

## Identifying hospital-acquired infections using retrospective record review from the Irish National Adverse Events Study (INAES) and European point prevalence survey case definitions

### AUTHOR(S)

Natasha Rafter, Ronan Finn, Karen Burns, Sarah Condell, Ronan Conroy, Anne Hickey, Paul O'Connor, David Vaughan, Gillian Walsh, David Williams

### CITATION

Rafter, Natasha; Finn, Ronan; Burns, Karen; Condell, Sarah; Conroy, Ronan; Hickey, Anne; et al. (2021): Identifying hospital-acquired infections using retrospective record review from the Irish National Adverse Events Study (INAES) and European point prevalence survey case definitions. Royal College of Surgeons in Ireland. Journal contribution. <https://hdl.handle.net/10779/rcsi.17032007.v1>

### HANDLE

[10779/rcsi.17032007.v1](https://hdl.handle.net/10779/rcsi.17032007.v1)

### LICENCE

CC BY-NC-ND 4.0

This work is made available under the above open licence by RCSI and has been printed from <https://repository.rcsi.com>. For more information please contact [repository@rcsi.com](mailto:repository@rcsi.com)

### URL

[https://repository.rcsi.com/articles/journal\\_contribution/Identifying\\_hospital-acquired\\_infections\\_using\\_retrospective\\_record\\_review\\_from\\_the\\_Irish\\_National\\_Adverse\\_Events\\_Study\\_INAES\\_and\\_European\\_point\\_prevalence\\_survey\\_case\\_definitions/17032007/1](https://repository.rcsi.com/articles/journal_contribution/Identifying_hospital-acquired_infections_using_retrospective_record_review_from_the_Irish_National_Adverse_Events_Study_INAES_and_European_point_prevalence_survey_case_definitions/17032007/1)

# Journal of Hospital Infection

## Identifying hospital acquired infections using retrospective record review from the Irish National Adverse Events Study (INAES) and European point prevalence survey case definitions

--Manuscript Draft--

<b>Manuscript Number:</b>	JHI-D-18-00829R1
<b>Full Title:</b>	Identifying hospital acquired infections using retrospective record review from the Irish National Adverse Events Study (INAES) and European point prevalence survey case definitions
<b>Corresponding Author:</b>	Natasha Rafter Royal College of Surgeons in Ireland Dublin, IRELAND
<b>Article Type:</b>	Original Article
<b>Additional Information:</b>	
<b>Question</b>	<b>Response</b>
<b>Publishing Open Access</b>  In addition to publishing subscription content, Journal of Hospital Infection also publishes Open Access Articles which are free to access and reuse by both subscribers and the general public.  Authors can choose to publish Open Access. In this case a fee is payable by the author or research funder to cover the costs associated with publication. For information about funding body policies or other mandates that may apply visit <a href="http://www.elsevier.com/fundingbodies">www.elsevier.com/fundingbodies</a>  <a href="#">Learn about publishing Open Access in this Journal</a> .  Please indicate below whether you intend to publish Open Access.	No, I do not intend to publish Open Access

## Article title

Identifying hospital acquired infections using retrospective record review from the Irish National Adverse Events Study (INAES) and European point prevalence survey case definitions

## Names of all authors and affiliations

Dr Natasha Rafter, Department of Epidemiology & Public Health Medicine, Division of Population Health Sciences, Royal College of Surgeons in Ireland (RCSI)

Mr Ronan Finn, Medical student, RCSI

Dr Karen Burns, Departments of Clinical Microbiology, RCSI and Beaumont Hospital, Health Protection Surveillance Centre

Dr Sarah Condell, Clinical Effectiveness Unit, National Patient Safety Office, Department of Health

Prof Ronan Conroy, Division of Population Health Sciences, RCSI

Prof Anne Hickey, Department of Psychology, Division of Population Health Sciences, RCSI

Dr Paul O'Connor, Discipline of General Practice, National University of Ireland, Galway

Dr David Vaughan, Director Quality and Safety, Children's Hospital Group

Ms Gillian Walsh, Royal College of Physicians of Ireland

Prof David Williams, Department of Stroke & Geriatric Medicine, RCSI and Beaumont Hospital

## Corresponding author contact details

Dr Natasha Rafter, Department of Epidemiology & Public Health Medicine, Division of Population Health Sciences, Royal College of Surgeons in Ireland (RCSI)

123 St Stephens Green, Dublin 2

[natasharafter@rcsi.com](mailto:natasharafter@rcsi.com)

+353 402 5197

## Running title

Hospital acquired infections in the INAES

## Key words

Adverse events, epidemiology and detection, chart review methodologies, hospital medicine, infection control

## SUMMARY

**Background:** Point prevalence surveys (PPSs) collect data on hospital acquired infections (HAIs) at one point in time but do not provide information on incidence over the entire admission or impact on patients or healthcare resources. Retrospective record review examines the entire admission to determine adverse event prevalence, incidence, preventability, physical impairment and additional length of stay.

**Aim:** To establish whether European HAI surveillance definitions can be applied to the Irish National Adverse Events Study (INAES) retrospective record review data to determine HAI burden.

**Methods:** In the INAES, 1574 admissions were reviewed using a two-stage methodology and 247 adverse events were found. These were examined against European HAI case definitions to determine whether the event was a HAI. Results were compared with the 2011/12 European PPS data for Ireland.

**Findings:** The prevalence of HAI adverse events in INAES was 4.4% (95% CI 3.1-6.1%) with an incidence of 3.8 (95% CI 2.5-5.2) HAI adverse events per 100 admissions. The PPS HAI prevalence for Ireland was 5.2%. HAI types and micro-organisms were similar in INAES and the PPS. Approximately three-quarters of INAES HAI adverse events were preventable, 7% caused permanent impairment and 7% contributed to death. A mean of ten additional bed days were attributed to HAI adverse events, equivalent to €9,400 per event.

**Conclusion:** Retrospective record review is an accurate source of information on HAI incidence, preventability and impact that complements PPS prevalence rates. HAI adverse events result in higher costs to the healthcare system than other adverse events.

## Introduction

Hospital acquired infections (HAIs) result in prolonged hospitalisation, readmission, antimicrobial resistance plus healthcare and societal costs.[1, 2] Improved surveillance is a key objective of the WHO Global Action Plan on Antimicrobial Resistance in order to demonstrate changes in HAI patterns and evaluate intervention effectiveness.[3, 4] This will involve establishing accurate baseline data incorporating a range of methodologies to ensure that HAI occurrence and their consequences are well characterized and can be monitored for change.

Most national level HAI data come from point prevalence surveys (PPS) and targeted incidence surveillance systems (e.g. notifiable diseases, *Clostridium difficile* surveillance).[5, 6] The first European PPS in acute hospitals, conducted by the European Centre for Disease Prevention and Control (ECDC) across 33 countries in 2011/12, reported a 6% HAI prevalence for Europe and 5.2% for Ireland.[7, 8]

A PPS captures prevalence at one point in time, therefore excluding HAIs occurring at other times and underestimating total burden.[9] Repeated surveys provide important trend data on HAI types, antimicrobial resistance and treatment patterns. They can be used to assess compliance with guidelines, monitor effectiveness of infection control programmes, identify changes in antimicrobial use and guide future priority setting.[10-12] Limitations include the need to derive incidence; patient outcomes and resource use cannot be determined (due to the absence of data after the survey date); and the lack of preventability assessment.[1, 11, 13] Retrospective record review using the Harvard Medical Practice Study methodology could help address these gaps as it allows for the collection and analysis of longitudinal data encompassing the entire admission and readmissions with in-depth review of each adverse event.[14, 15] However, standard retrospective record review for adverse events does not incorporate HAI surveillance definitions and only a handful of studies have reported on HAIs.[16-19] Therefore, we aimed to establish whether adding European HAI surveillance definitions to retrospective record review data from the Irish National Adverse Events Study (INAES) could determine HAI incidence, preventability and impact and complement ECDC PPS results.[14, 15]

## METHODS

The INAES was a two-stage retrospective record review study.[15] All 30 acute public hospitals in the Republic of Ireland were invited to participate. Of the 18 hospitals that agreed to participate, one large and one small were randomly selected from each of the four health regions. A random sample of 300 - 400 'index' admissions was generated at each site using the hospital's local electronic discharge database. The sampling frame included all inpatient admissions for patients aged at least 18 years in 2009 who had a minimum stay in hospital of 24 hours (or died within 24 hours), excluding admissions with obstetrics or psychiatric principal diagnoses. Admissions were stratified by whether or not a surgical procedure was likely to have been performed based on anaesthetic procedure coding.[15]

**Stage-one:** Nurses screened medical records of the first 200 eligible admissions (plus 12 months before and after) at each participating hospital for 18 adverse event triggers.

**Stage-two:** Physicians reviewed triggered admissions to determine adverse event presence (defined as ‘an unintended injury or complication resulting in disability at the time of discharge, prolonged hospital stay or death and that was caused by healthcare management rather than by the underlying disease process’).[14, 15] Physician reviewers wrote clinical summaries of each admission and evaluated adverse events for: physical impairment due to the adverse event on discharge (six-point scale: 1 = no impairment, 6 = death); preventability (six-point scale: 1 = no evidence for preventability, 6 = certain evidence); and additional length-of-stay attributed to the event.[15]

## HAI review

In INAES, 1,574 eligible admissions were reviewed, 45% were triggered and 703 proceeded to stage-two review by physicians who identified 247 adverse events in 211 admissions.[15] The clinical summaries of these 247 events were analysed for HAIs by two authors (RF and NR) trained in the ECDC PPS methodology. Discrepancies were resolved with a consultant clinical microbiologist (author KB), national coordinator for Ireland in ECDC PPS 2011/2012 and 2017.

A HAI adverse event was defined as ‘an adverse event due to an infection acquired during, or as a consequence of, an acute care hospital stay with onset of symptoms on day three or later of the index admission

OR the patient was readmitted with infection within two days of discharge from the index hospital

OR the patient was readmitted within 30 days of the operation with a surgical site infection (or with a deep or organ/space SSI that developed within a year of surgery that involved an implant)

OR the patient was readmitted with *Clostridium difficile* infection within 28 days after a previous discharge from the index hospital

OR an invasive device was placed on day one or day two, resulting in an HAI before day three.’[7]

Each HAI adverse event was classified using the ECDC PPS 2011/12 case definitions (protocol version 4.3).[7] Where information was available, the causative microorganism(s) and antimicrobial resistance markers were noted. The case definitions were adhered to as much as possible, within the context of the data available in the INAES dataset.

## Analysis

HAI adverse event period prevalence was calculated as the proportion of admissions associated with one or more HAI adverse events out of all admissions. HAI incidence

density was the number of HAI adverse events occurring per 100 admissions excluding events occurring prior to the index admission (to avoid double counting).[15] Logistic regression was used to compare HAI adverse event prevalence between subgroups. HAI adverse event analyses were weighted to reflect the sampling criteria (i.e. ratio of surgery and non-surgery admissions in each hospital's eligible study population). Confidence intervals (CIs) for binary variables were modelled using logistic regression; CIs for incidence were calculated using Poisson regression with robust variance estimation; p-values were derived from logistic regression, unless otherwise noted.

To establish the baseline cost of HAI adverse events in adult inpatients in 2009, the product of (1) number of HAI adverse events [= incidence density of HAI adverse events x number of adult inpatient admissions to acute Irish public hospitals in 2009 (n=339,844[20]); and (2) average cost of a HAI adverse event [= mean number of added bed days attributed to HAI adverse events x 2009 inpatient bed cost (€909 per day, Healthcare Pricing Office)] was estimated.[21] The rationale for using 2009 costs was that this is the year from which the data was collected.

Analyses were undertaken using Stata release 13.1. INAES results were compared with the ECDC PPS 2011/12 results for Ireland, as the closest reference dataset.[8, 22]

## RESULTS

Of the 247 adverse events, 78 were HAIs (in 73 admissions) representing a weighted proportion of 32.5% (95% CI 26.3-39.4%, table 1). The weighted prevalence of HAI adverse events was 4.4% (95% CI 3.1-6.1%). The PPS prevalence of HAIs for Ireland was 5.2% (95% CI 4.7-5.6%) and 5.0% if patients aged ≤15 years of age and acute psychiatric patients were excluded.[22] The INAES weighted incidence density was 3.8 HAI adverse events (95% CI 2.5-5.2) for every 100 admissions. In the INAES study, 17.9% of the HAI adverse events were related to previous admissions and this was 23.8% in the PPS for Ireland.

### Table 1 Comparison of INAES and ECDC PPS 2011/12 results

The majority (77.1%) of INAES HAI adverse events had a recovery time of ≤ six months. However, in 6.7% the HAI may have contributed to, or resulted in, death (table 1). Almost three-quarters of HAI adverse events were deemed preventable. INAES admissions with HAI adverse events were longer (median 18 days) than admissions without (4 days, p<0.001, Wilcoxon Mann-Whitney test). The mean number of additional hospital days attributed to HAI adverse events was 10.3, resulting in an additional cost of €9,400 for each HAI adverse event, which when extrapolated nationally equates to a €121 million annual cost to the Irish healthcare system. The PPS data for Ireland found increasing prevalence of HAIs with increasing age (age up to 44 years prevalence 3.4%, age 45 and above prevalence 6.0%).[22] The INAES determined that the mean age of patients with a HAI

adverse event was 64.6 years versus 55.8 without ( $p < 0.001$ , t-test) and with each ten-year age increment there was a 26% increase in HAI adverse event prevalence (OR 1.26, 95% CI 1.14-1.39). There was no difference in HAI adverse event prevalence between male and female admissions ( $p = 0.401$ ) or between elective and emergency admissions ( $p = 0.897$ ) in INAES. However, the PPS found a higher prevalence of HAIs in males (5.8%) compared with females (4.6%,  $p = 0.008$ ).[22]

The INAES prevalence of HAI adverse events was higher in admissions which included treatment in an intensive care environment than in those without (14.6% versus 3.6% respectively,  $p = 0.001$ , table 1). In the PPS, HAI prevalence in augmented care units was 16.5% compared with 7.3% in mixed specialty wards and 6.7% in surgical wards.[22] In INAES admissions where surgery was likely to have been performed had a higher HAI adverse event prevalence (6.7%) compared with non-surgery admissions (3.6%,  $p = 0.03$ ). However, when the analysis was performed using the specialty of the consultant associated with the principal diagnosis, no significant difference was observed (surgical 5.3%, medical 3.8%,  $p = 0.176$ ). In the PPS data the prevalence of HAIs was 11.5% in patients who had undergone surgery (defined as involving an incision and taking place in an operating room) since admission, 5.9% for other operative procedures and 4.1% if no surgery had taken place.[22]

HAI types were similar in both INAES and the PPS data - the top two in both were SSIs and pneumonia/lower respiratory tract. Microbiology results were available for 59.0% (46/78) of HAI adverse events in INAES and 52.1% in the PPS (table 2).[22]

Table 2 Distribution of type of HAI in INAES and ECDC PPS 2011/12 Ireland

In the PPS *Escherichia coli* was the most commonly identified pathogen, whereas it was third in INAES. The most common organisms in INAES were *Staphylococcus aureus*, *Clostridium difficile*, and *Escherichia coli* (table 3).[22]

Table 3 Distribution of microorganisms in INAES and ECDC PPS 2011/12 Ireland

In INAES antimicrobial susceptibility information was documented in 36.7% (11/30) of isolates where resistance data was required by the ECDC PPS protocol, whereas in the PPS this was over 90% for Ireland.[7] Over half (6/11) of *Staphylococcus aureus* isolates were methicillin resistant *Staphylococcus aureus* (MRSA) and 75% (3/4) of *Enterococcus spp.* were vancomycin resistant enterococci.

## DISCUSSION



This is the first time the HMPS retrospective record review methodology has been adapted to incorporate international HAI definitions.[14] This is also the first study to calculate the national incidence, preventability and physical impact of HAI adverse events in Ireland and estimate their annual cost. We found a marked increase in length-of-stay for HAI adverse events compared to other adverse events - our previously published INAES main analysis found that adverse events resulted in a mean of six additional bed days, whereas for HAI adverse events this is over ten.[15] Therefore, while HAI adverse events represent 32.5% of the burden in numbers, they contribute more than 60% of the cost. This is consistent with a Dutch national adverse events study where HAI AEs had the longest additional length of stay and highest costs when compared to other types of adverse events.[23]

## Comparison of INAES with ECDC PPS 2011/12

The INAES and PPS analyses provide similar results although the study populations differ: the PPS included neonatal, paediatric, maternity and psychiatric populations; all excluded from INAES. In addition, the INAES HAI adverse event prevalence does not capture HAIs that do not satisfy the adverse event definition (i.e. resulting in prolonged hospitalisation or disability at discharge or death) or those originating in hospitals other than the index hospital.[15] Hence, we would expect that the actual prevalence of all HAIs to be higher than 4.4%.

In INAES there were few urinary tract infection (UTI) adverse events, whereas these were prominent in the PPS. Many of the INAES admissions' clinical summaries did include mention of a UTI, but if they were not adverse events then they were not captured in the HAI adverse event analysis. This is likely because a large proportion of UTIs are managed within an admission without substantial morbidity.[2] This in turn impacts on the causative pathogens: in the PPS *Escherichia coli* (the most frequent UTI pathogen) was the most commonly identified pathogen, whereas it was third in INAES.

INAES provides an overall estimate of the 2009 HAI cost to the healthcare system (€121 million). This is very similar to the Irish Health Service Executive estimate of €118 million which was not based on Irish data but drew on a number of sources for mortality, prolonged hospitalisation and cost information.[24-26] Both figures are underestimates as bed days only account for 30-40% of inpatient costs which in turn represent less than half of all healthcare costs.[25, 27-29]

## Strengths and limitations

The major strengths of the INAES HAI results are that the entire admission plus readmissions are reviewed using an internationally standardised methodology with the ability to estimate incidence, physical impact, preventability and cost. Therefore, the INAES provides additional information on incidence, impact and preventability not supplied by PPS methods.

1  
2 A further strength is that the ECDC PPS 2011/12 protocol and case definitions were  
3 employed by trained reviewers; thus allowing direct comparison with international  
4 prevalence data. The use of 2009 admissions establishes a baseline which is able to be  
5 compared with the ECDC 2011/12 PPS and can be used to track progress in infection  
6 control as direct comparisons are now possible with the ECDC 2017 PPS and INAES-2  
7 (currently underway reviewing 2015 admissions).  
8  
9

10  
11  
12 INAES is an adverse event, not a HAI surveillance, study. The focus of INAES was on  
13 identifying adverse events; thus HAIs not satisfying the adverse event definition were not  
14 included in the analysis. There was no separate category for HAIs in the stage-two review.  
15 Therefore information on HAI diagnoses, microorganisms and sensitivities, surgical  
16 prophylaxis, device insertion, care bundles, hygiene patterns, skin issues and antimicrobial  
17 treatment were not collected in dedicated fields. Despite this, the level of absent  
18 microorganism data was lower in INAES compared with the PPS but resistance information  
19 was poorly documented in INAES.[8]  
20  
21  
22  
23  
24  
25

26 As with any retrospective record review, data collection was limited by the healthcare record  
27 documentation and for the INAES HAI review this was further restricted to information in the  
28 reviewers' clinical summaries.[15] As a result of this, INAES HAI reviewers were not always  
29 able to strictly apply some of the ECDC case definitions. For example, the 2011/12 ECDC  
30 PPS case definition for pneumonia requires two chest x-rays for patients with underlying  
31 cardiac/pulmonary disease.[7] In INAES if a prior chest x-ray was likely to have been taken  
32 (e.g. presentation with chest symptoms) and a diagnosis of hospital-acquired pneumonia  
33 was documented, then the case definition was assumed to be satisfied.  
34  
35  
36  
37  
38  
39

## 40 **Future Work**

41 Work is underway to adapt the INAES data collection instrument into an audit tool to make it  
42 accessible to frontline clinical personnel, infection control departments and hospital quality  
43 and risk staff. As part of this, a separate HAI category consistent with ECDC definitions will  
44 be incorporated and compulsory fields for HAI assessment. It is hoped that this  
45 methodology, as well as providing national data, will be used for ongoing local HAI  
46 monitoring. Furthermore, the collection of clinical summaries allows a depth of data to draw  
47 upon which could also be adapted to elucidate hospital and human factors influencing HAI  
48 occurrence.  
49  
50  
51  
52  
53  
54

## 55 **CONCLUSION**

56  
57 Retrospective record review provides additional information on the incidence, impact and  
58 preventability of HAI adverse events not provided by current surveillance methods. It has the  
59 potential to be used to generate both national and local level HAI data in the future. This  
60  
61  
62  
63  
64  
65

2009 INAES HAI analysis expands on the 2011/12 HAI surveillance PPS data and together they give a more comprehensive baseline impression of HAIs in acute hospitals. Both methodologies are being repeated incorporating the same definitions and will therefore further contribute to the longitudinal information needed to monitor HAI trends and the effectiveness of control measures.

INAES received ethics approval from the Royal College of Surgeons in Ireland (REC815) and the Royal College of Physicians of Ireland (RCPI RECSAF 04).

## References

1. Cassini A, Plachouras D, Eckmanns T, Sin MA, Blank H-P, Ducomble T, et al., *Burden of six healthcare-associated infections on European population health: estimating incidence-based disability-adjusted life years through a population prevalence-based modelling study*. PLOS Medicine, 2016. **13**(10): p. e1002150.
2. World Health Organization, *Report on the Burden of Endemic Health Care-Associated Infection Worldwide. Clean Care is Safer Care. A systematic review of the literature*. 2011, WHO.
3. World Health Organization, *Global Action Plan on Antimicrobial Resistance*. 2015, World Health Organization,: Geneva, Switzerland.
4. European Commission, *A European One Health Action Plan against Antimicrobial Resistance*. 2017, European Commission,.
5. Health Protection Surveillance Centre, *Notifiable Diseases and their respective causative pathogens*. 2016, Health Services Executive,.
6. Health Protection Surveillance Centre, *Enhanced Surveillance of Clostridium difficile Infection: Ireland – Q2 2017 National Report*. 2017, Health Protection Surveillance Centre,: Dublin.
7. European Centre for Disease Prevention and Control, *Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals - protocol version 4.3*. 2012, ECDC: Stockholm.
8. European Centre for Disease Prevention and Control, *Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals*. 2013, ECDC: Stockholm.
9. Michel P, Quenon Q, de Saraqueta A Scemama O, *Comparison of three methods for estimating rates of adverse events and rates of preventable adverse events in acute care hospitals*. British Medical Journal, 2004. **328**: p. 199-204.
10. Skoog G, Struwe J, Cars O, Hanberger H, Odenholt J, Prag M, et al., *Repeated nationwide point-prevalence surveys of antimicrobial use in Swedish hospitals: data for actions 2003-2010*. Euro Surveillance, 2016. **21**(25): p. 30264.
11. Humphreys H Smyth ETM, *Prevalence surveys of healthcare-associated infections: what do they tell us, if anything?* Clinical Microbiology and Infection, 2006. **12**: p. 2-4.
12. Reilly J, Cairns S, Fleming S, Hewitt D, Lawder R, Robertson C, et al., *Results from the second Scottish national prevalence survey: the changing epidemiology of healthcare-associated infection in Scotland*. Journal of Hospital Infection, 2012. **82**: p. 170-4.
13. Magill S, Edwards J, Bamberg W, Beldavs Z, Dumyati G, Kainer M, et al., *Multistate point-prevalence survey of health care-associated infections*. New England Journal of Medicine, 2014. **370**: p. 1198-208.
14. Brennan TA, Leape LL, Laird NM, Hebert L, Localio AR, Lawthers AG, et al., *Incidence of adverse events and negligence in hospitalized patients: results of the Harvard Medical Practice Study I*. New England Journal of Medicine, 1991. **324**: p. 370-6.
15. Rafter N, Hickey A, Conroy RM, Condell S, O'Connor P, Vaughan D, et al., *The Irish National Adverse Events Study (INAES): the frequency and nature of adverse events in Irish hospitals-a retrospective record review study*. BMJ Quality & Safety, 2017. **26**: p. 111-9.
16. Aranaz-Andres JM, Aibar-Remon C, Limon-Ramirez R, Amarilla A, Restrepo FR, Urroz O, et al., *Prevalence of adverse events in the hospitals of five Latin American countries: results of the 'Iberoamerican study of adverse events' (IBEAS)*. BMJ Quality & Safety, 2011.

17. Aranaz-Andres JM, Aibar-Remon C, Vitaller-Murillo J, Requena-Puche J, Terol-Garcia E, Kelley E, et al., *Impact and preventability of adverse events in Spanish public hospitals: results of the Spanish National Study of Adverse Events (ENEAS)*. International Journal for Quality in Health Care, 2009. **21**(6): p. 408-14.
18. Sari AB-A, Sheldon TA, Cracknell A, Turnbull A, Dobson Y, Grant C, et al., *Extent, nature and consequences of adverse events: results of a retrospective casenote review in a large NHS hospital*. Quality Safety Health Care, 2007. **16**: p. 434-9.
19. Sousa P, Uva AA, Serranheira F, Nunes C Leite ES, *Estimating the incidence of adverse events in Portuguese hospitals: a contribution to improving quality and patient safety*. BMC Health Services Research, 2014. **14**(311).
20. Healthcare Pricing Office, *Hospital In-Patient Enquiry Scheme*. 2009.
21. Health Service Executive. *National Service Plan 2009*. Available from: [http://www.hse.ie/eng/services/Publications/corporate/National\\_Service\\_Plan\\_2009.pdf](http://www.hse.ie/eng/services/Publications/corporate/National_Service_Plan_2009.pdf).
22. Burns K, Foley M Donlon S, *Point Prevalence Survey of Hospital Acquired Infections & Antimicrobial Use in European Acute Care Hospitals: May 2012 – Republic of Ireland National Report*. 2012, Health Protection Surveillance Centre,.
23. Hoogervorst-Schilp J, Langelaan M, Spreeuwenberg P, De Bruijne MC Wagner C, *Excess length of stay and economic consequences of adverse events in Dutch hospital patients*. BMC Health Services Research, 2015. **15**: p. 531.
24. National Clinical Effectiveness Committee, *Prevention and control methicillin-resistant staphylococcus aureus (MRSA) national clinical guideline No. 2*, Department of Health, Editor. 2013, Department of Health,.
25. Department of Health, *Ireland's National Action Plan on Antimicrobial Resistance 2017-2020. (iNAP)* Department of Health, Editor. 2017, Department of Health,; Dublin.
26. European Centre for Disease Prevention and Control, *Annual Epidemiological Report on Communicable Diseases in Europe 2008*. 2008, European Centre for Disease Prevention and Control,; Stockholm.
27. Plowman R, Graves N, Griffin M, Roberts J, Swan A, Cookson B, et al., *The rate and cost of hospital-acquired infections occurring in patients admitted to selected specialties of a district general hospital in England and the national burden imposed*. Journal of Hospital Infection, 2001. **47**: p. 198-209.
28. Ryan P, Skally M, Duffy F, Farrelly M, Gaughan L, Flood P, et al., *Evaluation of fixed and variable hospital costs due to Clostridium difficile infection: institutional incentives and directions for future research*. Journal of Hospital Infection, 2017. **95**: p. 415-20.
29. Thomas EJ, Studdert DM, Newhouse BI, Zbar K, Howard M, Williams EJ, et al., *Costs of medical injuries in Utah and Colorado*. Inquiry, 1999. **36**(3): p. 255-64.

## ACKNOWLEDGEMENTS

We gratefully acknowledge the support and assistance provided by the eight participating hospital sites, especially their managerial and administrative staff who facilitated the environment and chart access for the study. We are extremely grateful for the hard work of our nurse and physician reviewers. We thank Professor Ross Baker, Virginia Flintoft and Dr Anne Matlow at the University of Toronto for their training and advice. Thank you also to Dr Barry White, Dr Philip Crowley, Dr Ann Coughlan, Sarah Kennedy, Dr Lucia Prihodova, our surgeon advisor, and the members of the INAES advisory group. Thank you to the 2017 Ireland PPS team for allowing us to attend the ECDC PPS training.

## CONFLICT OF INTEREST

Prof Conroy, Prof Hickey, Prof Williams and Dr Rafter report receiving a grant from the Health Research Board of Ireland and Health Service Executive within the Research Collaborative in Quality and Patient Safety (RCQPS/2013/1) and financial support from Office for Nursing and Nursing Midwifery Services Director, Health Service Executive during the conduct of the study. Mr Finn reports support from Royal College of Surgeons in Ireland Research Summer School during the conduct of the study.

## SOURCE OF FUNDING

This work was supported by the Health Research Board of Ireland and Health Service Executive within the Research Collaborative in Quality and Patient Safety (RCQPS/2013/1), the Office for Nursing and Nursing Midwifery Services Director Health Service Executive and the Royal College of Surgeons in Ireland Research Summer School.

Table 1 Comparison of INAES and ECDC PPS 2011/12 results

Variable	INAES HAI adverse events*	ECDC PPS 2011/12 Ireland HAIs [22]
Prevalence (95% CI)	4.4% (3.1-6.1%)	5.2% (4.7-5.6%) (5.0% if patients aged ≤15 years of age and acute psychiatric patients excluded)
Incidence (95% CI)	3.8 HAI adverse events per 100 admissions (95% CI 2.5-5.2)	No data
Prevalence in males (95% CI)	5.0% (2.8-7.2%)	5.8%
Prevalence in females (95% CI)	3.9% (2.4-5.4%)	4.6%
Prevalence if surgery performed in admission (95% CI)	6.7% (5.2-8.2%)	11.5% (9.9-13.4%) (Other operative procedure 5.9% (3.9-9.0%))
Prevalence if no surgery performed in admission (95% CI)	3.6% (2.0-5.2%)	4.1% (3.6-4.5%)
Prevalence surgical consultant	(discharge) 5.3% (3.8-6.8%)	(admitting) 8.1% (7.1-9.3%)
Prevalence medical consultant	(discharge) 3.8% (1.9-5.6%)	(admitting) 5.1% (4.5-5.8%)
Prevalence in ICU (95% CI)	14.6% (5.8-23.4%) (admission included ICU stay)	16.5% (13.2-20.3%) (on augmented care unit)
Prevalence if no ICU stay (95% CI)	3.6% (2.4-4.8%)	7.3% (5.5-9.7%) (mixed specialty ward) 6.7% (5.7-7.9%) (surgical ward) 4.8% (4.1-5.6%) (medical ward)
% preventable (95% CI)	74% (50.7-88.7%)	No data
% resulting in no physical impact on discharge (95% CI)	22.0% (15.5-30.4%)	No data
% resulting in minimal impairment or recovery in 1month (95% CI)	31.4% (22.1-42.6%)	No data
% resulting in moderate impairment, recovery in 1-6 months (95% CI)	23.7% (15.2-35.0%)	No data
% resulting in moderate impairment, recovery in 6-12 months (95% CI)	2.6% (0.6-10.0%)	No data
% resulting in permanent disability (95% CI)	6.8% (1.6-25.3%)	No data
% contributing to death (95% CI)	6.7% (2.2-18.2%)	No data
Median duration of admission with HAI (interquartile range)	18 days (7,31)	No data
Median duration of admission without HAI (interquartile range)	4 days (2,8)	No data
Mean additional bed days due to HAI (95% CI)	10.3 (6.8-15.7)	No data

\*Point estimates and CIs were weighted to account for the sampling frame



Table 2 Distribution of type of HAI in INAES and ECDC PPS 2011/12 Ireland

INAES*		ECDC Ireland[22]	
HAI type	%	HAI type	%
Pneumonia/LRT	31	Pneumonia/LRT	19
Surgical site	27	Surgical site	18
Gastrointestinal	19	Urinary tract	15
Bloodstream, including catheter-related bloodstream infections	15	Bloodstream, including catheter-related bloodstream infections	13
Skin/soft tissue	3	Gastrointestinal	10
Urinary tract	2	Systemic	10
Catheter-related infection, no positive blood culture	2	Eye, ear, nose, mouth	5
Systemic	1	Bone/joint	4
CNS	1	Skin/soft tissue	3

\*Point estimates were weighted to account for the sampling frame

Table 3 Distribution of microorganisms in INAES and ECDC PPS 2011/12 Ireland

INAES*		ECDC PPS 2011/12 Ireland[22]	
Microorganism	%	Microorganism	%
Staphylococcus aureus	16	Escherichia coli	20
Clostridium difficile	16	Staphylococcus aureus	15
Escherichia coli	11	Enterococcus spp.	11
Pseudomonas spp.	11	Clostridium difficile	9
Norovirus	9	Candida spp.	7
Enterococcus spp.	6	Pseudomonas aeruginosa	4
Gram-negative bacilli, non enterobacteriaceae, not specified	4	Other	19
Coagulase-negative staphylococci	4		
Klebsiella spp.	4		
Proteus spp.	4		

\*Point estimates were weighted to account for the sampling frame