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Intensifying the Focus on the Contribution of the Inanimate Environment to Healthcare Associated Infections

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Reducing transmission of multidrug-resistant organisms and *Clostridium difficile* in hospitals is a critical priority; bacterial infections caused by these pathogens are increasingly common and frequently are associated with adverse outcomes.(1, 2) Historically, cleanliness and disinfection of the hospital environment have been logical foci for healthcare epidemiology. As antimicrobial options for treating multidrug-resistant bacterial infections are becoming fewer and fewer, the importance of accurately identifying routes of spread and implementing effective preventive interventions become even more critical.

A longstanding debate over the relative role the environment plays in the transmission of healthcare-associated infections (HAIs) has resulted in investigators and others in the healthcare epidemiology community vacillating for decades between skepticism and conviction. Unlike near universal acceptance of the importance of hand hygiene, the pendulum has swung back and forth with respect to the prevailing view of the contribution of the inanimate healthcare environment to the spread of HAIs. Both cultural shifts and new studies have elicited virtually polar opinions about the role of the environment in HAI transmission and the role of disinfection in reducing hospital infections.(3) Although convincing healthcare personnel to clean their hands at every opportunity is challenging, maintaining a hospital environment that is free from contamination is perhaps even more difficult.

A major challenge to determining the precise contributions of the environment to HAI transmission is the design of studies that are not only capable of yielding high-quality data, including patient-centered outcomes,(4) but that also take into consideration the inextricable interrelationships among environmental contamination, hands of healthcare personnel and patients, and patient care equipment. The complexity of these interactions is redoubled by the fact that hospital cleaning processes are often far less than ideal. Even under study conditions, using structured educational and procedural interventions for housekeepers, a maximum of only 77% of surfaces studied were adequately cleaned.(5)

After more than a century of suspecting that the environment plays a critical role in transmission of healthcare-associated pathogens, the healthcare epidemiology community has a modest volume of, primarily, circumstantial evidence, summarized nicely in this issue of the *Annals* by Han *et al.* The authors also describe some of the newly available tools that are necessary to answer questions about the significance of environmental contributions to HAIs, underscoring that we now have direct, rapid molecular assays, whole-genome

sequencing, and ATP detection kits to assess environmental contamination and to help establish links to patient isolates. Despite the increasing availability of such sophisticated tools, many questions about the role of the environment remain. Current tools cannot necessarily determine the directionality of transmission between colonized patients and the environment. Even whole genome sequencing, which can type isolates with exquisite resolution and determine relatedness, cannot differentiate whether a surface or sink drain was the source or the recipient of a patient's isolate. The gaps in the evidence base for hospital environmental cleaning and disinfection methods and monitoring will be filled best by randomized, controlled trials, rather than quasi-experimental studies. These are some of the key issues addressed in the systematic overview by Han and colleagues.

Han *et al.* did not include studies of fabric (e.g., curtains), healthcare personnel attire, or portable equipment, such as cell phones and stethoscopes, as these items are generally not surface cleaned and disinfected by environmental service staff. Their review also did not include studies of environmental contamination with gram-negative bacteria, as the role of the environment in the spread of these organisms in healthcare setting is even less well studied than that of gram-positive bacteria that were included in the review. Research on the importance of environmental contamination with gram-negative pathogens in the spread of HAIs is needed urgently, given the declining antimicrobial options for treating infections caused by gram-negatives as well as the complexity of their relationship with the hospital environment. For example, multiple studies have identified contamination of point-of use hospital plumbing with multidrug-resistant gram-negative pathogens. Virtually all of these studies underscore the fact that patient room surface cleaning does not disrupt bacteria that are ensconced in dense sink drain biofilm.(6, 7)

In addition to a tight web of evidence, we still lack the means to ensure that the environmental cleaning procedures are followed consistently. Even in a facility with a strong culture of safety, environmental service workers are sometimes a marginalized part of the healthcare staff, and may not always appreciate or be appreciated for the patient safety aspect of their work. Effective communication and education are essential, as are actionable, meaningful outcome measures.

The limited high quality data carefully assembled by Han and colleagues underscore the need for multicenter, carefully designed and controlled studies that can help us understand the magnitude of contribution of the inanimate environment to the pathogenesis of HAIs.(4, 8) Such studies can provide the scientific basis for the design and development of interventions that ultimately can be used to reduce harm and increase patient safety in the healthcare environment for decades to come.

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