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Healthcare associated infections (HAI) perspectives

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Summary Healthcare associated infections (HAI) are among the major complications of modern medical therapy. The most important HAIs are those related to invasive devices: central line-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), ventilator-associated pneumonia (VAP) as well as surgical site infections (SSI). HAIs are associated with significant mortality, morbidities and increasing healthcare cost. The cited case-fatality rate ranges from 2.3% to 14.4% depending on the type of infection. In this mini-review, we shed light on these aspects as well as drivers to decrease HAIs.

Introduction

Healthcare associated infections (HAI) are among the major complications of modern medical therapy due to the increasing age and complexity of patients, increased utilization of invasive devices and often inappropriate use of antimicrobial therapy. The most important HAIs are those related to invasive devices: central line-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), ventilator-associated pneumonia (VAP) as well as surgical site infections (SSI). Many of these device associated infections and SSI are caused by multi-drug resistant organisms (MDRO) such as *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant Enterococci (VRE) and multi-resistant Gram-negative bacilli. While outbreaks often capture the attention of the media and the public, endemic HAI represent the majority of infections encountered in healthcare and are associated with

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significant morbidity, mortality and healthcare costs [1].

There are multiple factors contributing to HAI and include healthcare associated factors, environmental factors, and patient-related factors. Healthcare related factors include the use of invasive devices, surgical procedures, and selection pressure from excessive antibiotic use. Environmental factors include contaminated air-conditioning systems and the physical layout of the facility (e.g., open units with beds close together). These factors interact in any given healthcare system and multiple factors may play a role such as staffing (e.g., nurse-to-patient ratio) and the lack of effective intervention programs designed to reduce HAI. Patient-related factors include; severity of underlying illness, use of immunosuppressive agents, and prolonged hospital stays.

Mortality and morbidity

Hospital acquired infections are associated with significant mortality and morbidities. These have been quantified in a number of studies although the mortality impact is likely to be affected by the case mix. In a study from the USA, case fatality rates of CLABSI were 12.3%, VAP 14.4%, CAUTI 2.3%, and SSI 2.8% [2]. In a study in a surgical intensive care unit, the attributable mortality to CLABSI was 35% [3]. It was argued that for most HAIs additional studies are needed to determine the attributable mortality as it is difficult to attribute death in such patients to infection only in patients with multiple cofactors in intensive care units [4]. Of all HAIs, CLABSI and VAP are associated with the highest number of preventable deaths [6]. The calculated estimates of lives saved in the United States by reduction in the number of cases of CLABSI are 5520—20,239 lives, and for VAP 13,667—19,782 lives [4].

Costs

HAIs are associated with substantial cost and burden on healthcare organizations [2,5]. In the United States, it is estimated that HAIs occur in about two million patients a year with a total number of deaths of 99,000, and cost of $33 billion each year [2,5]. The SENIC (Study for Efficacy of Nosocomial Infection Control) study estimated the cost of HAIs to be $4.5 billion in 1992, which reached to almost $6.6 billion in 2007 after adjusting for inflation [2]. The economic impact of HAIs in low- and middle-income countries is poorly studied. In a study from Mexico City ICUs, CLABSI was associated with a mean extra hospital cost of US$ 11,591, and an attributable extra mortality of 20% [6]. A systematic review is beyond the scope of this commentary but Stone et al. have recently reviewed the subject [7].

The relation between HAI rates and the country's socioeconomic level

The country's economic level is generally classified as low income, mid low income and high income. The relation between HAI rates and the socioeconomic level was recently analyzed and published [7,8] and showed that a higher country socio-economic level was correlated with a lower infection risk [7,8]. The device utilization rate in the developing countries' ICUs was similar to that reported in US ICUs but the pooled rate of CLABSI and VAP in the International Nosocomial Infection Control Consortium (INICC) system was higher than the reported rate in comparable US ICUs [8]. Studies from Europe also shed light on the prevalence and incidence of HAIs in ICUs. For example in one study, 20.6% of patients had ICU-acquired infection including: pneumonia (46.9%), lower respiratory tract infection (17.8%), urinary tract infection (17.6%), and bloodstream infection (12%) [9]. Of a total of 3360 patients with HAIs in Europe, the commonest types of HAIs were respiratory tract infections (22.8%), urinary tract infections (UTI) (17.2%), and surgical site infections (SSI) (15.7%) [10]. In Africa, the overall prevalence of HAI range was 2.5—14.8% [11], and was twice the average rate from European prevalence as reported by the European Center for Disease Prevention and Control [12].

Benchmarking is being established in many regions and was established in the United Kingdom in the 1990s [13]. The Nosocomial Infection National Surveillance Scheme (NINSS) in United Kingdom is run by the Health Protection Agency (HPA) and is based on US NNIS system [14]. Similarly, the Krankenhaus-Infektions-Surveillance-System (KISS) is a German HAI surveillance system that was established in 1997 [15]. For decades, the CDC was the only source available to provide a basis for comparison of infection rates with hospitals worldwide. Comparing US CDC's hospitals' rates with those of hospitals from Western Europe and Oceania is considered valid, due to their similar socioeconomic conditions. The comparison of between CDC's rates and hospitals with limited resources or with limited experience in the field of infection control—is difficult. The US hospitals

enjoy more than 50-year unrivaled experience in infection control and surveillance, sufficient human and medical supply resource availability, and a comprehensive legal framework backing infection control programs and including mandatory surveillance and hospital accreditation policies. These characteristics lead to significantly lower HAI rates for CDC's hospitals, and hospitals from high income countries, in contrast to hospitals from developing economies or with insufficient resources and experience in infection control. The chosen benchmark should have similar data collection and presentation methods [16]. It is important also to take into consideration any differences in surveillance environments including regulations [16].

Strategies for reduction of HAI

For more than 30 years, it has been recognized that many of these infections are partially preventable and healthcare can be made safer. Two broad approaches have been used to work toward the reduction of device-associated infections (DAI). The first is a passive strategy in which surveillance protocols lead to reduction in infections through prompt and timely feedback [17]. The classic study demonstrating the importance of this was the SENIC study [18], funded by the United States Centers for Disease Control and Prevention (CDC) and included 338 hospitals randomly selected and stratified by geography, inpatient bed capacity, and teaching status [18]. The study showed that infection control programs with dedicated hospital epidemiologists and surveillance programs reduced nosocomial infections by 32% compared to settings without infection control programs [18]. In their recommendations, the Society for Healthcare Epidemiology in America (SHEA) Consensus Panel on essential activities of Infection Prevention and Control (IPC) programs in hospitals considered surveillance activities of HAI to be a Category I recommendation [19]. These recommendations suggest that surveillance should include: standardized definitions of numerators and denominators, identification and description of data sources and data collection personnel and selection of appropriate methods of measurement [19]. While surveillance provides important baseline data, in recent years, more active intervention protocols have been introduced to further reduce the incidence of HAI. Recently the use of the bundle concept has focused attention on the reduction of DAI in particular. After successful trials in a wide variety of settings [20], a multimodal approach for the prevention of HAI has emerged globally. In this multimodal approach for example, for the reduction of CLABSI, different strategies are included such as education and training, standardized processes, use of maximal sterile barrier precautions, use of chlorhexidine in alcohol for skin preparation, hand hygiene and catheter care [21]. The benefit of the use of combined measures (multimodal approach) has been documented on the rate of vascular-access infections more than 15 years ago [22]. This study employed catheter-care techniques that included maximal aseptic precautions, use of sterile gloves, gown and drapes and a continuing education program and regular feed-back of the rates of CLABSI to the involved staff [22]. A land mark study, the Pronovost study, showed that a similar evidence-based intervention resulted in up to 66% reduction in rates of catheter-related bloodstream infection and was maintained over an 18-month period [23]. This was further sustained with reductions in catheter related bloodstream infections for up to 36 months [24].

In 2008, the Society for Healthcare Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA) and partner organizations published a compendium of strategies to prevent HAIs in acute care hospitals [25]. The compendium is an evidence-based practical guide for the prevention of common HAIs including CAUTI, SSI and CLABSI.

While there is an increasing body of evidence for various evidence-based interventions to reduce HAIs, they continue to be a problem and multi-drug resistant organisms (MDRO) rates continue to rise. The problem has been in getting healthcare organizations to adopt or adapt the best interventions in reduction of HAI in their routine practice. Changing the behavior of the individual healthcare worker is challenging as well as changing the culture of any given healthcare organization. It was estimated that despite widespread incontrovertible evidence, adapting healthy life styles to quit smoking took 50 years to decrease smoking rates from 80% to 36% in men 35—59 years of age and to 21% in men more than 60 years of age [26]. We hope that culture change in HAI prevention will not take that long!

How can we reduce HAI?

Several initiatives have been started to try to implement evidence based interventions to reduce HAIs. For example, the QUEST performance improvement program is a collaborative sponsored by Premier with technical assistance provided by the Institute for Healthcare Improvement (IHI) [27]. This

project developed strategies in key areas such as CLABSI, VAP, SSI and CAUTI. They are designed to ''hardwire'' best practices into healthcare systems such as reminders and automatic stop orders to reduce device usage. Changing the culture of an organization so that everyone can speak up if they detect unsafe practices is another way forward. In this new culture, organizations implement training programs and encourage communication and teamwork to empower staff with a focus on reducing preventable infections. Establishing local and national targets for improvement is another key to success. The U.S. Department of Health & Human Services had put nine national targets for elimination of HAI and monitors the progress overtime [28]. There are some concerns that highly publicized and visible targets may occasionally be counterproductive as administrators try to ''game'' the system by stretching definitions in order to meet targets.

What are the drivers to prevent HAI?

Despite strong public support and institutional pressure, the adherence to evidence-based infection control measures was estimated to be around 60% [29]. The drivers for reduction of HAI are multiple and include: pressure from patients, regulation by the health authorities; fear of legal action; financial assistance; and convincing guidelines [30]. In USA, public reporting of HAIs has attracted significant attention in the past few years. The CDC has put guidelines on public reporting of HAIs to try to alleviate some of the problems caused by ''gaming'' the system or undue pressure on infection preventionists while still trying to achieve accountability and safer patient care [31]. The authors call for clear definition of the goals, objectives, and priorities of a public reporting system. They also strongly recommend that the outcomes should be meaningfully and clearly measurable [31]. Process measures are more easily adhered to and might be less ambiguous than outcome measures [31]. The same group evaluated 10 studies, to assess the evidence for the effectiveness for public reporting to improve health care and found in conclusive results. No studies specifically investigated reduction of HAI as an outcome [32]. In addition, the lack of validated risk adjustment methods is a major concern for public reporting as consumers and regulators are likely to use public reporting to benchmark hospitals [33]. Cost of HAIs is another major driver for the reduction of these infections. In the United States, HAIs were found to be major contributors to hospital readmission [34]. Others have also found significantly increased costs associated with HAIs.

The Institute for Healthcare Improvement cites multiple infection control activities such as: appropriate precautions, identification of colonization with active surveillance, cleaning of environment and equipment, hand hygiene, bundle use, and appropriate antimicrobial selection [35] as the drivers to reducing HAIs. The evidence for some of these is stronger than for others and this has been one of the challenges to amass a strong evidence based database for many infection control recommendations. Recent high quality studies [36,37] have provided interesting insights into the relative roles of the different components of the infection control bundles. Some work has been done in the developing world and outside North America using the bundle concept or multi-modal approaches to reduce HAI [38—41]. Hopefully more of these studies will be done outside of North America to provide data which can be generalized globally.

One controversial aspect of the modern infection prevention movement is the call to adopt zero tolerance of HAI [42]. While everyone accepts that HAIs should not occur, there is a lively debate on whether ALL HAIs are truly preventable. Thus while reducing HAIs is an important goal, it is important primarily to reduce harm to patients instead of being fixated on numbers. The two are not mutually exclusive but an unrelenting focus on ''Getting to zero'' driven by the media and regulators can lead to demoralization of the infection control teams and a paradoxical worsening of the patient safety climate [42].

Barriers to successful implementation of HAI prevention programs are widespread and vary with the different settings. These can include resource limitations which have been well documented by the INICC group [43], institutional culture (''we have always done it this way'') and sometimes a lack of support from senior leadership. Often, there is also a paucity of high grade clinical evidence which some clinicians need to alter their clinical practice and it is difficult to amass this evidence base.

With increasingly educated populations and the widespread dissemination of information via social media, there is a window of opportunity for good science to drive community and patient centered approaches to reducing HAIs and protecting patient safety. It is somewhat ironic that the most effective measure to reduce infections had evidence generated a century and a half ago and still is not universally practiced. It is without doubt that hand hygiene is the cornerstone of any infection control measures to reduce HAI [38,44]. The renewed interest in Semmelweiss and his seminal intervention

surely augurs well for infection control and prevention programs although we would hope that we have more success than he did in his lifetime!

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