118	(17.8%)	8253	(18.8%)
4	90	(13.6%)	7327	(16.7%)
5 (least deprived)	116	(17.5%)	8294	(18.9%)
Unknown	3	(0.5%)	247	(0.6%)
Hospital type				
Teaching hospital	607	(91.4%)	30,804	(70.3%)
General hospital	57	(8.6%)	13,037	(29.7%)
Admission type				
Emergency admission (Yes)	562	(84.6%)	32,407	(73.9%)
Specialty				
Medical	267	(40.2%)	22,501	(51.3%)
Surgical	246	(37.1%)	16,681	(38.1%)
HDU	59	(8.9%)	1128	(2.6%)
ICU	81	(12.2%)	2059	(4.7%)
Obstetrics–gynaecology	11	(1.7%)	1472	(3.4%)
Comorbidities				
Diabetes (Yes)	101	(15.2%)	3850	(8.8%)
Chronic renal failure (Yes)	177	(26.7%)	4038	(9.2%)
Cardiovascular disease (Yes)	331	(49.9%)	15,882	(36.2%)
Cancer (Yes)	66	(9.9%)	2092	(4.8%)
Last inpatient procedure (days to admission)				
None	300	(45.2%)	28,533	(65.1%)
≤30	104	(15.7%)	1348	(3.1%)
31–90	80	(12.1%)	2185	(5.0%)
91–180	53	(8.0%)	2609	(6.0%)
≥181	127	(19.1%)	9166	(20.9%)
Total LOS (days) up to 2 years prior to admission				
0	235	(35.4%)	27,192	(62.0%)
1–2	61	(9.2%)	4342	(9.9%)
3–7	65	(9.8%)	4710	(10.7%)
8–14	70	(10.5%)	2710	(6.2%)
15–30	86	(13.0%)	2384	(5.4%)
>30	147	(22.1%)	2503	(5.7%)
HAI type[a]				
BSI	96	(14.5%)	N/A	N/A
GI	98	(14.8%)	N/A	N/A
LRI	122	(18.4%)	N/A	N/A
PN	52	(7.8%)	N/A	N/A
SSI	107	(16.1%)	N/A	N/A
UTI	161	(24.3%)	N/A	N/A
Other	28	(4.2%)	N/A	N/A

HAI, healthcare-associated infection; SIMD, Scottish Index of Multiple Deprivation; HDU, high-dependency unit; ICU, intensive care unit; LOS, length of stay; BSI, bloodstream infection; GI, gastrointestinal infection; LRI, lower respiratory tract infection; PN, pneumonia; SSI, surgical site infection; UTI, urinary tract infection; N/A, not applicable.
[a] Patients with multiple HAIs during their stay were assigned to the HAI type of the first infection.

Cost of GP appointments was based on the PSSRU with a plausible range of ±20% [29].

Estimation of post-discharge excess costs due to HAI

The statistical analysis accounted for the uncertainty in the unit costs and excess resource use parameters. First, an empirical distribution was determined by drawing Monte Carlo samples from log–normal and normal distributions shown in Table I. Second, a non-parametric bootstrap approach was used to calculate confidence intervals (CIs) of estimated resource use. The post-discharge cost of HAI was defined as the product of vectors of unit costs and excess resource use by HAI patients. The empirical distributions were combined with the bootstrapped data to calculate 95% CIs. Finally, the cost for a case of HAI was multiplied by the annual estimated number of HAIs in NHS Scotland. Data sources and how these were combined are shown in Figure 1.

Results

The final sample included a total of 44,505 patients (see Appendix Figure A1 for a strobe diagram). A slightly higher proportion of HAI patients (8% of HAI patients) died in the 90-daypost-discharge period than non-HAI patients (5% of non-HAI patients).

The descriptive characteristics of the HAI and non-HAI patients in the sample are presented in Table II. HAI patients tended to be older, but the two groups had similar gender ratios. There was a greater proportion of emergency admissions compared with elective admissions within the HAI group. The HAI group showed a greater proportion of comorbidities than the non-HAI group, had more recent inpatient procedures, and a greater number of days in hospital within the two years preceding their index admission.

The results of the regression model are presented in Table III. The coefficients of excess resource use, in Table III, may be interpreted as the marginal effect of HAI on post-discharge outcomes. After controlling for covariates, HAI was associated with an increase in hospital total bed-days of 2.9 days (standard error (SE): 0.3) but not the total number of readmissions (0.003; SE: 0.04), so patients with HAI when readmitted stayed for a longer period. There was no difference in the number of surgeries for patients with HAI compared to those without HAI (0.000; SE: 0.03). HAI patients showed a small increase in the number of outpatient visits of 0.371 (SE: 0.97) within 90 days after discharge compared to those without HAI.

Antibiotic costs during the 90-day period following the index hospitalization were £12.80 (SE: 2.2) higher for HAI patients compared to non-HAI patients. HAI patients were prescribed 6.4 DDD more than non-HAI patients. The total number of prescriptions for antibiotics was 0.27 greater in the HAI group and the number of dispensed antibiotic items was 0.27 greater in the HAI group. In the HAI group 41% of patients received an antibiotic within 90 days of discharge compared with 24% of

Table III
Mean excess resource use per HAI patient within 90 days post-discharge from hospital

Patient outcomes 90 days post-discharge	Excess resource use[a]	SE	95% CI[b]
Acute care			
No. of readmissions to hospital	0.003	0.039	0.000–0.078
Length of total stay (days)[c]	2.851	0.297	2.518–3.672
Length of stay in ICU (days)[d]	0.085	0.039	0.033–0.218
No. of surgeries	0.000	0.029	0.000–0.062
No. of outpatient visits[e]	0.371	0.097	0.220–0.622
Community care			
Daily defined doses[f]	6.368	0.686	5.496–8.640
Gross ingredient cost (£)	12.796	2.202	10.328–23.799
Dispensed antibiotics	0.274	0.038	0.224–0.388
Prescriptions for antibiotics[g,h]	0.269	0.037	0.220–0.360

HAI, healthcare-associated infection; SE, standard error; CI, confidence interval; ICU, intensive care unit.
[a] Coefficients in this column represent point estimates. All models adjusted for type of hospital, sex, age, specialty of admission, type of admission (elective or emergency), Scottish Index of Multiple Deprivation, time since last inpatient procedure, length of stay (LOS) in the two years before admission, diagnosis of cancer, cardiovascular disease, chronic renal failure, and diabetes.
[b] Bias-corrected 95% CI based on 5000 bootstrap samples.
[c] Total LOS includes stay in any facility such as intensive care, ICU, high-dependency unit, and other wards.
[d] LOS in ICU is estimated separately and should not be added to total LOS.
[e] An individual can have more than one outpatient attendance on the same day in the sample.
[f] This is daily defined doses (DDD) prescribed in the period of analysis, which may not reflect actual DDD taken.
[g] One prescription may have more than one item, and each item may have different quantities of the same drug.
[h] Calculated from the number of prescription dates per person in period.

non-HAI patients. HAI resulted in an increase in resource use for each outcome except number of repeat hospitalizations and surgeries where there was no difference between HAI and non-HAI patients.

Based on results in Table III, the total excess LOS of readmitted HAI patients was the biggest estimated coefficient (2.851) by far. Excess LOS for these readmissions by HAI type is reported in Table IV. The longest additional LOS in readmissions was seen in patients with bloodstream infection (BSI), followed by gastrointestinal infection (GI), pneumonia, and urinary tract infection (UTI). SSIs and lower respiratory tract infections had the least impact on post-discharge LOS.

In Table V, the excess post-discharge costs for patients with HAI compared to those without HAI are shown. The total extra cost per patient with HAI was £1,457 (95% CI: 1,004–4,244) in the 90 days post discharge. The greatest cost was associated with repeat hospital admissions.

Table IV
HAI coefficients for 90-day post-discharge length of stay by HAI type with bias corrected

HAI type	Length of total stay (days)[a]	95% CI[b]
Bloodstream infection	5.44	4.36–7.85
Gastrointestinal infection	3.80	2.71–5.89
Lower respiratory tract infection	1.21	0.28–3.09
Pneumonia	2.76	1.37–6.13
Surgical site infection	1.74	0.73–3.90
Urinary tract infection	2.66	1.85–4.37

HAI, healthcare-associated infection; CI, confidence interval.
[a] Point estimate was reported at a patient level and excludes all patients with incomplete follow-up. Adjusted for type of hospital, sex, age, specialty of admission, type of admission (elective or emergency), Scottish Index of Multiple Deprivation, time since last inpatient procedure, length of stay in the two years before admission, diagnosis of cancer, cardiovascular disease, chronic renal failure, and diabetes.
[b] Bias-corrected 95% CI based on 5000 bootstrap samples.

Discussion

This is the first nationally representative study in Scotland to investigate the burden of HAI in the post-discharge period from an NHS perspective based on whole-hospital incidence. The results suggest that patients who develop HAI in hospital have longer LOS if they are readmitted, and they are prescribed more antibiotics in the 90 days post-discharge period than non-HAI patients. On average HAI patients were prescribed one single additional prescription of antibiotics given that most antibiotics in the community are prescribed for between five and seven days. Overall, the results of this study suggest that 95% of the post-discharge costs associated with HAI were due to hospital readmissions. These hospital costs are mainly staff costs associated with the direct cost of patient

Table V
Estimated excess post-discharge costs (£) of HAI

Patient outcome	Cost per patient	95% CI[a]
Acute care		
Cost of repeat hospital admissions	1,386.58	781.83–3,754.31
Cost of number of surgeries	0.00	0.00–41.58
Cost of outpatient visits	49.65	28.58–89.09
Subtotal	1,436.23	
Community care		
Cost of antibiotics	12.80	10.33–23.80
Cost of GP appointments (prescription)	7.53	5.89–11.26
Subtotal	20.33	
Total cost per patient	1,456.56	1,004.23–4,243.61

HAI, healthcare-associated infection; CI, confidence interval; GP, general practitioner.
[a] Based upon 5000 bootstrap samples for the regression estimates and 5000 Monte Carlo simulations of the costs.

care [26]. Excess community care costs are ∼1.4% of the total cost associated with HAI in the post-discharge period. The rest of the post-discharge cost is associated with outpatient appointments (3.4%).

Based on the total annual numbers of HAI in teaching and large general hospitals in NHS Scotland (7437 (95% CI: 7021—7849) estimated elsewhere), annual post-discharge costs equate to approximately £11 million (9.5m—14.4m) [19]. During 2018—2019 the total inpatient expenditure in NHS Scotland was £4.1 billion, making the post-discharge cost of treatment ∼0.3% of the total acute inpatient budget [30]. The direct inpatient cost due to HAI has been estimated elsewhere to be £30.1 million (14.1m—74.4m) per year [31]. This means that on average the post-discharge period increases inpatient costs by 36%.

This study found patterns of community resource use for patients with HAIs identified in hospital comparable to those found by Plowman *et al*. [8]. This study also confirms other previous findings that HAI burden does not stop during the inpatient period but continues after hospital discharge [14]. Our results are similar to those of Chopra *et al*. who showed that patients with *Clostridium difficile* infection (CDI) have 5—6 days excess LOS when readmitted [9]. This study shows that GI, which could have been caused by any pathogenic agent including CDI, increases LOS in readmissions by ∼4 days. The results of this study are also similar to those of Nelson *et al*. who showed that patients with HAI caused by meticillin-resistant*Staphylococcus aureus* have increased LOS when readmitted with additional pharmacy costs [13].

The findings of this study have similarities with inpatient costs reported elsewhere which suggest that BSIs and pneumonias are the most burdensome infection types [31]. However, other infection types seem to have relatively higher costs in the inpatient period but are less costly in the post-discharge period. For example, UTIs have been estimated to have zero excess LOS in the inpatient stay but showed 2.6 days excess LOS in the post-discharge period [32]. One explanation for this result may be that some UTI patients are discharged before their infections are completely treated and display complex treatment patterns if readmitted. This could also be due to unobserved patient characteristics that increase the likelihood of developing HAI but also increase hospital stay in the post-discharge period, or there might be omitted factors that confound the estimated excess LOS due to HAI. SSI has been estimated previously to be a significant burden in the post-discharge period and has also been estimated to be the third most costly infection type in the inpatient stage [31,33]. This study has shown SSI to be one of the least costly infection types in the post-discharge period. Some very costly SSIs occur after hospital discharge and these were not included in this study [34]. Another explanation may be that SSIs in the post-discharge period consume other types of services such as community nursing, which was not included.

The limitations of this study must be noted. HAIs presenting post-discharge and exclusively treated in the community would not have been identified and would potentially be within the non-HAI group. Therefore, estimates of this study are likely to be an underestimate of the true post-discharge cost of HAI. Patient-level data on community nursing visits were not available, which means that the burden on community care may also be an underestimate. Patients who either died in hospital or in the post-discharge period were excluded. This means that patients who were seriously unwell were excluded, but they may have had a different pattern of resource use. The analysis was repeated, including some of these patients (deceased in the 90 days post discharge), and the values were found to be very similar (see Appendix Table A4). The regression model may not have controlled for every factor that is correlated with both the propensity to develop HAI and the level of resource use in the post-discharge period. If that is the case, the estimates of the regression model do not uniquely capture the marginal impact of HAI but are a composite of HAI and these uncontrolled factors.

The unit costs in this study are accounting costs, which, under conditions of spare capacity, may not reflect opportunity costs (see Manoukian *et al*. for a discussion of issues around using opportunity costs [31]). In this study the unit cost of a bed-day in wards was calculated by excluding more resource-intensive facilities such as ICUs and high-dependency units. Some of the excess LOS due to HAI readmissions may have taken place in these more expensive units. The regression results suggest that ∼3% of the total excess LOS due to readmissions takes place in ICUs. This implies an extra cost of £154 on average associated with readmissions of HAI patients in ICUs, meaning that the estimated post-discharge cost of HAI was underestimated. The purpose of this study was to investigate resource use in the post-discharge period but it is important to recognize that HAI also affects quality of life. Quality of life can be measured using quality-adjusted or disability-adjusted life-years but this was out of scope for this study. This study did not examine societal costs such as informal care, loss of income due to work absence, and other personal costs. These indirect costs are not routinely collected but may be substantial for some individuals affected by HAI and are not always visible to policy-makers.

The strengths of this study are its data sources and the methodology. This study is important because it provides information on where future IPC resources could be directed to increase efficiency within the health system. A 10% reduction in HAI incidence could result in more than 2100 bed-days being made available by limiting the length of readmission episodes. It is important to note that the costs reported in this study cannot be recovered as cash savings if HAI is prevented, but are valuations of alternative uses such as treating other patients [15]. These findings indicate that a reduction in HAI cases would mainly impact acute care rather than community care. However, patients with HAI had on average one additional prescription for antibiotics post discharge, and although the cost of these antibiotics and the associated GP prescribing time was small, these contribute to the overall burden of community prescribing, and therein may have secondary unmeasured impacts such as a higher risk of antimicrobial resistance.

In conclusion, this is the first study for more than 20 years in the UK to examine the cost of HAI in the post-discharge period. It presents comprehensive data on all HAI at the facility and national level. The evidence presented is consistent with existing literature and shows that HAI increases costs and antibiotic consumption after discharge. More research is needed, especially on the post-discharge impact of HAI on patients and informal carers. Economic evaluations of IPC studies should incorporate post-discharge costs, including readmission costs, which may be a substantial proportion of total costs attributed to HAI. These findings can be used nationally and internationally to support decision-making on the impact of IPC interventions.

Acknowledgements

Data collection could not have been completed without the enormous effort from the ECONI research nurses: N. Williamson, H. Thain, R. Boyle, A. McAlpine, and C. Beith. Thanks are extended to all members of the infection prevention and control teams, microbiology departments and research and development teams in the study sites for their support in initiating the study. The study was supported by the clinical staff in the study hospitals, particularly the infection control teams, laboratory staff, and research and development teams.

Author contributions

S.M. contributed to aspects of the study design and led data collection for economic analysis, calculated the unit costs and prepared the manuscript. S.S. led the study design, wrote study protocols and ethics and Public Benefit and Privacy Panel approvals, contributed to the development of statistical analysis, the manuscript, and costed the cash treatment costs. N.G. prepared the manuscript and contributed to the study design. H.M. contributed to the study design, led on health economic aspects of the study design, and contributed to the manuscript. C.R. contributed to the concept of the study, study design, statistical analysis plan, and the manuscript. S.K. and J.P. undertook the statistical analysis and prepared results. L.H. contributed to the final manuscript. S.D. and B.C. are the Principal Investigators at the recruiting sites and contributed to the final manuscript. J.R. conceived the study, is Chief Investigator for the study, and contributed to the manuscript.

Non-author collaborators

The ECONI Steering Committee. M.A. represented the funder, A.L., R.D., A.M., M.S. and J.I. represented the Scottish Government HAI policy unit on the Steering Committee. E.R. and L.R. represented Infection Prevention Society (IPS). M.W., L.B., and M.R. were lay representatives on the Steering Committee and M.W. and L.B. contributed to the development of the patient-facing materials for the study. Committee: Professor J. Reilly (J.R.), Professor M. Adil (M.A.), Dr H. Mason (H.M.), Professor C. Robertson (C.R.), Professor N. Graves (N.G.), J. Ives (J.I.), M. Syme (M.S.), R. Dunk (R.D.), A. Mullings (A.M.), E. Ross (E.R.), Professor S. Dancer (S.D.), Dr B. Cook (B.C.), Professor A. Leonard (A.L.), M. Whyte (M.W.), M. Rodgers (M.R.), L. Brown (L.B.), S. Stewart (S.S.).

Conflict of interest statement

None declared.

Funding sources

This work was supported by Health Protection Scotland Programme, NHS National Services Scotland (RIE reference 14-154) from October 2015 to January 2020. The work was also pump-primed by the Scottish Healthcare Associated Infection Prevention Institute (SHAIPI), which has been set up with Scottish Government funding via the Scottish Infection Research Network.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2020.12.026.

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