

ORIGINAL ARTICLE

The financial impact of improved hand hygiene on healthcare-associated infections in the UK

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ABSTRACT

Background: Though high hand hygiene (HH) levels significantly reduce the risk of healthcare-associated infections (HCAs), the current cost of HCAs and the impact of optimal HH practices on HCAs are poorly defined. The last NHS England financial assessment was in 2009.

Methods: The number of HCAs per bed per year for NHS England were calculated and average costs were attributed using data from three sources; National Audit Office report, a commercially available calculator, and a financial analysis by a specialist paediatric hospital in England. Improved HH compliance for NHS England was based on a sustained rise in compliance rates from 50 to 80% combined with an HCAI reduction of at least 20%. The cost savings based on such improvements were then calculated.

Results: In 2020, it is estimated that the number of HCAs per bed per year ranges from 3.0 to 9.3, with a midpoint of 5.1. The direct costs of HCAI to NHS England were found to lie between £1.6 and £5 billion. Based on a 20% reduction in HCAI rates, this could lead to cost savings of between £322 million and £1 billion per year.

Conclusion: Current direct costs of HCAs consume approximately 1.3% to 4.1% of NHS England's annual budget. Improving HH compliance among healthcare workers can lead to significant cost savings. There appears to be a strong financial argument for investment into innovative HH compliance technologies that have been historically perceived as too expensive.

KEYWORDS

Healthcare-associated infections; hand hygiene; financial analysis

INTRODUCTION

Healthcare-associated infections (HCAs) caused by methicillin-resistant *Staphylococcus aureus* (MRSA) and *Clostridioides difficile* (*C.difficile*) directly contributed to 9,000 deaths in the National Health Service (NHS) in 2007 [1]. In Canada, more recent data from 2013 shows that HCAs were responsible for 8,000 deaths in 2013 [2]. More than 50% of HCAs are considered to be preventable [3]. Hence, as every healthcare system has finite resources, it is vital to understand

the financial implications of HCAs in order to adequately allocate resources for prevention and intervention. Investment in combating HCAs means that resources will be redirected away from other competing healthcare needs. It is therefore essential that economic arguments are clearly put forward.

A financial review of HCAs in NHS England has not been published since 2009 [4]. The last national HCAI prevalence study in 2011 for NHS England found a prevalence of 6.4%, comparable to an earlier figure of 8.2% in 2006 [5]. It is

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therefore likely that the prevalence of HCAs was within this range when the National Audit Office (NAO) report was published in 2009. It is, however, reasonable to assume that HCAI costs have risen. In 2009, these costs were found to be over £1 billion a year for NHS England [4]. For comparison, a similar US review in the same year suggested HCAI costs of between \$28 billion and \$45 billion per year [6].

Though good HH compliance is one of the most influential factors in preventing HCAs, its quantitative contribution to HCAI reduction has been poorly described [7]. HH compliance in the healthcare environment is an ongoing challenge for Infection Prevention and Control (IPC) teams, with monitoring of staff compliance being time consuming, labour intensive and methodologically flawed [8]. Innovative technologies to improve HH compliance could be the key to prevent at least some HCAs. However, without a clear understanding of the costs of HCAs, it is impossible to make an economic argument to invest in such technologies. We, therefore, present an analysis of the current financial impact of HCAs in NHS England and assess the financial significance of sustained improved hand hygiene compliance rates on HCAI reduction.

METHODS

HCAs per bed per year

The number of acute non-specialist and specialist trusts in NHS England were identified from data held by the NHS Confederation [9]. The current number of general acute hospital beds in NHS England was obtained from the latest report by the Kings Fund [10]. The average number of general acute hospital beds per trust was then determined.

The average annual number of HCAs per hospital bed per year was determined from a number of sources; the NAO report from 2009 [4], a commercially available calculator 'Surewash' [11], and NHS Digital data from 2018-2019 [12]. Data was retrieved from the commercially available calculator in 2018 prior to being archived on the provider's website. Using NHS digital data, HCAs per bed per year were estimated by comparing Finished Admission Episodes (FAE) [12] with the most current HCAI prevalence reports from Europe [13], England [5] and Scotland [14]. FAEs are periods of inpatient care under one consultant in one provider [12].

For the purpose of this study, HCAs were defined according to the protocol used by the Health Protection Agency in the most recent survey of inpatients in England [5].

The term HCAI covers a wide range of infections. The most well-known include those caused by MRSA, *C.difficile* and *Escherichia coli*. Though key data are not available for all HCAs, the five with the highest impact on healthcare systems are considered to be surgical site infections (SSIs), central line-associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), ventilator-associated pneumonia and *C.difficile* infection (CDI) [3]. These types of HCAs are the ones considered in this financial analysis.

The annual average number of HCAs per bed were calculated both at an individual trust level and for NHS England as a whole.

Financial cost of HCAs

The annual financial burden of HCAI costs to NHS England was determined by calculating and then combining three key variables: the average cost of an HCAI, the annual number of HCAs per bed for a hospital trust and the average number of total hospital beds for an NHS trust.

Average cost of an HCAI was estimated from three independent and valid sources; the NAO report [4], a commercially available calculator 'Surewash' based on US HCAI data [11] and a local calculation of average HCAI cost, undertaken by Alder Hey Children's NHS Foundation Trust finance department (AHFT), following national costing guidance.

Variables considered in the NAO costings were nursing care, hospital overheads, medical time, investigations, consumables, and drugs [15]. The commercially available calculator used an algorithm not visible to the end user [11]. The AHFT cost calculation used the national Patient Level and Costing System (PCLIS) methodology [16]. This included an average increased length of hospital stay of at least seven days to determine the minimum average HCAI cost. NHS England has previously stated that inpatient stay may be extended by at least eight days as a result of an HCAI [17]. To illustrate individual HCAI costs, using a Patient Level Information and Costing System (PLICS), AHFT also calculated the financial cost of two specific HCAs based on 2019/20 surveillance data submitted to Public Health England: CLABSIs due to *S. aureus* and CDIs. AHFT did this by extracting the actual costs of each individual patient from the trust's local PLICS database.

Average annual cost of HCAs per trust were calculated by combining the average cost of an HCAI with the average number of HCAs per bed per year and the average number of beds per trust.

Annual HCAI costs for NHS England were determined by combining the average cost of an HCAI with the number of HCAs per bed per year and the total number of beds within NHS England.

Impact of sustained HH compliance improvement on HCAI rates.

For the purposes of financial modelling, current HH compliance rates in NHS England were assumed to be 50% at best, if assessed by independent auditors [18]. A realistic and sustainable improvement goal was set at 80% HH compliance. This was based on a Swiss multicentre analysis published in 2017 [19].

A recent report suggests that for every 10% improvement in HH compliance, this correlates with a 6% reduction in HCAI rates [7]. An historical review from 1995 estimated that good HH compliance (63 – 90%) can lead to at least a 50% reduction in HCAs [20]. With all these sources considered, this financial model assumes that improving HH compliance from 50% to 80% leads to at least a 20% overall reduction in rates of HCAI.

The average annual costs of HCAs to an individual trust and to NHS England were used to establish cost savings when there is a 20% reduction in HCAI rate.

RESULTS

Number of beds in an NHS England hospital

Within NHS England, there are currently 135 acute non-specialist trusts and 17 acute specialist trusts giving a total of 152 acute trusts [9]. For 2019-20, NHS England had 101, 255 general and acute beds [10]. Bed occupancy for 2019/20 was estimated to be 90.2%. However, the true level of hospital bed use was even higher than this figure as it regularly exceeds 95% in winter [10]. For the purposes of the financial analysis, the average number of beds per acute trust was estimated at 666 (101,255/152).

Average number of HCAs per bed per year

The average number of HCAs per NHS England general/acute bed per year was estimated from a variety of sources. The 2009 NAO report estimated that there were at least 300,000 HCAs per year [4]. If it is assumed that in 2020 the HCAI number remains unchanged, the average annual number of HCAs per trust would be 1,974 (300,000/152). In 2009, the figure for total general and acute beds in NHS England was 122,538, which would indicate that the number of annual HCAs per bed in 2009 was 2.4 (300,000/122,538). If it is assumed that the overall number of HCAs per year has not altered significantly since the NAO report, this figure would rise to 3.0 (300,000/101,255) in 2020.

Based on a hospital with 666 beds, the commercially available calculator [11] estimated 3,386 HCAs per year. This gives an annual per bed HCAI rate of 5.1 (3,386/666).

For 2018/19, NHS Digital identified 17.1 million FAEs [12]. HCAI prevalence rates from Europe [13] and England [5] in 2011, and Scotland in 2016 [14] were 5.7%, 6.4% and 4.5% respectively. Assuming the current HCAI prevalence in NHS England is an average of these rates (5.5%), the number of HCAs per year was estimated to be 940,500 (5.5% of 17.1m) for NHS England. This equates to 9.3 HCAs per bed per year (940,500/101,255).

The average number of HCAs per bed per year in NHS England may be in the range of 3.0 to 9.3.

Financial cost of HCAs

Using the NAO report, the cost of each HCAI was approximately £3,333 (£1billion/300,000) at that time [4]. Assuming an average annual inflation rate of 2% between 2009 and 2020, this figure would rise to £4,125 per HCAI.

The commercially available calculator produced a cost of US\$ 25 million for 3,386 HCAs (US\$ 7,383 per HCAI or £5,687 per HCAI) [11].

AHFT average costs were similar at £5,300 per HCAI. The average HCAI costs for CLABSI and CDI at AH were approximately £27,000 and £8,600 respectively. For the purposes of the economic calculation £5,300 was chosen as the average cost of an HCAI due to being a mid-scale figure. The average direct costs for HCAI per trust and for NHS England are shown in Table 1.

Impact of improved HH compliance on HCAI costs per bed

Assuming that HH compliance is improved from 50% to 80%, HCAI rates would see a 20% reduction. Table 2 shows the average

TABLE 1: Average direct costs for HCAI per trust and for NHS England as a whole, using a range of HCAs per bed. Average cost of an HCAI is £5,300.

HCAs per bed per year	HCAs per average 666-bed trust per year	Average annual HCAI cost per trust per year (£)*	Average annual HCAI cost for NHS England per year (£)**
3.0	1,998	10.6 million	1.6 (CA\$ 2.7) billion
5.1	3,397	18.0 million	2.7 (CA\$ 4.6) billion
9.3	6,194	32.8 million	5.0 (CA\$ 8.5) billion

*Number of beds in an average trust is 666.

**Number of beds in NHS England in 2020 is 101,255.

TABLE 2: Average cost saving per trust and for NHS England when hand hygiene compliance is 80%, leading to a 20% reduction in HCAI. Table provides estimates using a range of HCAs per bed. Average cost of an HCAI is £5,300.

HCAs per bed per year with 50% HH compliance	HCAs per bed per year with 80% HH compliance	Difference in HCAs per bed per year from 50 to 80% HH compliance	Average annual cost saving per trust per year (£)*	Average annual cost saving for NHS England per year (£)**
3.0	2.4	0.6	2.1 million	322 (CA\$ 564) million
5.1	4.1	1	3.5 million	537 (CA\$ 912) million
9.3	7.4	1.9	6.7 million	1.0 (CA\$ 1.7) billion

*Number of beds in an average trust is 666.

**Number of beds in NHS England in 2020 is 101,255.

annual cost saving for a trust and for NHS England as a whole with improved HH compliance.

DISCUSSION

Our analysis found that the total annual cost of HCAI to NHS England in 2020 is likely between £1.6 billion and £5 billion. Total NHS England commissioning budget for 2019/20 was £121 billion, thus the cost of HCAI represents roughly 1.3% to 4.1% of the total budget [21]. For context and comparison, the total budget allocated to General Practice in the same period was £8.8 billion (7.2% of total budget) [21].

The costs we identified are deliberately prudent and are likely an underestimate of the real costs to NHS England. For example, the number of HCAs (300,000 annually) was originally reported in 2000, which, at the time, was highlighted to be conservative [22]. Graves *et al.* reported that HCAI costs have a tendency to be overestimated, which can be problematic when cost savings are not realized following implementation of IPC interventions [23]. It is therefore better to underestimate costs, rather than overestimate, so resources are not unintentionally directed away from other areas within the health economy.

Our analysis provides a proposal for the current financial burden of HCAs in NHS England. With relevant financial costs for 2020, a strategy for reducing this burden must be explored. The first step is to break down which HCAs contribute most to this cost. A study by Zimlichman *et al.* demonstrated that surgical site infections (SSIs) contribute most (33.7%) to the overall frequency and cost of HCAs, although these types of infections are not well tracked due to their diversity, use of day surgery, early discharge of patients, combined with lack of coordinated follow up [3]. However, from an HCAI cost-per-case basis, CLABSI are the most costly HCAs. Our analysis confirms this. The average CLABSI costs £27,000, which is five times higher than the average HCAI cost used in this analysis. CLABSI due to *S.aureus* and CDIs are arguably the most well tracked as they are included in the Public Health England mandatory reporting scheme for acute trusts. Currently these avoidable costs are simply incorporated into trusts' ongoing revenue costs. Using our proposed financial model, healthcare organizations can attribute costs to their HCAI data, allowing clearer sight of this significant financial burden. In the UK, PLICS has recently replaced reference costs as the official NHS cost collection methodology. The PLICS portal gives hospital trusts the ability to analyze and compare their own costs against those of all healthcare providers [16].

Though there are many factors that may reduce HCAs, effective HH is considered the most important way to prevent pathogen transmission in healthcare settings. However, maintaining high levels of HH compliance remains challenging and is often difficult to measure.

Our financial model of sustained HH compliance linked to HCAI reduction was based on a prolonged rise in compliance rates from 50% to 80% associated with a HCAI reduction rate of at least 20%. Though demanding, we believe that such targets are achievable. Using a multimodal strategy to improve and sustain HH compliance, Staines *et al.* were able to achieve

an improvement from 61.9% to 88.3% over 18 months across five participating hospitals, which was sustained at 88.9% 12 months after the intervention concluded [19]. Furthermore, Sickbert-Bennett *et al.* have demonstrated that an improvement in HH compliance from a high baseline level (>80%) to an even higher level (>95%) can lead to further hospital-wide decreases in HCAs [7].

Innovative HH monitoring technologies have been developed to improve surveillance of HH compliance with a goal to reduce HCAI rates. A reduction in HCAs, specifically CDI [24], CAUTI and CLABSI [25] and MRSA infection [26], has been reported with the introduction of an automated HH monitoring system (AHHMS) when combined with an organization's existing HH campaign strategy. However, simply introducing an AHHMS is not a panacea for hand hygiene improvement. Nevertheless, they do provide robust data, which can be used to drive improvements in patient safety if coupled with effective interventions to affect behaviour change. Such a multimodal strategy should include complementary activities such as goal setting, reward incentives and accountability [27].

A targeted MRSA focused HH campaign demonstrated cost savings of \$1.2 million and \$2.5 million Canadian (£699,000 – £1.45million) annually at the hospital level [28]. Developing this further, our analysis showed that when there is a 20% reduction of all types of HCAs, this can lead to savings in the region of £2.1 million to £6.7 million for each hospital trust. Though HH monitoring systems are perceived as costly, there does appear to be a strong financial argument for their implementation. Our commercial review of such systems shows that prices range from \$460 – 650 (£365 – 527) per bed per year [29], or £243,000 to £351,000 per 666 bed trust. Providing their ability to sustain a reduction in HCAs is well evidenced it makes economic sense to invest in such technologies.

Our study has some limitations. Concerns have been raised about the validity of previously applied methods used to determine the cost of an HCAI [23]. Our financial model has therefore been deliberately cautious, potentially causing our cost estimates to be overly conservative. Similarly, though the World Health Organisation estimates that HH could reduce HCAs by between 30 to 70% [30], our model has been set at the very low end of the range. This may result in an underestimate of the cost savings involved. National HCAI prevalence studies occur infrequently. The current HCAI prevalence within NHS England is not known, though we have tried to address this point by pooling the results of three relevant prevalence reports. There is not a comprehensive national HCAI surveillance programme in NHS England to capture the prevalence and costs of all five key HCAs considered in this study. In the US, SSIs and CDI have been estimated to be the most frequent HCAs nationwide, with SSIs contributing most to overall costs (33.7% of the total) [3]. Though few studies have examined the total economic burden of SSIs, one from the UK estimated the mean additional cost attributable to SSIs at £5,239 [31]. Our economic calculation

of an average HCAI cost at £5,300 may again suggest that our financial estimate may be conservative.

In summary, our analysis provides an up-to-date financial model for healthcare organizations to estimate the local financial burden from HCAIs. The quality of published economic evaluations on HCAI interventions is, at best, moderate [28]. Ongoing research is therefore needed to assist IPC teams in making evidence-based decisions on which HCAI prevention strategies to invest in.

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