Outbreak column 18: The undervalued work of outbreak: prevention, preparedness, detection and management

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Abstract

There are oft-quoted studies which advise that between 1% and 10% of healthcare-associated infections (HAIs) present as healthcare-associated outbreaks (HAOs). Examination of these studies showed they lacked validity due to a low sensitivity to detect HAO, and because they pre-date both advanced healthcare systems and the emergence of recent nosocomial pathogen challenges. The accepted inference: that as there are so few HAOs the focus of surveillance programmes should be on endemic and not epidemic infections (outbreaks), is therefore called into question.

Current estimates of HAI burden are derived from Point Prevalence Surveys (PPS) which are neither designed to nor are capable of detecting HAOs. We considered the extensive Infection Prevention and Control Team (IPCT) work to prevent and prepare for perennial and novel HAOs and suggest that at present this endeavour is largely unseen, underestimated and undervalued.

Any HAI burden estimate needs to comprise a more complete HAI summary than PPS data. This can only be done with a more inclusive surveillance system that has a wider focus than just prevalent infections. There is a real risk of redirection of the IPCT resource from outbreak prevention and preparedness work towards HAI that are counted: such a change could only further increase HAO risks.

Introduction

This outbreak column emerged from a search for an answer to what appeared to be a simple question: what proportion of healthcare-associated infection (HAIs) present as healthcare-associated outbreaks (HAOs)? To answer this question we searched for papers that estimated the HAO burden. There are oft quoted figures in the range of 1–10% (Wenzel et al., 1983; Haley et al., 1985; Gaynes et al., 2001). There is also, as a rule, an inference that because the HAO incidence is small compared to endemic HAIs, the focus of surveillance programmes should be on endemic infections (Haley et al., 1985; Gaynes et al., 2001). We reviewed these studies and will show they lack validity due to low sensitivity to detect outbreaks and because they pre-date both advanced healthcare systems and the emergence of current nosocomial pathogen challenges. The answer to the question therefore is that, as it has never been precisely measured, the actual proportion is at present unknown.

As the relied on papers were themselves unreliable, we undertook four further investigations, to explore:

- The capability of national surveillance systems to detect HAOs
- The IPCT work on outbreak prevention, preparedness, detection and management (HAO: PPDM)
- How the HAO challenge has and is evolving over time
- The potential consequences of directing IPCT work to HAI that are counted at the expense of work that is needed to prevent HAO.

To begin, a review of the papers which estimate the proportion of HAI which present as HAOs.

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Studies that estimate the proportion of HAI that are HAO

Our first example is by Wenzel, et al (1983) who evaluated the proportion of HAI that present as HAO. There were four frequently cited papers which stated that HAO accounted for 1–10% of HAI (Stamm et al., 1981; Wenzel et al., 1983; Haley et al., 1985; Gaynes et al., 2001). Wenzel et al. (1983) evaluated 5 years of surveillance data (1978–1982) and identified 11 HAO, of which 10 occurred in critical care units (sensitivity for detecting infections was 69%). The methodology was heavily ICU focused which may explain the findings (Wenzel et al., 1983).

‘Outbreaks comprise 2% (1–5%) of all nosocomial infections’

Haley et al. (1985) set out to identify outbreaks of nosocomial infection in seven US community hospitals over a 12-month period 1972–1973 using a computerised algorithm. In single month periods the computer algorithm looked for clusters of patients with the same site of infection and the same pathogen. Eight outbreaks were confirmed of which five had been identified by the hospitals. Thus HAOs were found to comprise 2% of all HAI with an estimated range of 1–5% (Haley et al., 1985). The authors note limitations with their study: the surveillance system was only 70% sensitive; the system could not detect outbreaks due to viruses and identification of small clusters might have been missed. This study also took place at a time when there was a let-up in what can be described as nosocomial infection hostilities. The early devastating outbreaks caused by sensitive *Staphylococcus aureus*, from which infection control as a service evolved were over (Curran, 2014a); and yet to materialise were the effects of meticillin resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile* infections (CDI) and risks/infections associated with advancing medicine.

The conclusion from this study is, however, still apt today. Aware of the importance of surveillance but also mindful that HAO can arise and devastate patients and the healthcare systems, the authors state: ‘Thus the ideal surveillance programme should be primarily oriented toward the ongoing monitoring and prevention of endemic infections. At the same time however: “sensitive surveillance systems should be maintained to identify [HA] outbreaks and sufficient time must be reserved to mount a sufficiently rapid and competent investigation to control them expeditiously when they occur.’ (Haley et al., 1985, p. 236).

Outbreaks comprise 5–10% of nosocomial infections

In a paper detailing the Centers for Disease Control and Prevention’s (CDC) National Nosocomial Infection

Surveillance (NNIS) system, reference is made to work which shows that ‘Similarly only 5–10% of hospital acquired infections occur in recognized outbreaks’ (Gaynes et al., 2001, p. 295). To support the statement, this influential paper (244 Google citations), provides two references. The first reference appears to be related to statements made earlier in the paragraph as it refers to the famous *Out of the Crisis* book by W. E. Deming: this excellent industrial quality improvement text is not about infection control or outbreaks. The second reference is to a paper comparing endemic and epidemic infections by Stamm et al. (1981).

The Stamm et al. (1981) paper compared 252 US outbreaks (1956–1979) which were referred to the CDC for assistance with control, with NNIS data collected from (1975–1978). The outbreak data were, as the authors state, a unique and non-random sample of US outbreaks. At no point in the Stamm et al. (1981) paper is there reference to a proportion of nosocomial infections that occur as outbreaks. Stamm et al. (1981) state ‘*At present the relative proportion of all HAI that occur as part of an epidemic or cluster remains uncertain*’. There is no NNIS denominator provided by Stamm et al. (1981), therefore it is difficult to see what Gaynes et al. (2001) used to make their calculation. The Gaynes et al. (2001) paper is not that old (14 years at the time of writing); however, the data from which the assertion that outbreaks ‘*account for a small proportion of preventable infections*’ is (Stamm et al., 1981). HAO risks arising from healthcare systems (1956–1979) are different to the HAO risks and pathogens that occurred since 1985.

To determine whether the Gaynes et al. (2001) mistake had been repeated, relevant public health databases (CINHAL, OVID Medline and Embase) were searched for articles citing either Gaynes et al. (2001) or Stamm et al. (1981). This was not an exhaustive search; however, Stamm et al. (1981) was cited in several papers, textbooks and presentations as the original source of ‘less than 10% of HAI are caused by epidemics’ (or variations thereof). Others too have identified statistics that are absent in the Stamm et al. (1981) work; one paper found epidemics comprising 10% and another 5% of all nosocomial infections respectively (Jenner et al., 1999).

The incorrect citation in the Gaynes et al. (2001) paper has likely shaped current perceptions of the importance of HAO. It seems highly unlikely that so many sources could misinterpret the same paper. What is more likely is that careless duplication of references took place. In fact, Gaynes et al. (2001) was incorrectly cited at least three times as the original source for the ‘10%’ claim. In summary, the influential work by Gaynes et al. (2001) refers to old data from which evidence to support their inference is missing. Having described accepted estimates of HAO as invalid, the capability of national surveillance systems to detect HAO was then explored.

Can existing national surveillance systems detect outbreaks?

Most national HAI surveillance systems took the lead from the CDC and mirrored their development with a focus at least initially on surgical site infections (SSI). For example, the 2013/14 SSI report for England details outcome results of 133,427 operations by 17 different surgical categories (Public Health England, 2014). This is a standard industrial quality improvement approach to the binomial outcome of infection or non-infection for each performed procedure (Benneyan, 1998a; Benneyan, 1998b). At a national level data are examined for variations between institutions as well as within institutions, and over time. Effective quality improvement necessitates that assessments are made following the addition of each new data point, with investigations and actions taken should an indication of unnatural variation arise (Curran et al., 2002). The responsibility for this intervention lies with the local IPCT. National SSI surveillance, which is evidently extremely useful for identifying outliers and benchmarking, is not capable of detecting HAO in real time.

In addition to national surveillance of SSI, HAI point prevalence surveys (PPS) are performed periodically. Data derived from PPS are used to direct international, national and then local IPCT activity. The first stated objective of the European Centers for Disease Control (ECDC's) PPS is as follows:

- To estimate the total burden (prevalence) of HAI and antimicrobial use in acute care hospitals in the EU (ECDC, 2013, p. 16).

For this objective to be met, the process must count – as far as is possible – all the infections that are present in health-care settings on a given day. Although the PPS looks to identify HAIs by category, there is no attempt to determine if any of the HAIs are related to each other, i.e. there is no objective to detect outbreaks. One of the commonest types of HAO are caused by norovirus (Kambhampati et al., 2015); however, the ECDC definition for (gastroenteritis [excluding CDI]), includes a fever of >38°C (which is not a consistent feature of norovirus gastroenteritis) and a positive sample (ECDC, 2012) p(56). There is little surprise therefore that norovirus accounted for just three (0.3%) of all identified GI pathogens (ECDC, 2013, p. 43). As an example of what HAOs are missing, one large NHS board in Scotland identified for a 23-month period a total of 2331 norovirus cases and 192 unit outbreaks (Danial et al., 2011). One further limitation of PPS is the assessment that the burden on any given day will be roughly similar; this is untrue for winter pathogens which have HAO potential such as norovirus and influenza. No cases of influenza were identified in the ECDC's PPS report (ECDC, 2013).

For all the limitations of PPS acknowledged by ECDC the first recommendation by which surveillance is to be improved is by repeating PPS. There is a recommendation

to 'support the timely detection of new epidemics with alert organisms' (ECDC, 2013, p. 111). Overall there is limited talk of epidemics; and epidemic surveillance is not discussed. A key limitation is recognising that an estimate of HAI burden comprises much more than what is prevalent; recognition is needed of the requirements that keep HAI and HAO data low. For the first time, ECDC included three new and readily available markers of 'infection control structure and process indicators', i.e. alcohol-based hand rub consumption, single room provision and IPCNs were provided. What might have been more useful is to extract other markers, that also should be readily available, e.g. number of new alert organisms and alert conditions by unit specialty per annum and the number of unit-based outbreaks of alert organisms and alert conditions (including norovirus and influenza).

There are other surveillance systems that focus on infections in specific populations, such as intensive care units (HPS, 2014). These systems again focus on the countable and not the totality of the challenge. National norovirus surveillance systems have been established (HPS, 2015; Public Health England, 2015). Novel national outbreak surveillance systems are emerging. Surveillance of HAO in Germany is now mandatory and the first data have been published (Haller et al., 2014); in 1 year to November 2012, 578 outbreaks were reported. The authors argue that such surveillance will enable greater intelligence for further preventative work (Haller et al., 2014). Exciting though this work is, there are two key issues with such HAO surveillance: (1) ensuring completeness of the data; and (2) potential diversion of resource, i.e. if IPCTs are redirected to counting and reporting HAOs, their capability for HAO: PPDM will be compromised. With regard to completeness of national mandatory surveillance, one team in Brazil investigated the effectiveness of their system and found that only 15/87 (17%) of HAO had been officially reported (other HAOs were identified from literature searches and conference papers) (Maciel et al., 2014).

So at present, existing national SSI and PPS surveillance systems are not designed to detect HAOs. The attempts by ECDC to estimate the 'total burden of HAI' by counting that which is prevalent, largely omit the commonest HAO pathogens (norovirus and influenza). These surveillance systems are complemented by national alert organism surveillance which emerged in response to perceived public health crises.

When the HAO challenge exceeds the IPCTs' ability to control: MRSA and CDI

The emergence of MRSA and CDI from the mid-1990s onwards evolved as an ever-increasing number of reports in voluntary surveillance systems which eventually became visible to all. It has been argued that when hazards and dangers become recognised beyond society's conception of

security, there follows a ‘redefining of previously attained standards (of responsibility, safety, control, damage limitation and distribution of the consequences of loss)’ (Beck, 2002). Society’s conceptions of security were exceeded by MRSA outbreaks by the early 2000s. The redefinition came from Sir John Reid, then Secretary of State for Health who declared in 2004: ‘I expect MRSA blood stream infection rates to be halved in our hospitals by 2008’ (Reid, 2004). Outbreaks of CDI provided another such ‘society exceedence’; this was not just related to the number of infections and outbreaks but also, it could be argued, to the management of the outbreaks themselves as presented in enquiry reports that were subsequently showcased by the media (Healthcare Commission, 2007). Thus began a national focus on quarterly rates published by Health Protection Scotland (HPS) and the Health Protection Agency (HPA).

Although these rates have fallen, the infections have not been eliminated; they are being managed. At the time of the political interventions there was no doubt that the MRSA and CDI problem was largely arising inside the hospital and because of what was going on (and not going on) therein, in part due to competing priorities that conflicted with optimal IPC (Healthcare Commission, 2007). Today, however, for CDI there is debate about the origin of the significant proportions of the remaining infections (Khanna et al, 2012; Leffler and Lamont, 2012; Gupta and Khanna, 2014).

Whatever the origin of the residual infections, patients with these pathogens still present an ongoing HAI and HAO risk to others. Although national surveillance of these organisms continues to provide critical information on trends, and identifies differences between reporting centres, overall it is a crude and unhelpful tool with which to detect outbreaks. For all the national data on the increasing MRSA and CDI in 1990s to mid-2000s, actual outbreak incidence data at this time was sparse. Even though today MRSA and CDI might not be such a ubiquitous indicator of IPC practices, politicians will be reluctant to stop or reduce monitoring / targets. A public that has had its conception of security exceeded by such pathogens is unlikely to allow it. So in addition to work on pathogens of perhaps reducing nosocomial importance (MRSA and CDI), the IPCT and national surveillance systems need to be mindful of, and working towards, detecting and preventing any new emerging pathogens from ‘exceeding society’s conception of safety’.

IPCT activity to prevent, prepare for and detect outbreaks

It has been shown that the ingredients for an HAO are present in every clinical setting every day (Curran, 2013). People are colonised with micro-organisms, which survive happily in care environments and healthcare procedures (invasive and non-invasive) provide ‘ways in’ for exogenous pathogens and the translocation of endogenous organisms.

The number of alert organisms (AO) and communicable diseases (CD) which have HAO potential is legion and

includes much more than the national alert infections of CDI and MRSA. The actions required following the identification of a patient with any AO/CD are reported by Health Protection Scotland (HPS Infection Control Team, 2014), i.e. collect relevant data from the computer, confirm if the patient is still an inpatient, visit the clinical area to advise the clinical team on the precautions required to prevent onward transmission, confirm that precautions are in place, identify if any cross-transmission/exposure has already occurred, identify if the AO/CD was acquired within the care setting, identify where likely transmission took place, determine if there is an outbreak and if there is take specified actions. Of note this work is required on the basis of the isolation of an alert organism regardless of the presence of an infection. Despite the number of different AO/CD there is at present only local quantification of this surveillance work.

The ECDC’s objective of determining ‘total burden of HAI’ via prevalence of HAI is missing a considerable amount of IPCT’s local HAI burden, i.e. patients who are colonised with alert organisms, e.g. MRSA, carbapenase-producing enterobacteriaceae (CPE), or patients with a community infection which has HAI or HAO potential, e.g. patients with smear positive tuberculosis, or invasive Group A Strep disease. More importantly patients can have significant community infections which present a major HAI risk, e.g. MERS-CoV or avian influenza. These alert organisms and conditions place a huge burden on hospitals and their IPCTs who expend strenuous efforts trying to prevent HAIs and HAOs arising – even if the source patients do not have an existing HAI. Patients with these AO/CD present outbreak-provoking conditions.

One key problem in HAO detection is this: in the absence of unique or distinguishing characteristic, determining whether organisms causing infection were endogenous or exogenous in origin. Detection of all HAO is at present still not possible (Bukhari et al., 1993; Sukhrie et al., 2011). Recent outbreaks of CPE involving endoscopes could be indicating a new deterioration in decontamination processes. However, they could also be revealing that outbreaks involving endoscopy-related Gram-negative organisms have always been present but thus far avoided detection as they lacked a unique resistance pattern to serve as a marker of cross-transmission (Kola et al., 2015; Muscarella, 2014).

Outputs from local surveillance also provide other assessments of local HAI burden, e.g. the ability of the organisation to prevent HAO by having available sufficient isolation facilities. Failures to isolate patients with AO/CD also present outbreak-provoking conditions. Local surveillance data provide local epidemiology and can be effectively used, for both quality improvement work and care evaluation (HPS Infection Control Team, 2014, p. 11).

Even if HAOs are small in number, the IPCTs’ efforts needed to keep them small and prevent them altogether can be disproportionate. For example, consider a single case of

nosocomial BBV transmission. The IPCT will be required to undertake: in-depth investigations of possible transmission pathways, observe healthcare practices, attend meetings, interview healthcare workers (HCW), explain the situation to patients and families, advise on system redesign, plan and execute re-training, and of course documenting everything. Therefore small outbreaks can present an immense HAI IPCT burden. Huge IPCT efforts are also required for HAO preparedness. Consider the recent IPCT-led work on Ebola preparedness; it was (and is) necessary for HCWs in every care setting to be prepared and able to identify and care for a possible Ebola case.

The HAO risk increases – all the time

The latest PPS data show that HAIs now have a lower prevalence (Reilly et al., 2012); however, a list of continuous as well as novel and emerging pathogens from the past 40 years; clearly demonstrating that the number of new HAO challenges has and continues to increase (Table 1). Local IPCTs have absorbed these challenges and continuously manage the risks within their organisations. For the efforts of all HCWs no HAI category has been eliminated – yet the list of AO/CD continues to grow. Experience over the past 40 years would suggest that the proportion of HAIs that present as HAOs is not static and reflects the risks associated with the healthcare interventions of the time. Consider the sensitive *Staph aureus* outbreaks of the 1960s, the quiet 1970s and 1980s which were followed by MRSA and CDI challenges thereafter. HAO risks evolve as healthcare and the locations in which it is performed also evolve (Richards and Jarvis, 1999), e.g. one of the commonest location for a *S. aureus* outbreak arising since is now outpatient settings (Curran, 2014b). This factor alone provides an argument for ongoing national HAO surveillance.

Comments and conclusion

A simple question of what proportion of HAI present as HAO has led to revelations regarding perceived HAO risks and the unseen, underestimated and undervalued work of IPCTs in HAO: PPDM. National surveillance systems do not control infection; but they do create the arguments for control activity. As such, estimates of HAI burden should include HAOs and IPCT work to minimise both HAI and HAO risk. There is often discussion about what proportion of HAI is preventable – a precursor to this question should be: what proportion of HAIs (and HAOs) are currently detected?

Surveillance systems which count HAI are both costly and imperfect (it takes an average 12 days per hospital to count PPS data (ECDC, 2013, p. 11)); for the 1149 participating hospitals this equates to an estimated 13,788 working days. There is always a compromise of consistency and

accuracy and for epidemiology the later takes precedence. Yet for all its limitations without such PPS data the visibility of HAI (if not the problem) would disappear. Existing national surveillance systems provide pieces of the HAI burden jigsaw – but not the entirety of it. What this paper has identified is that current estimates of HAI burden omit that which is needed to keep HAI and HAO low. Perhaps a first step is a wider problem definition of HAI burden. It should be further recognised that it is not possible to have good national and international data without first having good local surveillance data.

Estimating the HAI burden by only counting selected infections is like measuring ill-health by counting the patients in hospitals and omitting the ill-health of people in the community. By focusing on the numbers of HAI present via PPS negates the IPCTs' HAI burden arising from patients with AO/CD and thus the importance of actions needed to keep low HAI and HAO risks. None of the existing national surveillance systems are designed to count (all) HAO and most completely omit HAO altogether. Bias arises on two fronts: infections that can be counted have a 'feature-positive effect' on the estimation HAI burden (Dobelli, 2013, ch. 95). And the inability to see HAOs and the impact of the outbreak prevention activity is exerting the availability heuristic bias of 'what you see is all there is' (WYSIATI) (Kahneman, 2011, p. 85). The danger of these biases in estimation of HAI burden reporting is that three potential erroneous assumptions of reality could arise:

If what you see is all there is, and you are not seeing it, it's not happening and the resource can be deployed elsewhere.

If the HAI burden is what can be counted then this is where IPCTs should spend their prevention time.

As HAOs are small in number the problem itself, and that needed to manage it, must also be small.

The above assumptions have been shown in this column to be erroneous; mainly because they negate the work of the IPCT in HAO: PPDM and because there is no system at present for accurately counting HAO that arise.

In summary we have shown:

- There are no current valid estimates of the proportion of HAI that present as HAO
- Existing PPS, and many other national surveillance systems, are not designed to detect HAO
- Current estimates of HAI burden reflect HAI which is counted but omit the work undertaken to prevent HAO, i.e. the total HAI burden
- Critical IPCT work on HAO prevention and preparedness is currently unseen, underestimated and undervalued

Table 1. Continuous, novel and emerging organisms with HAO potential.

Continuous risks	Novel and emerging risks (sensitive)	Emerging antibiotic resistant organisms
Tuberculosis	Legionnaires' disease	Meticillin resistant <i>S. aureus</i>
<i>Streptococcus pyogenes</i>	Norovirus	Vancomycin resistant <i>S. aureus</i>
<i>Staphylococcus aureus</i>	<i>Clostridium difficile</i>	<i>Strep pneumonia</i> (penicillin resistant)
Influenza (seasonal)	Human Immunodeficiency Virus	Drug-resistant Gram-negative organisms
Chickenpox	Hepatitis B	Carbapenemase-producing enterobacteriaceae
Other childhood viruses	Hepatitis C	Carbapenemase-producing non-enterobacteriaceae
<i>Salmonella</i> spp	Hepatitis E	Tuberculosis: multi-drug resistant
<i>N. meningitidis</i>	Coagulase negative staphylococci	Vancomycin resistant enterococci
Gram-negative organisms (sensitive)	(Variant) Crutzfeldt Jacob Disease	
Conjunctivitis (viruses)	Fungal infections	
	Respiratory syncytial virus	
Continuous outbreak risks	Influenza (pandemic)	
Shared contaminated equipment	<i>Pseudomonas</i> (in water augmented care)	
Shared contaminated environment	<i>Acinetobacter</i> spp	
Food poisoning	Other non-enterobacteriaceae Listeriosis Bio-terrorism risks Non-TB <i>Mycobacteria</i> spp Severe acute respiratory syndrome Viral haemorrhagic fevers (Ebola) Middle-East Respiratory Syndrome Corona Virus (MERS CoV) Adenovirus HAdV C	

- If IPCTs are redirected to counting and reporting HAOs, their capability for HAO: PPDM will as a consequence be compromised
- That over time HAI and HAO risks evolve; new risks arise in addition to, but never in replacement of, existing challenges; ergo the HAI and HAO challenge – unlike PPS estimates of HAI burden – is actually increasing.

We argue that any HAI burden estimate needs to be comprised of a more complete HAI summary than PPS data. This can only be done with a more inclusive surveillance system with a wider focus than infections that are present. There is a real risk of redirection of the IPCT resource from outbreak prevention and preparedness work towards HAI that are counted. The IPCTs' HAO: PPDM work must be recognised, estimated and protected. Failure to do so will increase the risk of HAOs.

So what should happen next? The first part of good strategy development includes an accurate statement of the problem / situation. Therefore, a paper detailing (and succinctly summarising) the current HAI burden in its totality should be commissioned. In the interim, a greater recognition is needed that there is more to HAI than which can be seen or counted.

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