# Healthcare-associated infections: where we came from and where we are headed

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Healthcare-associated infections (HCAIs) are those infections acquired by an individual who is seeking medical care in any healthcare facility, including acute care hospitals, long-term care facilities (including nursing homes), outpatient surgical centres, dialysis centres or ambulatory care clinics.[1] They are further defined as occurring at least 48 hours after hospitalisation or within 30 days of receiving medical care.[2] HCAIs have plagued hospitals, physicians and patients for centuries and likely played a role in the reputation that hospitals historically had as dangerous places.[3] In the mid-19th century, Ignaz Semmelweis observed that labouring mothers in an obstetrics unit had a high incidence of Puerperal (Childbed) fever, which he thought was related to direct contact with medical students. After working with cadavers, students often moved directly from the anatomy lab to the hospital, leading Semmelweis to postulate that students were contaminated and bringing a pathogen into the unit. He saw dramatic improvements in maternal mortality after introducing a chlorinated lime hand wash for healthcare providers.[4] Though not quickly accepted at large, his observations would become part of the foundation of the germ theory that we intuitively accept today.

Over a century after Semmelweis introduced the idea of hand hygiene, infection prevention in healthcare settings has been thrust into the spotlight worldwide. In the 1960s, the US Centers for Disease Control and Prevention (CDC) conducted research within the Comprehensive Hospital Infections Project and introduced surveillance and control techniques still used today. The creation of the National Healthcare Safety Network (NHSN) propelled infection control onto a national public health platform in the USA.[3] Today, reduction of HCAIs has become a regulatory, financial and quality imperative across the world.

Healthcare frequently involves the use of invasive devices and procedures that can increase the risk of HCAIs, including catheter-associated urinary tract infections, central-line associated bloodstream infections (CLABSIs), surgical site infections and ventilator-associated events.[5] The development of antimicrobial resistance related to antibiotic misuse or overuse[6] has given rise to multidrug-resistant organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA), extended spectrum beta lactamase-producing Enterobacteriaceae, carbapenem-resistant Enterobacteriaceae and diarrheal infections with *Clostridioides difficile*. Today, most states in the USA have passed legislation mandating that healthcare facilities publicly report HCAIs, most often using the CDC NHSN surveillance definition for event reporting.[7] Globally, the WHO's *Clean Care is Safer Care* Programme is working alongside many nations to introduce surveillance and reporting programmes to strengthen the international response.[8]

The patient environment has become a major focus of infection control interventions. Although a large proportion of HCAIs are attributed to a patient's endogenous microflora, up to 40% of nosocomial infections are cross-infections from the hands of healthcare providers, including transmission from high-touch patient-care surfaces.[9] In order for pathogens to be transmitted, they generally must have characteristics that make them more robust in the environment, such as the ability to frequently colonise, survive and remain virulent on environmental surfaces and the ability to transiently colonise and pass from the hands of healthcare providers to patients or environmental surfaces.[9] *C. difficile* poses additional challenges for environmental control because of its ability to form spores that resist dry heat and many disinfectants.[9] Even with active surveillance and the introduction of new environmental disinfection technologies, such as ultraviolet germicidal irradiation,[10] studies have demonstrated that patients hospitalised in rooms with previous occupants who were MRSA colonised or infected with *C. difficile* were more likely to become contaminated,[7] supporting the notion that hospital environments play an important role in HCAI transmission.

Both the duration of hospitalisation and frequency of transfer between and within healthcare facilities increase the likelihood of exposure to contaminated environments. Intrahospital transfers refer to the movement of a patient within a healthcare facility, including transfers from the emergency room to an inpatient unit on admission, between two different units, to a different department for a procedure or diagnostic study or between rooms on the same unit.[11] McHaney-Lindstrom and colleagues conducted a retrospective case-control study that found that with every additional intrahospital transfer, the odds of acquiring an infection with *C. difficile* increased by 7%.[12] These transfers require a complex cascade of events and are affected by environmental control and communication challenges, professional conflicts related to variation in culture between units, hospital census and provider workload.[13] In a systematic review, Bristol and colleagues found that intrahospital transfers are frequently associated with adverse outcomes, such as delirium, increased risk of falls, increased length of stay and prolonged duration of mechanical ventilation and central venous catheterisation.[13] This therefore further highlights the significance of intrahospital transfers on patient outcomes.

In this issue, Boncea and colleagues report on a retrospective case-control study conducted to estimate the risk of developing a HCAI depending on the number of intrahospital transfers between inpatient units or the same unit.[11] The study was conducted in three urban hospitals within one UK hospital organisation. The study focused on patients aged 65 or older, given their higher frequency of access to medical care. Data were collected from the electronic health record (EHR) over a 3-year period and included a total of 24 240 hospitalisations of which 2877 were cases where the patient had a positive clinical culture obtained at least 48 hours after hospitalisation. Cases and controls were matched by potential confounding variables, including Elixhauser comorbidities, age, gender and total number of admissions. Using multivariable logistic regression modelling, they found that for every additional intrahospital transfer, the odds of acquiring a HCAI increased by 9%, with the most common HCAI being *C. difficile* infection.

This study is one of the first to quantify the risk associated with the number of intrahospital transfers and HCAIs. Cases and controls were well matched, and the statistical modelling provides very compelling results. However, it is worth noting some features of the study that can affect the findings. The study does not provide specific details on the active surveillance testing practices of the hospital network. Without these data, theoretically (and by chance), cases selected for this study could have been colonised by MRSA more frequently than controls, which would introduce a level of bias. *C. difficile* infection was measured from the EHR by positive toxin immunoassay results, but the clinical context of this testing is not clear, raising the possibility that some positive patients may have represented colonisation and not acute infection. The study also did not adjust for the indication for transfer (eg, transfer to or from the intensive care unit based on patient acuity, transfer for isolation precautions or transfer due to bed capacity or staffing issues) to determine if the patient care needs, isolation status or hospital strain modify the observed risk. As the authors acknowledge, prospective studies are needed to identify the clinical, administrative and systems factors that contribute to more frequent intrahospital transfers.

Guidelines for prevention and control of HCAIs include evidence-based interventions that can be broadly categorised as either vertical or horizontal. Vertical interventions focus on reducing colonisation, infection and transmission of specific pathogens,[7] and include surveillance testing for asymptomatic carriers, contact isolation precautions and targeted decolonisation.[7] Horizontal interventions aim to reduce the risk of infection by a larger group of pathogens, independent of patient-specific conditions, such as optimisation of hand hygiene, antimicrobial stewardship and environmental cleaning practices.[7]

Infection control programmes are tasked with weighing the risks and benefits of interventions to reduce rates of HCAIs while also being cost effective. Vertical approaches to prevent MRSA transmission and infection remain controversial due to inconsistent findings.[7] In a nationwide US Veteran's Affairs study that assessed the impact of MRSA surveillance testing and contact isolation in MRSA carriers, researchers demonstrated that these interventions resulted in reduced rates of MRSA infection and colonisation as well as reductions in the incidence of healthcare-associated *C. difficile* and vancomycin-resistant Enterococcus infections.[14] In contrast, other studies evaluating similar practices in intensive care units found little impact of vertical control measures on MRSA rates[15] and describe unintended consequences, such as decreased provider-patient contact, increased patient anxiety and patient dissatisfaction with quality of care.[16]

Under endemic conditions, horizontal interventions may be more cost effective and beneficial given the broader number of microorganisms that can be targeted.[7] Hand hygiene remains a core horizontal intervention, but hand hygiene compliance varies widely, with some countries' hospitals compliance reported as low as 15%.[17] Several studies focused on intensive care units have shown significant declines in MRSA colonisation rates when hand hygiene practices improve.[7] In addition to hand hygiene, universal decolonisation strategies that typically use chlorhexidine gluconate bathing of high risk patients are more impactful than active surveillance testing for individual pathogens at reducing rates of HCAIs such as CLABSIs.[7] A central pillar of infection control is antimicrobial stewardship. These programmes use coordinated interventions to promote appropriate antimicrobial use, improve patient outcomes, decrease antibiotic resistance and reduce the incidence of infections secondary to multidrug-resistant organisms.[18] Given variation in environmental disinfection practices and provider-to-provider communication, reducing the frequency of intrahospital transfers is another potential horizontal intervention to reduce the burden of HCAIs.

Boncea and colleagues' study adds to the growing body of literature that intrahospital transfers may increase the risk of HCAIs. Prior studies have identified that patients experience an average of 2.4 transfers during a hospitalisation and approximately 96% of individuals experience a transfer during hospitalisation.[13] Transfers within the hospital also affect patient care and safety in other ways, resulting in delays in diagnosis and treatment due, in part, to poor coordination of care and inadequate handoffs between units.[19] Additionally, intrahospital transfers take an average of 1 hour to complete, adding significantly to nursing workload.[19]

The field of infection control must continue to adapt to changing hospital environments in order to further reduce the risk of HCAIs. In the most recent progress report from US CDC, one in every 31 US patients will experience a HCAI while hospitalised,[20] contributing to preventable deaths and permanent harm and to a tremendous excess cost of care.[21] While the impact of these infections is readily recognised in the developed world, recent studies indicate that the impact of HCAIs in the developing world is staggering, with one study reporting that the pooled-prevalence of HCAIs in resource-limited settings is 15.5 per 100 patients, compared with 4.5 per 100 patients in the USA and 7.1 per 100 patients in Europe.[22] Infection control programmes must continue to survey their respective hospital populations and evolve to the demand of the time, weighing benefits, balancing measures and costs. Reducing the number of intrahospital transfers and improving care coordination across these transitions represent a future opportunity to further reduce the burden of HCAIs.

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## REFERENCES

1 APIC. What are healthcare-associated infections?Available: https://apic.org/monthly_alerts/what-are-healthcare-associated-infections/ [Accessed 13 Dec 2020].
2 Haque M, Sartelli M, McKimm J, *et al*. Health care-associated infections - an overview. *Infect Drug Resist* 2018;11:2321–33.
3 Dixon RE. Control of Health-Care–Associated infections, 1961–2011. *MMWR* 2011;60:58–63.
4 Kadar N, Romero R, Papp Z. Ignaz Semmelweis: the "Savior of Mothers": On the 200th anniversary of his birth. *Am J Obstet Gynecol* 2018;219:519–22.
5 Centers for Disease Control and Prevention. Types of healthcare-associated infections, 2019. Available: https://www.cdc.gov/hai/infectiontypes.html [Accessed 13 Dec 2020].
6 Escobar DJ, Pegues DA. How Nurses Can Educate the "Thoughtless Person Playing with Penicillin". *Jt Comm J Qual Patient Saf* 2020;46:605–7.
7 Septimus E, Weinstein RA, Perl TM, *et al*. Approaches for preventing healthcare-associated infections: go long or go wide? *Infect Control Hosp Epidemiol* 2014;35:797–801.
8 Facts K. Health care-associated infections fact sheet. Available: https://www.who.int/gpsc/country_work/gpsc_ccisc_fact_sheet_en.pdf [Accessed 21 Dec 2020].
9 Weber DJ, Rutala WA, Miller MB, *et al*. Role of hospital surfaces in the transmission of emerging health care-associated pathogens: norovirus, Clostridium difficile, and Acinetobacter species. *Am J Infect Control* 2010;38:S25–33.
10 Lindblad M, Tano E, Lindahl C, *et al*. Ultraviolet-C decontamination of a hospital room: amount of UV light needed. *Burns* 2020;46:842–9.
11 Boncea EE, Expert P, Honeyford K, *et al*. Association between intrahospital transfer and hospital-acquired infection in the elderly: a retrospective case-control study in a UK Hospital network. *BMJ Qual Saf* 2021;30:457–66.
12 McHaney-Lindstrom M, Hebert C, Flaherty J, *et al*. Analysis of intra-hospital transfers and hospital-onset Clostridium difficile infection. *J Hosp Infect* 2019;102:168–9.
13 Bristol AA, Schneider CE, Lin S-Y, *et al*. A systematic review of clinical outcomes associated with intrahospital transitions. *J Healthc Qual* 2020;42:175–87.
14 Jain R, Kralovic SM, Evans ME, *et al*. Veterans Affairs initiative to prevent methicillin-resistant Staphylococcus aureus infections. *N Engl J Med* 2011;364:1419–30.
15 Huskins WC, Huckabee CM, O'Grady NP, *et al*. Intervention to reduce transmission of resistant bacteria in intensive care. *N Engl J Med* 2011;364:1407–18.
16 Morgan DJ, Diekema DJ, Sepkowitz K, *et al*. Adverse outcomes associated with contact precautions: a review of the literature. *Am J Infect Control* 2009;37:85–93.
17 Engdaw GT, Gebrehiwot M, Andualem Z. Hand hygiene compliance and associated factors among health care providers in central Gondar zone public primary hospitals, Northwest Ethiopia. *Antimicrob Resist Infect Control* 2019;8:190.
18 APIC. Antimicrobial stewardship. Available: https://apic.org/professional-practice/practice-resources/antimicrobial-stewardship/ [Accessed 27 Dec 2020].
19 Webster J, New K, Fenn M, *et al*. Effects of frequent patient moves on patient outcomes in a large tertiary hospital (the

path study): a prospective cohort study. *Aust Health Rev* 2016;40:324–9.
20 Summary E. National and state healthcare-associated infections progress report, 2019. Available: https://www.cdc.gov/hai/pdfs/progress-report/2019-Progress-Report-Executive-Summary-H.pdf
21 Burke JP. Infection control - a problem for patient safety. *N Engl J Med* 2003;348:651–6.
22 Allegranzi B, Bagheri Nejad S, Combescure C, *et al*. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. *Lancet* 2011;377:228–41.