

How an intelligent infrastructure can help optimize hospital safety and security

by Michael Sullivan
Graeme Robertson
Steve Nibbelink
Ginni Stieva
Chris Roberts
Grant Neave

Executive summary

The Joint Commission, a non-profit organization that accredits and certifies U.S. healthcare organizations, has reported that 8-10% of all of the adverse events that lead to death or permanent loss of function in hospital patients are directly related to poorly designed hospital facility systems. This paper discusses how implementing or improving automated facility systems can systematically reduce preventable adverse events and explores the key areas of patient safety that can be most greatly affected by adopting this automated approach.

Summary

- Executive summary.....3
- Poorly designed facilities affect patient safety and staff performance.....4
- Automated building infrastructure solutions for the “intelligent hospital”8
- Increasing patient security and preventing violence8
- Reducing airborne infections 10
- Safeguarding against power failures and electrical fires 12
- Patient rooms designed for safety..... 14
- Case study: Improving patient security and reducing risk of violence 15
- Conclusion..... 16

Executive summary

No one ever expects it. A fire in a Florida hospital's electrical vault destroys the emergency power system, resulting in surgeons completing operations by flashlight, patient evacuations, and the total shutdown of the facility. In the U.K., two are injured in a hospital stabbing, while across the globe in Australia mental patients attack a nurse.

Patient safety is a serious problem in healthcare organizations around the world – whether the threat is a power failure, a security breach, or airborne infections. According to the World Health Organization (WHO), about one in 10 patients is harmed while receiving care in even the most advanced hospitals. Compare this statistic to the chances of being harmed in a commercial airplane or in a nuclear power plant – 1 in 1,000,000.

In 2005, WHO launched the World Alliance for Patient Safety program. Sadly, despite the positive outcomes of this program to date, it is estimated that 2 million patients will be harmed and 120,000 patients will die annually due to preventable adverse events in U.S. hospitals. In the U.K., the National Health Service (NHS) estimates that 850,000 patients are harmed due to adverse medical events. And in Germany, a 2010 article by UPI.com reveals that 17,000 deaths in that country are the result of lapses in patient safety, as reported by the German Coalition for Patient Safety. In light of worldwide statistics like these, it is no surprise that patient safety is one of the top two concerns of hospital senior managers today.

One of the first steps to reducing errors and situations that threaten patient safety is to make them more transparent and easier to report. While hospitals have already begun to do this by implementing patient identification strategies, they need to extend this kind of transparency to the hospital building infrastructure itself in order to guard against power loss, security breaches, and airborne infection threats. And for good reason. Statistics compiled by the Joint Commission, a non-profit organization that accredits and certifies more than 18,000 healthcare organizations and programs in the United States, indicate that 8 to 10 percent of all of the adverse events that lead to death or permanent loss of function in hospital patients are directly related to poorly designed hospital facility systems.¹

This white paper will discuss how hospitals can implement or improve their automated facility systems to systematically reduce preventable adverse events resulting from hospital violence, hospital-acquired infections, and power losses, as well as IT glitches that prevent access to electronic health records and patient identification systems. It will also explore the key areas of patient safety that can be most greatly affected by adopting this automated approach. Ultimately, by implementing “intelligent” facility systems, hospitals can improve patient safety and quality of care, and provide a secure hospital environment.

¹ Statistics are calculated based data for sentinel events related to facilities in the 2010 Joint Commission report: Summary Data of Sentinel Events Reviewed by The Joint Commission ([http://www.jointcommission.org/assets/1/18/SE_Data_Summary_4Q_2010_\(v2\).pdf](http://www.jointcommission.org/assets/1/18/SE_Data_Summary_4Q_2010_(v2).pdf))

Poorly designed facilities affect patient safety and staff performance

Patient safety has been at the forefront of hospital management concerns, particularly since the Institute of Medicine’s (IOM) report, *To Err is Human: Building a Safer Health System*.² In November 1999, this groundbreaking book, based on the analyses of multiple studies by a variety of organizations, exposed the frightening statistic that between 44,000 and 98,000 people die each year as a result of preventable medical errors. Since then, the IOM has continued its crusade by focusing on preventable medication errors.

However, multiple healthcare watchdogs across the globe, including WHO, the Joint Commission, and the Joint Commission International, along with private hospital accreditation organizations such as DNV Healthcare and nonprofit groups such as the U.K.’s Patient Safety Research Program at the University of Birmingham, have collaborated to identify and develop solutions for patient safety that extend beyond medication management. For example, in their Patient Safety Solutions Preamble of May 2007³, WHO and the Joint Commission expressed their goal to “promote an environment and support systems that minimize the risk of harm despite the complexity and lack of standardization in modern healthcare.”

Hazards

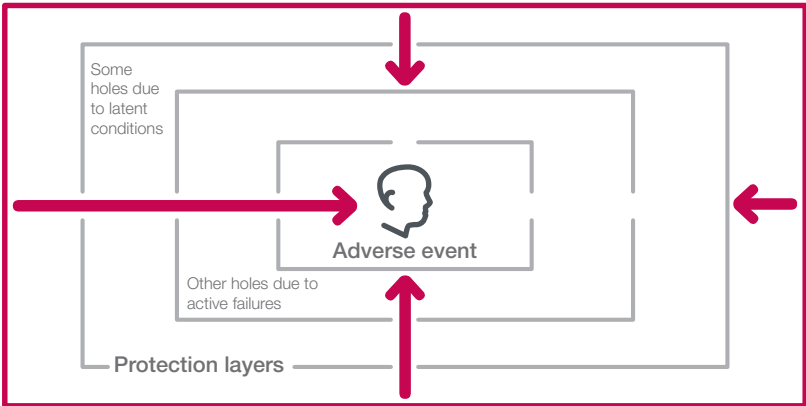


Figure 1. Active failures and latent conditions cause adverse events. Based on the “swiss cheese” model by J. Reason.

Patient safety begins with the prevention of preventable adverse events, which are usually an indicator of “missing” systems, checks and balances, or failure to adhere to systems that would ordinarily catch and prevent errors, as shown in Figure 1.

² Institute of Medicine. “To Err is Human: Building a Safer Health System.” November 1999.
³ World Health Organization in collaboration with The Joint Commission, and the Joint Commission International. “Patient Safety Solutions Preamble.” May 2007.

Typical approaches that healthcare facilities use to improve patient and staff safety include:

- Improving the level of staff attention and focus on potential sources of errors and adverse events.
- Developing manual procedures to prevent individual errors and perform audits to ensure compliance.
- Performing root cause analysis and development of systematic approaches to avoid errors.

While these general approaches are good first steps, one of the best defenses for hospitals is to implement intelligent, automated facility systems that help to prevent error from happening in the first place and enforce compliance with healthcare industry patient safety standards.

So what makes hospitals so dangerous? The Joint Commission has created a list of “sentinel events” that comprise the most common threats to patient safety. From this list, researchers at the Boston University School of Health⁴ identified key preventable adverse events that can be directly related to the performance of hospital facility systems (Figure 2).

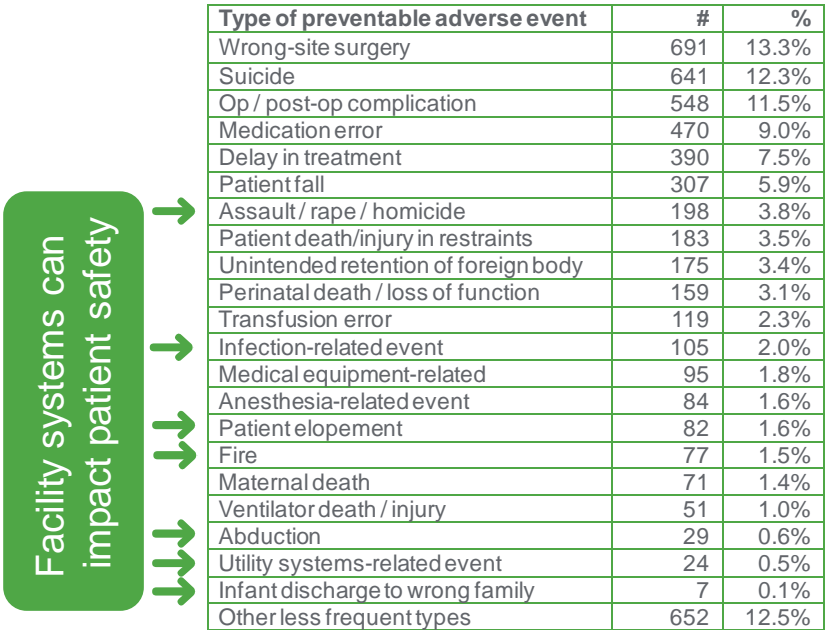


Figure 2. Preventable adverse events related to facility systems

⁴ Koseki, S., Lucas, R., Schwarzer, "A. Energy to Patient Safety." December 2010.

The above events fall into several key threat areas: violence, power failures and electrical issues, airborne infections, and more indirectly, failure of IT systems that support electronic health records (EHRs) and other patient identification systems. As you can see, the quality of a hospital's building infrastructure and operation contributes greatly to the overall quality of patient care and degree of patient safety.

What's more, a growing body of evidence⁵⁻¹² now links the physical environment with safety and quality outcomes for both patients and staff. Working in a hospital environment that is exceptionally noisy, with poorly regulated temperatures (too hot or too cold), and with poor air quality can take a physical toll on staff, leading to fatigue, cognitive overload, and poor communication. All of these factors affect the performance of hospital staff and bring about the human error that precedes many of these preventable adverse events. Psychologically as well, staff and patients alike can suffer emotional stress and possible physical harm in facilities with inadequate security systems to protect against violence or unstable power systems that cannot reliably sustain life-saving medical devices and machines.

A November 2010 presentation, *Hospital Construction with Infection Control in Mind* by Constance Nestor, FACHE, Chair, Standards Committee, IFMA Healthcare Council, paints a clear picture of these threats. Nestor reported that of all of the categories of sentinel events reported to the Joint Commission in the second quarter of 2010, 67 percent resulted in death of the patient. Specific to the hospital environment, 3.8 percent of the incidents were related to assaults/rape/homicide; 2.1 percent were related to infections; 1.5 percent to patient elopement; 1.5 percent to fire; and 0.5 percent to abductions.¹³

⁵ Ulrich RS, Zimring C, Joseph A, Quan X, Choudhary R. "The Role of the Physical Environment in the Hospital of the 21st Century: A Once-in-a-Lifetime Opportunity." Concord, CA: The Center for Health Design; 2004.

⁶ Reason J. "Human error." New York: Cambridge University Press; 1990.

⁷ Reason J. "Human error: models and management." *BMJ* 2000;7237:768-70.

⁸ Ternov S. "The human side of mistakes". In: Spath, PL, editor. *Error reduction in healthcare*, pp.97-138. San Francisco: Jossey-Bass; 2000.

⁹ Moray N. "Error reduction as a systems problem". In: Bogner, MS, editor. *Human error in medicine*, pp.67-91. 10 Hillsdale, NJ: Lawrence Erlbaum Associates; 1994.

¹¹ Nolan TW. "System changes to improve patient safety." *BMJ* 2000;7237:771-3.

¹² Reason J. "Swiss Cheese Model of Human Error," 1991

¹³ Nestor, C. "Hospital Construction with Infection Control in Mind" (presentation). November 2010.

Among the root causes, the safety and security of the hospital environment accounted for more than 35 percent of these events. Some of the key environmental factors indicated by the IFMA were noise, temperature, and faulty processes that contributed to staff fatigue, distractions, and interruptions.

The IFMA report also cited airborne infections, especially ones caused by multi-drug resistant organisms, as a key threat to hospital patient safety. Moreover, Nestor pointed out the risk of harmful nosocomial aspergillus (mold) outbreaks caused by poorly maintained plumbing fixtures, ceiling tiles, and the demolition debris produced by hospital construction or renovation. Once released, mold can be literally tracked throughout a hospital facility on the soles of staff and visitor shoes.

Automated building infrastructure solutions for the “intelligent hospital”

Hospitals have the opportunity to create safer environments for patients and staff alike by strategically building defenses, barriers, and safeguards into building management systems, security, and IT support systems (Figure 3). Automating these systems and making them more “intelligent” can minimize preventable adverse events that result from failure to adhere to protocols or from unexpected system failures.



Figure 3. Components of an intelligent healthcare and security infrastructure

Increasing patient security and preventing violence

Patient security issues range from the rare, but tragic infant abductions to more common patient elopements – when a patient leaves the hospital against medical advice. In these cases, the hospital is held responsible, and thus can suffer damage to its reputation, as well as ensuing financial damage in the form of lawsuits.

Violence against hospital staff and patients is another troubling and escalating hospital security issue. According to the International Association for Security & Safety (IAHSS) 2010 Crime and Security Trends Survey¹⁴, the overall number of violent incidents occurring in the 212 hospitals surveyed increased to 14,991 – specifically a total increase of 7,227 crimes, representing twice as many as reported in the IAHSS’s 2004 survey. The IAHSS survey respondents who have seen improvements in security at their hospitals cited physical security upgrades, alarm and CCTV system upgrades, and improved reporting procedures and mechanisms for reporting crime and violence among the key reasons for the improvements.

According to a 2007 study by the Emergency Nurses Association, the majority of ER nurses have experienced physical or verbal violence while at work. And these security threats occur around the world, in both public and private hospitals (Figure 4).

Physical violence	
Spit on	77%
Hit	72%
Pinched	71%
Scratched	70%
Kicked	68%
Pushed	56%

Verbal violence	
Sworn at	96%
Yelled at	96%
Called names	95%
Threatened	76%
Sexual innuendos	74%
Intimidated	70%

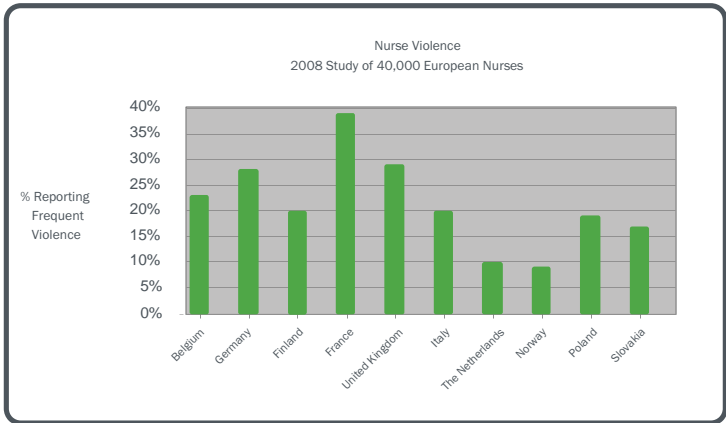


Figure 4. 2008 study of violence against nurses in Europe

In the U.K., research data from the National Health Service (NHS) report, Violence Towards NHS Staff from the Public, indicates that verbal abuse and threats of physical violence to hospital staff are also ongoing security issues. The report states that 2 in 5 or 41 percent of the respondents experienced verbal abuse from the public over the past 12 months. One in ten respondents reported that they have been threatened by physical violence, with 14 percent having experienced 6 or more threats over a 12-month period. Most disturbing, 2 percent of the respondents indicated that the threats were carried out with physical assaults.

¹⁴ Mikow-Porto VA, Smith T. "The IAHSS 2010 crime and security trends survey." *Healthcare Intelligence*. 2010;26(2):1-23. | 9

The primary goal of a hospital's security and safety department is its active support of the lifesaving mission of the healthcare organization. To that end, intelligent and integrated security management systems can improve patient, visitor, and staff security in many ways. Hospitals can:

- Enable security personnel to respond faster to adverse events through better availability of information delivered through integrated security technology, including access control, video surveillance, alarm systems, elevator access management, visitor management, perimeter protection, and patient management systems.
- Reduce the probability of violence through the combination of integrated security technology and comprehensive training of hospital and security staff in recognizing the warning signs of language and behavior prior to a violent event.
- Improve patient security to guard against infant abductions and “elopement” or patient leaving the hospital against medical advice with RFID devices for patients and infants. This could be particularly important in mental health wards, maternity and nursery wards.
- Tag medical equipment to improve patient safety because hospital staff will always know where the equipment is and can react to the patients needs more quickly.

Additional benefits of integrated security management systems include the ability to monitor hospital areas from a common dashboard, as well as automated maintenance management and the more efficient use of network bandwidth to integrate security systems with the hospital's IT infrastructure.

Reducing airborne infections

The Joint Commission has made the reduction of hospital-acquired infections – infections acquired as a result of a hospital's physical environmental conditions—a priority in the crusade for improved patient safety. Airborne infections in particular, which are spread by inadequately maintained ventilation systems, are continual threats to patients whose immune systems are already compromised by illness.

Hospital maintenance management is challenged daily to ensure that the indoor environment meets required standards to prevent infection without adding the operational expense of employing extra maintenance personnel. Without adequate resources, it is difficult for maintenance to maintain the correct number of air changes according to standards, humidity levels, and pressure differentials 24 hours a day, 365 days a year.

At any time, over 1.4 million people world-wide suffer from infectious complications associated with healthcare.

Source: WHO guidelines on Hand Hygiene in Healthcare

Healthcare-acquired infections cause approximately 90,000 deaths annually in the U.S. alone.

Source: U.S. Centers for Disease Control (CDC)

Because controlling the hospital environment and reducing human error leads to effective infection control, Schneider Electric recommends building intelligence into the ventilation system to optimize patient safety and maintenance. Recommendations include:

- Automatically monitoring and maintaining humidity, ventilation, air pressure, and HEPA filters in real-time to ensure that building systems conform to prescribed standards, thereby reducing airborne infections (Figure 5).
- Ensuring temperature and humidity conditions are controlled to the design requirements, not only to maintain comfortable and healing conditions for the patients, but also to prevent mold, fungi, and bacteria, as well as ensure that dust contaminants are ventilated out of the patient rooms.
- Reducing infections spread by contact by electronic monitoring of hand hygiene and reporting results to drive compliance via peer pressure.
- Installing passive infrared light switching and copper/silver surfaces to limit transmission of germs.

Hospital area	Minimum air changes per hour	Relative room pressure	Relative humidity	Temperature	Filter
Surgery and Critical Area					
Operating room	20	Positive	20-60%	20-23°C	HEPA
Delivery room	20	Positive	20-60%	20-23°C	MERV-14
Trauma room	15	Positive	20-60%	21-24°C	HEPA
Nursing					
Patient room	6	-	-	21-24°C	MERV-14
Newborn nursery suite	6	Negative	-	-	MERV-14
Airborne isolation room	12	Negative	-	24°C	HEPA
Protective environment room	12	Positive	-	24°C	HEPA

Figure 5. US standards for environmental control of airborne infections¹⁵

The Joint Commission also requires healthcare facilities to manage risks associated with their utility systems, including domestic hot water systems, portable water systems, and other aerosolized water systems, such as showers. Schneider Electric recommends the maintenance of hygienic conditions within water systems by installing automated flushing systems for patient rooms to prevent legionella, water stagnation, and microbiological growth while eliminating the need for regular manual flushing and resultant human error. Continuous monitoring of department DHWS pipe work is also recommended to avoid low temperature conditions leading to growth of legionella.

¹⁵ American Society of Heating, Refrigeration and Air Conditioning (ASHRAE) Standard 62.1-2010 – addendum D

Safeguarding against power failures and electrical fires

In the wake of Hurricane Katrina, a large New Orleans hospital and its corporate parent were sued by the families of two patients who died after the hospital's emergency power system failed and caused an interruption in the patients' care. But it doesn't take a natural disaster for a hospital to experience power failure issues. In a New Delhi, India, a hospital patient died after the patient's life support system collapsed when the hospital's backup power system did not kick in after a power outage. In another incident, patients had to be evacuated from a Wellington, New Zealand hospital after a massive power cut and failures of the hospital's backup generators. And the list goes on.

Reliable power and emergency backup is a must in hospitals to ensure patient safety. This is especially critical in the operating theatre, where the patient's life depends on medical machinery and advanced devices used by the surgical team. Even in the patient room, patient lives depend on the reliable operation of electrical-powered machinery for life support, kidney dialysis, and other sophisticated treatments. In addition, if the power quality is poor and unmitigated, breakers can trip, and equipment can shut off unexpectedly and/or be damaged.

The prevention of electrical fires is also high on the list of patient safety strategies. About 10 percent of all fires in hospitals are related to faulty electrical systems. Other typical causes of fire are sparking by damaged cables, improper disposal of heat devices and improper placement of light sources that maintain heat. In addition, there is the risk of surgical fires in the operating theatre or operating theatre, which can occur when electro-surgical units are activated in oxygen-rich environments and flammable alcohol-based prepping agents are ignited on the patient's skin.

To safeguard against power failures and electrical fires, Schneider Electric recommends the following solutions.

- Resilient electrical distribution architectures can minimize faults, protect critical areas, and reduce electrical risks to maintenance staff. Electric distributions systems need to be maintained, upgraded, and serviced to meet the always changing electrical demands of a healthcare environment, which will help to minimize ongoing costs.
- Automated monitoring ensures power quality and notification of any issues that arise. In addition, using UPSs on critical equipment will mitigate the risks caused by poor power quality.

- Automated testing of electrical distribution system and emergency power supply systems (EPSS) counteract the consequences of human error. By improving the electrical distribution system reliability, hospitals can both improve patient safety and reduce the financial risk of malpractice and wrongful death suits. Automated systems also ensure compliance to regulations and produce compliance reports.
- Automated solutions for monitoring data center power and cooling can make the IT infrastructure more robust and secure. As a result, hospitals can better protect their investment in EHR systems designed to improve patient safety by having updated and accurate information instantly available throughout the continuum of care. Most of all, these power solutions reduce the risk of not being able to access EHRs in life threatening situations.
- Isolated electrical systems for the critical areas of hospital ensure critical procedures can continue without delay or danger. Patients and staff in the operating theatre, intensive care units, and recovery units are protected from shock due to electrical ground faults.
- Solutions that monitor and alert staff to oxygen levels and heat sources in the room through localized and general air and heat detection systems can prevent surgical fires. The operating theatre staff can act on real-time electrical fault data provided on a screen in the operating theatre, without waiting for a notification from the maintenance staff. Secure, high availability power distribution provides a safer, isolated electrical supply to the operating theatre.
- Automatic alarming for overloaded circuits can prevent electrical fires and ensure that the electrical protection scheme is well coordinated to minimize any disruption.
- Implementation of industry standards and codes for specific electrical earth system connections helps prevent electric shock for staff, patients, and visitors who come in contact with high voltage medical machinery.
- Using redundant electrical distribution architectures throughout the facility ensures high levels of power availability and reliability.

Patient rooms designed for safety

Schneider Electric's experience with healthcare clients has proven time and again that intelligent hospital facility systems can help prevent adverse events and thus improve patient safety. And the most successful results come from the tight integration and automation of building management, power management, security management, room control, and IT infrastructure. Integrated systems manage the facility's active safeguards, while alarms across systems alert staff as soon as an event occurs that will impact patient safety.

In addition to the hospital-wide safety measures to reduce risk of violence, patient elopement, utility failure, and electrical fires, more focus should be paid to creating patient-safe rooms that include:

- Standardization of room design for electrical outlets, medical gases, nurse call buttons, panic buttons, and monitoring through PDAs, pagers, and nurse stations.
- Infection control through humidity/air change monitoring and laminar flow, surface decontamination, and electronic monitoring of hand hygiene.
- Integration of fall monitoring systems to reduce incidents of patient falls.
- Bedside computer integration systems to support barcode medication management systems, patient identification systems, and use of electronic health records.

Case study: Improving patient security and reducing risk of violence

Royal Children's Hospital Melbourne, in Victoria, Australia engaged Schneider Electric to design an integrated, automated building system to improve patient security and reduce the risk of violence to its staff and patients. As a result of Schneider Electric's solution, Royal Children's Hospital will benefit from:

Risk protection

- Reduced risk of violence thanks to defense perimeters supported with video surveillance, access control, panic buttons, and integration with visitor management and identification databases

Security effectiveness

- Lower CapEx and OpEx due to integrated security subsystems
- Ease-of-use and streamlined operations with an integrated command and control center
- Tight coordination between video surveillance, access control, infant tagging, and photo identification system reduces the risk of infant abduction incidents
- Video surveillance, wandering monitors, and access control for added security
- Convenient smart card/e-purse for access control reduces the risk of patient elopements
- Improved energy efficiency and maintenance with BMS integration

Royal Children's Hospital Melbourne (Australia)



Major pediatric hospital in Victoria

Intelligent BMS maximizes patient safety

One healthcare project management makes the project simple and efficient

Global supervision
> Intelligent BMS

Power management
• High density metering
• Local LV/MV protection & control

White space management
• Uninterruptible power supply

Building management
• HVAC control
• Lighting control
• Patient room control

Security management
• Video security
• Intrusion detection
• Access control

Ecostructure

Conclusion

Hospitals are meant to be places of healing and safety. Yet threats to patient safety and hospital staff security from both external and internal sources continue to overshadow the physician's oath to "do no harm." In Schneider Electric's view, implementing intelligent, automated facility systems is a hospital's best defense against adverse events that cause life threatening and debilitating injury to patients.

Moreover, hospitals whose facilities are designed to be safer can gain a competitive advantage. Patients have a choice of where they get healthcare – or the insurance companies make the choice in their provider networks. Hospitals that can demonstrate they have a safer facility will be the obvious choice of both.

In addition, hospitals can achieve significant cost savings by avoiding adverse events that harm patients. Most significantly, they can avoid costly litigation, fines, and lost revenue caused by bad publicity and lawsuits filed by the patient's family. Researchers at the Boston University School of Health estimated that the average settlement for a lawsuit related to a surgical fire in a U.S. hospital is \$1.75 million.

Schneider Electric is a global specialist in energy management with solutions to make the intelligent hospital a reality today. We partner with clinicians, facility managers, and the construction design team to anticipate patient safety concerns, minimize latent error conditions, and implement automated systems that include active defenses to prevent errors.

We integrate all facility systems so that the information flows directly to the people who need to respond to unsafe conditions as quickly as possible. Our intelligent integration solutions link systems in user-friendly format. For instance members of the facilities or security team can receive automatic notifications and view reports on facility systems or potential security threats and can respond quickly if problems arise.

Patient safety starts at the very foundation – the physical foundation – of hospital facility systems. As the world's population ages, as healthcare advances help people live longer, and as unhealthy lifestyles lead more people to seek care, hospital management must have stronger control over the physical environmental factors that can affect patient and staff safety. Schneider Electric believes that the intelligent hospital is the answer – and it is a solution that healthcare organizations can successfully achieve today.

Schneider Electric

One High Street,
North Andover, MA 01845 USA
Telephone: +1 978 975 9600
Fax: +1 978 975 9674
www.schneider-electric.com/buildings

