HAND HYGIENE:
A HANDBOOK FOR MEDICAL PROFESSIONALS

EDITED BY
DIDIER PITTET • JOHN M. BOYCE
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Hand Hygiene
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Hand Hygiene
A Handbook for Medical Professionals

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Preface

Do we need another medical textbook?
Does a textbook of hand hygiene exist?
Does hand hygiene deserve a textbook?

These are some of the questions I asked myself when I was invited to consider such a project. I write “project,” when, in fact, I mean “journey.” Editing *Hand Hygiene* was a journey; in the same way, hand hygiene promotion is a journey. But what a fantastic journey it is!

Together with my dear friends and colleagues John M. Boyce and Benedetta Allegranzi, we have had the unique privilege to ask the world’s pre-eminent scholars and clinicians on hand hygiene, infection control, and patient safety to contribute to the first comprehensive, single-source overview of best practices in hand hygiene. *Hand Hygiene* fully integrates the World Health Organization (WHO) guidelines and policies, and offers a global perspective in tackling challenges in both developed and developing countries. A total of fifty-five chapters includes coverage of basic and highly complex clinical applications of hand hygiene practices, and considers novel and unusual issues in hand hygiene, such as religious and cultural aspects, social marketing, campaigning, and patient participation. It also provides guidance on the best approaches to achieve behavioral change in healthcare workers that can also be applied in fields other than hand hygiene.

We asked authors to be concise, to review the evidence as well as what is unknown, and to highlight unique research perspectives in their own field. Each chapter reads easily and contains major issues summarized as bullet points, key figures, and tables. These are also available for download by accessing the e-version of *Hand Hygiene*, together with all of the instruments referenced in the book. My co-editors and I are extremely pleased by the work and commitment of the authors in this team effort, and take this opportunity to warmly thank them all.

Excellence is an attitude and excellence in hand hygiene, a journey.

May *Hand Hygiene* drive excellence in hand hygiene practices, research, and attitudes for many years to come, and contribute to save many more millions of lives every year worldwide.

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Foreword

Hand hygiene in healthcare settings seems like a pretty simple act. One places an antiseptic agent on the hands, rubs the hands together to reduce the transient microorganisms, dries the hands or lets them dry, and thereby reduces the risk of transmission of pathogens to patients and to the healthcare worker. In Hand Hygiene, Drs Pittet, Boyce, and Allegranzi, and their esteemed colleagues, show us how complicated – yet essential – hand hygiene really is.

The book encompasses all the important aspects of hand hygiene. Each chapter has a simple-to-read format: key messages; what we know – the scientific evidence; what we don’t know; and the research that needs to be done to fill these gaps. The authors begin by providing a summary of the current status of data on healthcare-associated infections (HAIs) in both developed and resource-limited countries. These data show the enormous impact that HAIs have throughout the world, including morbidity, mortality, and cost. This chapter also illustrates how even now – over thirty-five years since the Centers for Disease Control and Prevention’s (CDC) Study of the Efficacy of Nosocomial Infection Control (SENIC) programs documented the preventive impact of HAI surveillance and prevention intervention programs – many countries still do not have adequate surveillance systems in place to even answer what their HAI rates are, much less evaluate the impact of prevention interventions.

Next, the authors describe the history of hand hygiene from the time of Semmelweis, discuss the flora and physiology of skin, describe the dynamics of pathogen transmission from the skin, and culminate in three chapters on mathematical models of hand-borne pathogen transmission, methodological issues in hand hygiene science, and statistical issues in hand hygiene research. These last three chapters highlight the many gaps in our knowledge about hand hygiene, illustrate the weaknesses in many if not most of our current studies, and point out that conducting the studies that are necessary may be more difficult than Semmelweis’s challenge of convincing clinicians that hand hygiene should be done at all. Essential issues include antiseptic agent volume, method of application, duration of application, agent formulation, and when these are all optimized, and what percentage of HAIs are prevented by best practices. These methodological chapters are particularly important, as they illustrate that if our Guidelines are supposed to depend solely upon well-designed randomized controlled trials (RCTs) of hand hygiene – rather than on the entire body of epidemiologic data – such RCTs do not and probably never will exist, and hand hygiene will be relegated to an unresolved issue. These methodological
issues also should be kept in mind as one reads the rest of this book (or other published literature) in which many studies are referenced that suffer from these methodological design flaws.

The next three chapters discuss the various available hand hygiene agents, the methods for evaluating their efficacy and the hand hygiene technique. These chapters are incredibly important and discuss issues often not known or understood in the infection control/patient safety community. Data show that formulation of alcohol-based hand hygiene agents matters. The chapter on evaluating efficacy illustrates the differences between North American and European standards – that is American Society for Testing Methods (ASTM) vs. Comité Européen de Normalisation (CEN or EN) standard methods. Everyone in infection control should understand the different methods used, what these tests do and do not tell us about efficacy, how in vivo testing does or does not relate to clinical practice, and the importance of demanding that all manufacturers provide such data to us when we are comparing products. Formulation matters, and such testing can document this.

This leads to several chapters on compliance with hand hygiene best practices, barriers to compliance, and a discussion of physicians and the almost universal finding that they are the worst compliers with hand hygiene recommendations of all healthcare workers. We must ask ourselves exactly what compliance with hand hygiene best practices is. Is it as mentioned at the beginning of this foreword simply applying some agent (formulation and amount irrelevant) and rubbing our hands together (duration and method irrelevant)? Or does compliance with hand hygiene best practices mean using a formulation documented to be effective, using the correct volume of that specific product documented in the ASTM or EN standard testing (realizing that volume will differ by product and for gels, foams vs. rubs), applying the product in a specific manner (such as recommended by the World Health Organization [WHO]), for the correct duration, at each of the WHO five moments? With current visual observation of hand hygiene “compliance,” how many healthcare workers pay any attention to the volume of agent used, the method of application, the duration of application, and so on. All of these are critical elements in hand hygiene best practices, yet they are often ignored. We need more precise definitions of what hand hygiene best practices are and when they should be done and measured. From the patient’s perspective, moments 1 and 2 are most important. From the healthcare worker’s perspective, moments 3, 4, and 5 are most important. These chapters also raise questions about who should monitor hand hygiene compliance (self-reporting appears to generally be inaccurate), when and how.

The next general area includes a discussion of behavior and hand hygiene, hand hygiene promotion strategies, the WHO five moments for hand hygiene, system change, and education of healthcare professionals. These chapters illustrate the continual struggle that those of us in infection control/quality improvement have trying to educate our healthcare workers about the importance of hand hygiene and methods to improve behavior, reduce barriers to compliance, and
try to change our systems. Do we continue to invest enormous resources (time, personnel, and funding) to these activities to try to get our healthcare “professionals” to comply with hand hygiene best practices, or do we follow the dictates of the chapter on “Personal Accountability for Hand Hygiene”? As we have learned in the United States, if we do not regulate ourselves (e.g., through mandatory reporting of HAI rates, reduced funding for preventable HAIs), outside regulatory agencies will (i.e., the government). We all agree that proper performance of hand hygiene will reduce HAIs and improve patient safety. Then why do we accept noncompliance?

The chapter on monitoring hand hygiene compliance is critical. What should the gold standard be for measuring hand hygiene compliance? The majority of those measuring hand hygiene compliance (and/or publishing such studies) use “trained observer” visual observation. This chapter describes some flaws in such an approach: it is prone to bias, overestimates true performance, often captures <1% of hand hygiene opportunities at the time in the institution (yet is generalized to the entire facility), has large inter-rater variation, etc. As these authors state, “Today, a unique reliable and robust method to measure hand hygiene performance does not exist.” We know that indirect and less costly (time, personnel, etc.) methods for estimating hand hygiene compliance, such as measuring the amount of agent used, are not accurate. We know that merely measuring hand hygiene compliance on patient room entry or exit does not predict in-room practices (which are most important for the prevention of pathogen transmission to the patient). We know that self-reporting is grossly inaccurate. However, at least in developing countries, emerging technologies may be the answer for the future. The question becomes what we want the system to measure. Currently, electronic systems can measure whether hand hygiene is performed. Such systems generally do not assess the volume of the specific product, the method and duration of application, or specific compliance with each of the five moments or with specific invasive procedures. Video systems are just emerging and have the capacity not only to measure all these elements, but also to be a record to play back for healthcare workers who deny their noncompliance. In the future, where our systems truly demand individual accountability, such video/electronic systems may become essential. It does appear that at least in the developing world – as personnel clinician accountability is enforced and systems insist that hand hygiene best practices be a patient safety issue and thus must be complied with, for cost and personnel reasons – electronic or video systems for hand hygiene measure will become integral components of our measuring systems.

The book ends with chapters on national and international campaigns and regulatory/accrediting body approaches. Undoubtedly, such campaigns – whether local, system-wide, state or nationwide or worldwide – have improved hand hygiene awareness, importance, and compliance. Given the large number of elements we have learned in this book are required for true “hand hygiene best practices compliance” – that is, the best agent, the correct volume, application in compliance with the five moments, application in the correct fashion and for the
correct duration – it is hard to believe local or national hand hygiene compliance rates of 85%–95% or that such levels – even if they can be achieved – can be sustained.

This book provides the most contemporary comprehensive summary of what we do and do not know about hand hygiene. It is essential reading for all those who are involved in infection control, patient safety, and quality improvement, or who practice clinical medicine. We must realize that until we have a reliable and robust method to measure hand hygiene performance, we really do not know what our hand hygiene compliance rates really are, nor can we calculate what percentage of HAIs actually can be prevented with high hand hygiene compliance rates. It is my hope that through reading this book and understanding the challenges ahead, video or electronic systems for measuring true hand hygiene compliance with best practices will be developed, and that we will require clinician accountability with hand hygiene recommendations. Then, we will be able to calculate what percentage of HAIs are prevented with different levels of hand hygiene compliance (or with higher or lower compliance with different moments of the WHO five moments) and through achievement of high sustainable hand hygiene compliance rates, we will be leaders in a worldwide campaign to improve patient safety and prevent HAIs through this simple intervention – hand hygiene!

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Chapter 1

The Burden of Healthcare-Associated Infection

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KEY MESSAGES

• The World Health Organization (WHO) estimates that hundreds of millions of patients are affected by healthcare-associated infection (HAI) worldwide each year, leading to significant mortality and financial losses for health systems, but precise data of the global burden are not available.
• Of every 100 hospitalized patients at any given time, 6 to 7 will acquire at least one HAI in developed countries and 10 in developing countries.
• In low- and middle-income countries, HAI frequency, especially in high-risk patients, is at least two to three times higher than in high-income countries, and device-associated infection densities in intensive care units are up to 13 times higher.

Healthcare-associated infections (HAIs) affect patients in hospitals and other healthcare settings. These infections are not present or incubating at time of admission, but include infections appearing after discharge, and occupational infections among staff. HAIs are one of the most frequent adverse events during healthcare delivery. No institution or country can claim to have solved this problem, despite many efforts. Healthcare workers’ (HCWs’) hands are the most
common vehicle of microorganisms causing HAI. The transmission of these pathogens to the patient, the HCW, and the environment can be prevented through hand hygiene best practices.

WHAT WE KNOW – THE EVIDENCE

Although a national HAI surveillance system is in place in most high-income countries, only 23 developing countries (23/147 [15.6%]) reported a functioning system when assessed in 2010. In 2010, all 27 European Union (EU) Member States and Norway contributed to at least one of the four components of the Healthcare-Associated Infections Surveillance Network (HAI-Net), coordinated by the European Centre for Disease Prevention and Control (ECDC). Among these, 25 and 23 countries participated in the point prevalence surveys of HAI and antimicrobial use in long-term care facilities (LTCF) and acute care hospitals, respectively; 13 countries participated in the surveillance of surgical site infections (SSI); 14 in surveillance of HAI in intensive care units (ICUs); and 7 countries contributed to all surveillance components.

Based on a 1995–2010 systematic review and meta-analysis of national and multicenter studies from high-income countries conducted by the WHO, the prevalence of hospitalized patients who acquired at least one HAI ranged from 3.5% to 12%. Pooled HAI prevalence was 7.6 episodes per 100 patients (95% confidence interval [CI], 6.9–8.5) and 7.1 infected patients per 100 patients admitted (95% CI, 6.5–7.8). Very similar data were issued in 2008 by the ECDC based on a review of studies carried out between 1996 and 2007 in 19 countries. Mean HAI prevalence was 7.1%; the annual number of infected patients was estimated at 4,131,000 and the annual number of HAI at 4,544,100. In 2011–2012, a point prevalence study coordinated by ECDC in 29 countries indicated that, on average, 6% (range, 2.3%–10.8%) of admitted patients acquired at least one HAI in acute care hospitals. Based on these data, ECDC estimated that approximately 80,000 patients in Europe on any given day develop at least one HAI for a total annual number of 3.2 million patients (95% CI 1.9–5.2) with a HAI.

The estimated HAI incidence in the United States was 4.5% in 2002, corresponding to 9.3 infections per 1000 patient-days and 1.7 million affected patients. In the United States and Europe, urinary tract infection (UTI) used to be considered the most frequent type of infection hospital-wide (36% and 27%, respectively). In the recent European point prevalence study, lower respiratory tract infection (23.4%) was the most frequent HAI, followed by SSI (19.6%) and UTI (19%). According to several studies, the frequency of SSI varies between 1.2% and 5.2% in high-income countries. In European countries, SSI rates varied according to the type of operation; the highest were in colon surgery (9.9%) and the lowest in knee prosthesis (0.7%).

HAI incidence is much higher in severely ill patients. In high-income countries, approximately 30% of ICU patients are affected by at least one episode of
Chapter 1  The Burden of Healthcare-Associated Infection

HAI with substantial associated morbidity and mortality.\(^6\) Pooled HAI cumulative incidence density in adult high-risk patients was 17 episodes per 1000 patient-days (range 13.0–20.3) in a meta-analysis performed by WHO.\(^1\) Incidence densities of device-associated infections in ICUs from different studies including WHO reviews are reported in Table 1.1. In a large-scale study conducted in some middle-income countries in Latin America, HAIs were the most common type of incidents occurring in hospitalized patients; the most frequent were pneumonia and SSI.\(^7\)

According to a systematic review, WHO reported that HAIs are at least two to three times more frequent in resource-limited settings than in high-income countries.\(^1,8\) In low- and middle-income countries, HAI prevalence varied between 5.7% and 19.1% with a pooled prevalence of 10.1 per 100 patients (95% CI, 8.4–12.2); the reported prevalence was significantly higher in high-than in low-quality studies (15.5% vs. 8.5%, respectively).\(^8\) In contrast to Europe and the United States, SSI was the leading infection hospital-wide in settings with limited resources, affecting up to one-third of patients exposed to surgery; SSI was the most frequently surveyed HAI in low- and middle-income countries.\(^1,8\)

The reported SSI incidence ranged from 0.4 to 30.9 per 100 patients undergoing surgical procedures and from 1.2 to 23.6 per 100 surgical procedures, with pooled rates of 11.8 per 100 patients exposed to surgery (95% CI, 8.6–16.0) and 5.6 per 100 surgical procedures (95% CI, 2.9–10.5).\(^8\) This is up to nine times higher than in high-income countries.

In low- and middle-income countries, the proportion of patients with ICU-HAI ranged from 4.4% to 88.9% with an infection incidence as high as 42.7 episodes per 1000 patient-days (Table 1.1).\(^1\) This is almost three times higher than in high-income countries. The cumulative incidence of specific device-associated HAI in low- and middle-income countries was estimated by WHO and is regularly reported by the International Nosocomial Infection Control Consortium (INICC), a surveillance network comprising ICUs from 36 low- and middle-income countries. Again, the incidence was found to be at least two to three times higher than in high-income countries and even up to 13 times higher in some countries (Table 1.1). Newborns are also at higher risk in low- and middle-income countries with infection rates 3 to 20 times higher than in high-income countries. Among hospital-born babies in developing countries, HAIs are responsible for 4% to 56% of all causes of death in the neonatal period, and as much as 75% in Southeast Asia and Sub-Saharan Africa.\(^1\) HAIs are not limited to the hospital setting. They are a major problem in LTCF and nursing homes with high levels of antimicrobial resistance and can also result from any type of outpatient care (see Chapters 42C and 42D).

According to available data, the burden of endemic HAI is very significant in terms of excess costs, prolonged hospital stay, attributable mortality, and additional complications and related morbidities. European estimates indicate that HAIs cause 16 million extra days of hospital stay and 37,000 attributable deaths annually, but they also contribute to an additional 110,000 deaths; the annual economic impact in Europe is as high as £7 billion.\(^3\) In the United States, around
**Table 1.1** Cumulative Incidence Density of HAI and Device-Associated Infections in Adult ICU Patients in High-, and Low/Middle-Income Countries

<table>
<thead>
<tr>
<th>Surveillance Networks/Reviews, Study Period, Country</th>
<th>HAI/1000 (95% CI)</th>
<th>CR-BSI/1000 Central Line-Days (95% CI)</th>
<th>CR-UTI/1000 Urinary Catheter-Days (95% CI)</th>
<th>VAP/1000 Ventilator-Days (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO meta-analysis, high-income countries, 1995–2010</td>
<td>17.0 (14.2–19.8)</td>
<td>3.5 (2.8–4.1)</td>
<td>4.1 (3.7–4.6)</td>
<td>7.9 (5.7–10.1)</td>
</tr>
<tr>
<td>NHSN, 2006–2008, USA*</td>
<td>/</td>
<td>2.1 (10.5–13.9)</td>
<td>8.8 (7.4–10.3)</td>
<td>23.9 (20.7–27.1)</td>
</tr>
<tr>
<td>WHO meta-analysis, low- and middle-income countries, 1995–2010</td>
<td>42.7 (34.8–50.5)</td>
<td>12.2 (10.5–13.9)</td>
<td>8.8 (7.4–10.3)</td>
<td>23.9 (20.7–27.1)</td>
</tr>
<tr>
<td>INICC, 2004–2009, 36 developing countries†</td>
<td>/</td>
<td>6.8 (6.6–7.0)</td>
<td>7.1 (6.9–7.3)</td>
<td>18.4 (17.9–18.8)</td>
</tr>
</tbody>
</table>

*Medical/surgical ICUs in major teaching hospitals.
99,000 deaths were attributed to HAI in 2002. According to the Centers for Disease Control and Prevention (CDC), the overall annual direct medical costs of HAI to US hospitals ranges from US$36 to US$45 billion; of these, from US$25 to US$32 billion would be avoidable when considering that up to 70% of HAIs are preventable.

Very limited data are available at the national level to assess the impact of HAI in low- and middle-income countries. According to a WHO review, increased length of stay associated with HAI in low- and middle-income countries varied between 5 and 29.5 days. Crude excess mortality rates of 18.5%, 23.6%, and 29.3% for catheter-related UTI, central venous catheter-related bloodstream infection, and ventilator-associated pneumonia, respectively, were reported by INICC in adult patients in 173 ICUs in Latin America, Asia, Africa, and Europe. Wide variations in cost estimates associated with HAI were observed between countries. Methods used to estimate excess costs associated with HAIs also varied substantially among studies published in different countries. For instance, in Mexican ICUs, the overall average cost of a HAI episode was US$12,155; in Argentina, overall extra-costs for catheter-related bloodstream infection and healthcare-associated pneumonia were US$4,888 and US$2,255 per case, respectively. In a recent case-control study from Brazil, overall costs of hospitalization for methicillin-resistant Staphylococcus aureus bacteremia reached US$123,065 for cases versus US$40,247 for controls.

WHAT WE DO NOT KNOW – THE UNCERTAIN

Despite dramatic data related to specific countries or regions, HAI is not included in the list of diseases for which the global burden is regularly estimated by WHO or the Institute for Health Metrics and Evaluation. Precise estimates of the number of patients affected by HAI and the number of episodes occurring worldwide every year, or at a certain moment in time, are not available. Similarly, estimating the number of deaths attributable to HAI is extremely difficult because co-morbidities are usually present, and HAIs are seldom reported as the primary cause of death. Disability-adjusted life years estimates attributable to HAI are not available. Indeed, for instance, it is complex to calculate years of life lost due to a HAI in a cancer patient dying of HAI. In addition, little is known about the occurrence of HAI complications and associated temporary or permanent disabilities. Finally, the available information regarding indirect attributable costs associated with HAI is limited, in particular regarding the extent of economic losses potentially avoidable through better infection control.

Although the number of publications on HAI surveillance in settings with limited resources has increased over the last few years, the picture of the endemic burden of HAI and antimicrobial resistance patterns in low- and middle-income countries remains very scattered. Data from these countries are hampered in all
Hand Hygiene

the aforementioned areas, and HAI surveillance is not a priority in most countries. There is a need to identify simplified, but reliable protocols and definitions for HAI surveillance in settings with limited resources. In addition, standardized approaches are very much required to facilitate the best use of data to inform policy makers, raise awareness among frontline staff, and identify priority measures.

RESEARCH AGENDA

Further research is needed to:

- Identify reliable and standardized epidemiological models to estimate the global burden of HAI in terms of proportion of affected patients and number of HAI episodes, attributable mortality, length of stay, disability-adjusted life years, and costs per year saved.
- Develop and validate approaches to estimate the HAI incidence and disease burden using International Classification of Diseases codes and additional information available from computerized patient records.
- Develop and validate protocols and definitions suitable for HAI surveillance in settings with limited resources.
- Identify risk factors for HAI, in particular potential differences between high-income and low- and middle-income countries.

REFERENCES


Chapter 2

Historical Perspectives

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One could reasonably consider that the modern era of hand hygiene in healthcare started in the mid-nineteenth century with the work of Ignaz Semmelweis (1818–1865).\textsuperscript{1,2} Semmelweis was employed as assistant in obstetrics at the Vienna General Hospital in 1846, and he quickly became concerned about the high maternal mortality rate due to puerperal fever. At the time, women were admitted to one of two obstetric wards on the basis of alternating days: one ward staffed by doctors and medical students, and the other by midwives. In what was a landmark achievement in hospital epidemiology, this setting combined with Semmelweis’s careful surveillance of maternal mortality enabled him to dismiss contemporary hypotheses regarding the cause of the disease, such as miasma or patient-level factors. He concluded that the cause was a factor unique to the ward staffed by doctors and medical students, which had a mortality rate more than double of that staffed by midwives. The clue was provided by the death of his colleague, Jakob Kolletschka, with an illness resembling childbed fever following a scalpel laceration while supervising an autopsy. This led Semmelweis to hypothesize that the elevated mortality rate in the medical ward was due to contamination of medical student hands with “cadaverous particles” during autopsies, a newly popular teaching tool. As a result, Semmelweis instituted a new regimen of hand scrubbing with chlorinated lime. Initially required on entry to the obstetric ward, hand scrubbing was soon extended to between contact with each patient. While this intervention was effective in producing a sustained reduction in maternal mortality, it proved unpopular with students and colleagues, and his contract was not renewed. This failure was likely the result of a combination of the hand irritation caused by chlorinated lime, the absence of a biologic explanatory model, and