Health Care: Using Apparel and Textiles as Personal Protective Equipment

Current fabrics allow bacterial pathogens to colonize exponentially over 24-hour period

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Infection rates cause an alarming 99,000 deaths per year and are estimated to cost the United States $30 billion per year, indicating current measures to control infections in health care settings need to be reevaluated and/or fortified. In addition, 1.7 million hospital acquired infections (HAIs) are contracted each year.

According to the National Conference of State Legislatures, between 5 and 10 percent of all patients contract at least one HAI during their stay in an acute care hospital. Between 20 and 40 percent of these HAIs are actually transmitted to patients via hand contact from healthcare providers despite frequent hand-washing.

These alarming rates have been addressed by best practice guidelines set forth by the Association for Professionals in Infection Control and Epidemiology (APIC), Association of Registered Nurses (AORN), and the American Hospital Association (AHA) among others. Even though best practices have reduced infection rates since their implementation, many institutions still find it difficult to achieve a rate similar to that of the national average, suggesting additional preventative measures should be considered.

In many cases, there have been addendums to best practices within specific institutions based on an outbreak or pattern specific to their location, but this “band-aid” approach does not get to the core of the issue. Throughout this paper, guidelines from a variety of agencies and associations that are used as resources in the health care field are referenced. The goal is to show there may be more ways to help minimize bacterial pathogen pollution than what is currently suggested and enforced, and that proper program implementation can lead to cost reduction.

Infection Control Guidelines and Compliance

According to the American Journal for Infection Control, infection control specialists should identify and implement infection control best practice guidelines and strategies related to the following:

1.   Hand hygiene
2.   Cleaning, disinfection and sterilization
3.   Specific direct and indirect care settings
4.   Infection risks associated with therapeutic and diagnostic procedures and devices
5. Recall of potentially contaminated equipment and supplies
6. Initiation and discontinuation of isolation/barrier precautions when indicated
7. Patient placement, transfer and discharge
8. Environmental hazards
9. Use of patient care products and medical equipment
10. Immunization programs
11. Construction and renovation in patient care
12. The influx with communicable diseases

Those in infection control are charged with risk reduction and infection prevention and provide consultative input into the physical design of patient care environments and are also responsible with playing a key role in the evaluation of new procedures and clinical technologies in patient care. The graphic below demonstrates the suggested Association for Professionals in Infection Control (APIC) Competency Model for the Infection Preventionist:

At the center of this model is patient safety. However, even with the implementation of best practice guidelines within health care environments, according to Infection Control Today, only 50 percent of healthcare workers are compliant with hand-washing procedures alone. Further increasing surveillance and incentives on hand-washing may help the issue with compliance, but what if additional measures could be taken to minimize the risk associated with a worker not washing his or her hands appropriately?

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Underlying Issues with Bacterial Pathogen Growth

On April 19, 2013, FDA issued a safety alert indicating:

From January 2011 to January 2013, the FDA received 458 reports associated with medical bed mattress covers failing to prevent blood and body fluids from leaking into the mattress (fluid ingress). Fluid ingress may occur if mattress covers become worn or damaged from small holes or rips in the fabric or from incorrect cleaning, disinfecting and laundering procedures. The zipper on the cover may also allow fluid to penetrate the mattress. Some reports indicate that if blood and body fluids from one patient penetrate a mattress, they can later leak out from the mattress when another patient is placed on the bed. Patients are at risk for infection if they come into contact with blood and body fluids from other patients.

FDA made the following recommendation per the alert:

The Safety Communication lists several recommendations for inspection and maintenance including:

- Regularly check each medical bed mattress cover for any visible signs of damage or wear such as cuts, tears, cracks, pinholes, snags or stains.
- Routinely remove the medical bed mattress cover and check its inside surface. Once the mattress cover is removed, inspect the mattress for wet spots, staining, or signs of damage or wear. Check all sides and the bottom of the mattress.
- Immediately replace any medical bed mattress cover with visible signs of damage or wear to reduce the risk of infection to patients.
- DO NOT stick needles into a medical bed mattress through the mattress cover.

Bodily fluids and/or blood’s presence for an extended period of time on a mattress or mattress cover is clearly an issue health care professionals and institutions want to avoid, knowing that bacterial pathogens colonize the longer they remain in an area. However, while FDA puts the responsibility of managing the mattress and mattress cover into the employee’s hands, there are other ways, such as changing the fabric used on the patient bed that may eliminate the worry of contaminated fluid ingress affecting a patient.

Poly-cotton has been used as a traditional textile and garment fabric in hospitals dating back to the early 20th century, yet many studies have shown that it is a vector for bacterial pathogen growth. In 1969, The Lancet published one study that showed the discrepancy between the transfer of an airborne particle tracer and Staph. Staph-aureus carrying particles earlier found in the ward could be explained by the dispersal of Staph-aureus from nurses’ clothing.2

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In addition, a 1973 study in *The Journal of Hygiene* showed there is evidence that bacteria-carrying particles rather easily pass from the surgeon's skin into the air when a conventional surgical outfit is worn (Duguid & Wallace, 1948; Hare & Thomas, 1956; Bethune, Blowers, Parker & Pask, 1965; Charnley & Eftekhar, 1968; Sykes, 1970), and several workers have tried to diminish this source of infection in operating rooms by introducing new materials as well as by altering the design of the outfit (Blowers & McCluskey, 1965; Bernard, Cole & Gravens, 1967). Although it has been shown that nurses' clothing becomes contaminated with staphylococci common in the ward during work (Speers et al, 1909; Lidwell & Towers, 1972), the importance of this has been very little studied. It may well be that this is an important means of secondary transmission in ordinary ward work as well as in barrier nursing when common protective gowns are worn. In a previous investigation in a burns ward (Hambraeus, 1973) it was shown that the transfer of staphylococci within the ward was much greater than the transfer of an airborne tracer particle. This indicates that transfer of Staph. aureus is not only due to air movement. In addition, it has been found that 90 percent of soft surfaces, such as textiles and garments within a hospital can be contaminated with bacterial pathogens.3

Another fabric that has been studied includes hospital privacy curtains. Studies have shown that 92% of privacy curtains in hospitals have been contaminated with Methicillin- resistant Staphylococcus (MRSA), Vancomycin-resistant Enteroccus and/or other bacteria within a week of laundering.4

Scott and Bloomfield (1990) demonstrated transfer of Escherichia coli (E. coli), Klebsiella aerogenes, and Staph. aureus from contaminated cloths to fingertips or to a laminated surface. Boyce, et al. (1997) reported that 65 percent of nurses who had performed care activities on patients with MRSA in a wound or urine, contaminated their nursing uniforms or gowns with MRSA.5

**Pressure Ulcers**

Although quality initiatives look at infection rates and, in particular, HAIs, these initiatives don't pay as much attention to pressure ulcers as they do other infections such as surgical site infections and catheter infections. This is predominately because there are different schools of thought with regard to pressure ulcers. When a patient develops sepsis, it is rarely as a result of the pressure ulcers and is usually due to some other cause; however, when the patient dies, the death certificate will often list sepsis due to pressure ulcer as one of the causes of death. The biggest problem with pressure ulcers is that the infection cannot be diagnosed form a cultural swab and, instead, must be done through a biopsy. Infection rates due to pressure ulcers, therefore, are rarely published. There are studies, however, that address hospital fabric textiles in relation to pressure ulcers, attributing healthcare bed linens and patient gowns made from cotton-blend fabrics as inherently deficient in

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4 Ohl, M., et al; *Hospital Privacy Curtains are Frequently and Rapidly Contaminated with Potentially Pathogenic Bacteria; Am J Infect Control; 2012 Dec; 40(10): 904-06.
5 Boyce JM, Potter-Bynoe G, Chenevert C, King T. *Environmental contamination due to methicillin-resistant Staphylococcus aureus: possible infection control implications.* Infection Control Hospital Epidemiology. 1997;18:622-627
keeping patients’ skin dry and in minimizing skin friction and shear. Specifically, the study found that the ability to rapidly wick moisture, transport moisture vapor and dry quickly, were important factors in helping fragile skin stay dry and minimize maceration. “To provide a quick-drying interface between the patient and the support surface, much like performance athletic apparel, very fine filaments within the continuous-filament yarns create micro-channels that are designed to wick moisture away and dry the bedding and skin more quickly than cotton fabrics.”

**Joint Commission Laundering Guidelines**

If garments and textiles are washed in an on-premise laundry, most commonly in hospitals, but also found in nursing homes, or are sent to industrial laundries, they are washed at the temperature of 160 degrees per the joint commission guidelines and depending on what they have been exposed to, also treated with a pH leveling acid. While the textiles and apparel will be effectively cleaned if processed according to the joint commission’s ruling, once they are reintroduced to the bacterial pathogens in the medical setting, they will begin to grow bacteria again and that bacteria will live on the garment or textile until it is washed again.

Unfortunately, the joint commission guidelines only apply to industrial laundries and hospitals and/or nursing homes with their own laundries. Many other health care environments such as clinics, ambulatory care centers, etc., allow their staff to buy their own scrubs and wash them at home. Most standard household hot water heaters in today’s market typically cannot reach 160 degrees. This issue is one of the reasons why bacterial pathogens are continually brought home by workers and patients and then back into the hospital the next day. A fabric that rids itself of contamination once washed at home, independent of the temperature, could not only lower energy costs, but contribute to lowering the risk of growing bacterial pathogens.

**Cost Impact**

Specific health care costs associated with HAIs include increased intensive care unit (ICU) stays of up to eight (8) additional days, and an average cost per infection of $13,973. The average increased cost per patient who survived the HAI is approximately $40,000.00. A patient who contracts a post-surgical infection significantly increases the chance of hospital readmission and death, with a cost of as much as $60,000 per patient. In fact, studies have shown that patients with surgical site infections due to MRSA were 35 times more likely to be readmitted and 7 times more likely to die within 90 days compared to uninfected surgical patients. Approximately 95% of the estimated $5 billion total health care cost from HAIs falls directly on the shoulders of the hospitals and patients.

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7 Id.
8 Schwegman, David MD; Prevention Cross Transmission of Microorganisms is Essential to Preventing Outbreaks of Hospital-Acquired Infections.
9 Id.
10 “Post-Surgery Infection Can Add $60,000 to Hospital Bill”; Health Day, December 18, 2009 citing Duke University Medical Center Study published online December 15, 2009 in PLoS One.
As a result of the new HAI reporting regulations adopted by the Department of Health & Human Services (HHS), hospitals who participate in the Centers for Medicare & Medicaid services (CMS) pay for reporting program must comply with the new reporting requirements and report infection rates. Most hospitals in this country participate in the program. As a result, patients are now able to see how their hospital fares with respect to HAI in that particular institution.\(^{11}\) In fact, individuals can visit Medicare's website to compare hospitals in the individual's city including the rate of HAI at each facility.\(^ {12}\)

According to the Consumer's Union Safe Patient project, this public reporting of infection rates will help save lives and money by pressuring hospitals to improve preventive measures against HAI. Further, given that Medicare reimbursement to hospitals will now be tied directly to how well the hospital protects against HAI, the incentive for hospitals to address rampant HAI within their facility is increased. Specifically, as of June 2010, CMS stopped reimbursing hospitals for the costs of HAI, placing the financial burden directly on the hospital.

The Environmental Protection Agency (EPA) has reported that hospitals spend more than $6.5 billion a year on energy and energy costs are expected to climb through 2030. Cutting energy costs $1.00 a square foot would equal adding $20.00 a square foot or $5.76 million in new revenue for the average-sized hospital.

**Legal Consequences**

Because evidence shows that the majority of HAI are preventable, hospitals have been placed at a greater risk of medical malpractice lawsuits. If a jury believes that a hospital failed to implement necessary infection prevention practices, the hospital could be found negligent or even grossly negligent, resulting in significant financial costs to the hospital.

A handful of states have enacted laws mandating that certain healthcare facilities implement infection control plans, specifically targeting MRSA infections. For example, Pennsylvania was one of the first states to mandate HAI reporting and the first to release public reports on infection data. In 2007, the state went a step further by requiring health care facilities, including hospitals, nursing homes and ambulatory surgical facilities to develop internal infection control plans based on evidenced-based practices. The law specifically targets MRSA by mandating that hospitals screen high-risk individuals for the antibiotic-resistant bacteria. Bonus payments were offered as incentives for those facilities that reduced infection rates by January 1, 2009. Illinois, on the other hand, was the first state to enforce reporting of HAI. In 2007, the state enacted two opposing pieces of legislation regarding hospital infection control. The first law required each hospital to establish a MRSA control program and mandated that, as part of the infection control program, a system of active surveillance testing be put in place to identify all MRSA-colonized ICU patients and other at-risk patients. Any patient with the MRSA bacteria would then be isolated. The second law took a more gradual approach to infection control by mandating that hospitals perform annual

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\(^ {11}\) Importantly, however, it should be noted that the reported data is predominately limited to Medicare patients and does not necessarily include data on all patients who acquire infections while hospitalized.

\(^ {12}\) [www.medicare.gov/hospitalcompare](http://www.medicare.gov/hospitalcompare)
risk assessments and develop infection control plans that followed CDC guidelines for all multi-drug resistant organisms, not only MRSA.

Twenty-seven state laws require public reporting of hospital-acquired infection rates while two state laws allow confidential reporting of infection rates to state agencies. Three states have voluntary public reporting of infection information and five states have study laws on public reporting.

The 10th annual Hospital Professional Liability and Physician Liability Benchmark Analysis described a rise hospital professional liability claims. The study found that 1 out of every 4 claims and 24 percent of hospital professional liability costs were associated with hospital acquired conditions including infections. At the Changing Legal and Regulatory Landscape conference sponsored by the Association for Professionals in Infection Control and Epidemiology (APIC) held in November 2009, a panel of experts addressed the legal issues surrounding HAIs. Panelist Russell Nassof stated "Changes in the regulatory environment, reimbursement practices and legal standards along with drastic changes in healthcare itself are creating a potential 'perfect storm' of liability and increase risk for healthcare-associated infections in healthcare facilities today." He noted that events that were previously thought of as risks were now considered to be preventable adverse events.

In 2009, a jury in Suffolk County, New York awarded $13.5 million to a 40 year old woman who died of a flesh-eating bacteria she contracted during chemotherapy treatment at Dana-Farber Cancer Institute.

Likewise, in 2009, after losing both of his legs and arms to a HAI (MRSA), a Texas man was awarded 17.5 million by a Texas Court. The patient was treated by an infectious disease specialist after developing an infection after surgery. The physician prescribed a number of antibiotics; however, only one of the drugs administered was used for the treatment of MRSA. MRSA is renowned for its resistance to most antibiotics. Ultimately, the patient went into septic shock which resulted in extensive damage to his extremities. Once the MRSA was diagnosed, gangrene had already set in and both of the patient's arms and legs had to be amputated.

**Risk Mitigation**
Consequences of a HAI outbreak within a facility can affect the entire healthcare facility system. From a quality and risk perspective, the facility must consider whether it is prepared to respond to the risk. An occurrence of a HAI can impact the facility in a number of ways including, but not limited to, patient health, patient death, malpractice lawsuits and attrition rates with staff, licensure issues, loss of good will in the community, damaged reputation, and financial liability.

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13 This amount was later reduced to $7.5 million after the medical malpractice caps were applied.)
As stated above, a HAI can result in costs as high as $60,000 per patient for the hospital. A $60,000 intervention to prevent even one of these infections would be cost-effective for the institution. As a result, greater emphasis must be placed on an effort to design and evaluate specific preventative interventions to reduce the incidence of HAIs. According to a study by the Healthcare Management Council, infections due to medical care made up the fifth most prevalent hospital acquired condition. It was the fourth most expensive category, costing, on average, $252,600 per hospital on average and each afflicted patient, on average, required $24,500 more in care.

Examples include a patient admitted with acute pancreatitis who developed MRSA in the bloodstream after admission resulting in an additional 86 day stay at a loss for the hospital of $41,913. Without the infection, the hospital would have made a profit. A woman hospitalized for a stomach-reducing surgery that would have produced a $9,900 gross profit for the hospital developed a central-line associated bloodstream infection and had to spend 47 days in the hospital, leading to a loss of $16,000 to the hospital.

Post-op wound infections more than double a patient's hospital costs, with costs increasing 119% with a post-op infection at a teaching hospital. Patients with Staph infections incur hospital costs more than triple the average costs of other patients.14

**Occupational Health and Safety Association Standards**

The Occupational Health and Safety Association (OSHA), part of the United States Department of Labor, set forth guidelines for personal protective equipment for all industries, which must be adhered to, as appropriate, by employers. The most updated final rule on personal protective equipment includes a suggestion from The General Electric Company and was later incorporated into OSHA's guidelines15:

Protective equipment training needs to include:

1. Where and how personnel can get the equipment,
2. A system for identifying the correct equipment for an application * * * procedures and operating manuals should include specifics on protective equipment types, needs and objectives,
3. Equipment should be shown to individuals prior to using each for the first time * * * let them touch and try the items on, the more senses you allow one to use during training the better the person will recall what he/she learned,
4. Persons should not be considered competent in protective equipment items until they do a practical test * * * are able to properly put on the item, explain what protection it provides, etc.

In a 2008 study of healthcare uniforms as possible sources of infection in a 550 bed general hospital, clinical findings indicated that up to 50% of professional uniforms worn by physicians and nurses were colonized by pathogenic bacteria, and

up to 28% of isolated pathogens were multidrug resistant.\textsuperscript{16} Approximately 30% of healthy people are carriers of Staph aureaus.\textsuperscript{17} When a bacterium is shed into a textile fabric between the patient and the bed, either on the patient’s gown or directly on the sheet, the moisture and temperature in the textile microenvironment promotes its proliferation. This is indicated by the fact that bacterial colonization of sheets, including MRSA, was found in 22 out of the 30 sheets examined in a clinical setting.\textsuperscript{18}

Currently, health facilities do not enforce standard guidelines for personal protective gear in the garments or textiles they use. However, these items can actually act as personal protective gear if able to disallow bacterial pathogens to grow. Employees in health care are putting themselves at risk each time they enter their facility and other environments if they are wearing items contaminated with bacterial pathogens. Putting forth standard that United States facilities must adhere to for their uniforms, would protect patients and professionals. The Centers for Disease Control (CDC) has already determined that hospital textiles are significant vectors for transmission of bacterial pathogens and nosocomial infections.\textsuperscript{19}

**Affordable Care Act**

While appropriate antimicrobial usage is currently being investigated by the CDC, there will be a significant amount of time to pass before any decisions are made. While this information is being collected and analyzed, many people will be affected by nosocomial infections because health care facilities will continue business as usual until the guidelines are officially updated.

According to the CDC:

Investments provided through the Affordable Care Act (ACA)\textsuperscript{\textregistered} Prevention and Public Health Fund will be used to bolster states’ abilities to prevent healthcare-associated infections (HAI). Using our country’s proven public health infrastructure to prevent healthcare-associated infections strengthens our ability to improve the health and well-being of all Americans. The Affordable Care Act funding includes the activities outlined below:

1. **HAI Prevention Infrastructure** is the coordination and implementation of HAI prevention activities within the state, facilitation of the state multidisciplinary advisory group on HAI, and implementation and reporting on progress of the state HAI plan.

2. **HAI Prevention Initiatives** is the development and implementation of multi-facility HAI prevention efforts, including those to prevent multi-drug resistant organisms (MDRO) and *Clostridium difficile* infections.

3. **Antimicrobial Use Surveillance** supports measuring antimicrobial usage data to provide the foundation for implementing and evaluating interventions targeting the reduction of unnecessary and/or inappropriate use of antimicrobials.


\textsuperscript{17} Beggs, CB.; The airborne transmission of infection in hospital buildings: fact or fiction?; Indoor Built Environ 2003; 12:9-18.

\textsuperscript{18} Gabbay J., et al; Copper oxide impregnated textiles with potent biocidal activities; J. Indust Textiles 2006: 35: 323-35.

\textsuperscript{19} Borkow, G. and J. Gabbay. "Biocidal textiles can help fight nosocomial infections". 2008, Medical Hypotheses, vol 70(5), pp 990-994
4. **Electronic Laboratory Reporting** is the reporting of LabID Events to the [National Healthcare Safety Network (NHSN)](http://www.cdc.gov/hai/stateplans/aca/aca-funded.html) as well as the reporting of electronic laboratory records (ELR), ultimately resulting in a reduction of data-entry burden and increasing the validity of data reported by NHSN to Centers for Medicare and Medicaid (CMS) for value-based purchasing.

5. **Public Health Partnership** investments will fund a fellowship program to increase the number of HAI prevention staff in state health departments, identify and evaluate policies effective in moving towards HAI elimination, and provide HAI prevention training and tools to local health departments.20

**Reusables and H2E**

The history of Practice Greenhealth began in June of 1998, when the American Hospital Association and the US Environmental Protection Agency signed a landmark agreement to advance pollution prevention efforts in our nation’s healthcare facilities. The resulting Memorandum of Understanding became the cornerstone of the Hospital for a Healthy Environment (H2E) program, and called for: virtual elimination of mercury waste, reduction of the healthcare sector’s total waste volume, chemical waste minimization, and a variety of educational and information sharing activities focused on pollution prevention and toxics minimization.

In September 2001, H2E became a partnership of the AHA, EPA, Health Care Without Harm (HCWH), and the American Nurses Association (ANA). With funding from the EPA with assistance from HCWH, H2E hired core staff and began outreach efforts to the healthcare sector. A primary focus was getting hospitals to commit to the goals of the MOU by becoming “Partners for Change”. The program also targeted healthcare companies and the supply chain, encouraging participation in its “Champion for Change” program. A subsequent focus involved setting up state-level support networks for hospitals trying to achieve the goals of the MOU.

By 2006, the H2E program had 1,342 Partners representing 7,148 health care facilities including 1,604 hospitals, 3,674 clinics, 912 nursing homes and 958 other types of facilities. Despite H2E’s substantive success in engaging the sector, EPA funding for the initiative dwindled in 2006, and HCWH took a leadership role in helping H2E become an independent not-for-profit organization. H2E expanded upon the original goals to include:

- Virtual elimination of mercury
- Reduction of the quantity and toxicity of health care waste – from manufacturing, purchase and use of products and materials, to improved end-of-life management
- Minimization of use and exposure to hazardous chemicals, including persistent, bioaccumulative, and toxic (PBT) substances
- Reducing health care’s environmental footprint through resource conservation and other measurable environmental improvements

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20 [http://www.cdc.gov/hai/stateplans/aca/aca-funded.html](http://www.cdc.gov/hai/stateplans/aca/aca-funded.html); Accessed on April 29, 2013
Integrating sustainable design and building techniques with environmentally sound operational practices to create true healing environments

In January of 2008, H2E was reorganized and renamed Practice Greenhealth, in order to more accurately reflect its new role as a membership organization representing healthcare organizations committed to the integration of sustainability principles and practices as a means to better protect the health of patients, staff, the communities served, and the environment.21

Shifting to reusable products with a longer lifecycle that also have bacteriostatic and bactericidal properties, would carry out one of the key missions of H2E, which has already been widely adapted. In addition to helping the environment, these types of products would also lower costs.

**Personal Protective Gear in Health Care: New Model for Use of Fabric, Processing, and Handling Apparel and Textiles**

Some precautions can be taken now, while CDC collects its data on the appropriate use of antimicrobials. Focusing on the patient bed and health care professional can theoretically add to the reduction of bacterial pathogen growth in a medical environment.

*Suggested precautions can include, but are not limited to:*

- Phasing out the use of fabrics that allow bacterial pathogens to grow.
- Establishing an employee uniform for health care settings that includes scrubs and physician coats made of bacteriostatic fabric.
  - To positively affect energy costs, utilize a fabric that can be washed in cold water and dried at a low setting, while washing away bacterial pathogens regardless of temperature.
- Utilizing bactericidal fabrics for textiles in the patient bed – patient gown, pillow case, sheet, incontinent pad and patient curtains.
  - Implement operating room/special unit uniform made of bactericidal fabric.
  - Use only a top sheet (no fitted sheet) that does not need to be ironed. This approach cuts down on costs and can control up to 4 percent of airborne pathogens transferred to air when fitted sheets are changed (find source).
- Creating appropriate operational procedures for wearing uniforms in and out of the hospital.
- Implementing an RFID program to lower replacements needed for uniforms and for quality control.

*This white paper has been reviewed by Dr. George Allison Glass*

21 [https://practicegreenhealth.org/about/history](https://practicegreenhealth.org/about/history); Accessed May 2, 2013