How facilities design affects patient safety, quality and productivity

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Abstract This paper analyses the impact of facilities design on patient outcome, patient satisfaction, patient safety, and staff productivity. It examines the common facility selection and procurement criteria that often overlook usability. The different dimensions of usability and aspects of design that can serve as guides in facility planning and selection are presented. The paper reviews several pitfalls as well as best practices and standards in ergonomic facility design. It concludes that to ensure the human-centredness of hospital facilities, management should involve all stakeholders, process owners and direct users and their early participation in facility planning.

KEYWORDS: facilities design, human-centred design, human factors, ergonomics, facility selection and sourcing, fail-safe, fault-tolerant, mistake-proofing, future-proofing, patient safety

INTRODUCTION

A number of studies have established that the physical environment can impact overall hospital performance, including patient outcome and staff productivity.[1] Facilities design, configuration and usability determine the main characteristics of physical environments. Facilities selection and sourcing are not merely technical and financial decisions that should involve only medical directors, department heads, chief financial officers (CFOs), procurement managers, cost engineers and architects. These influencers and decision-makers, although mostly professionals, may have little knowledge or appreciation of ergonomics or human-centred design and how this can affect clinical outcome, patient safety, patient experience and the efficiency of the delivery of care. The hospital leadership should ensure that usability is a major criterion in facilities design and selection by also involving or

consulting direct users, such as clinicians, operators, patients and their families.

Several studies show evidence of the lack of prior user involvement in facility decision-making and planning. One report estimated that 70 per cent of surgeons felt that operating room (OR) devices were not 'intuitively usable'.[2] Another study pointed out that 46.1 per cent of surgeons and 21.1 per cent of OR nurses reported difficulty in matching tubes and cables with their properly corresponding sockets.[3] Another reported that in one hospital, nurses wasted 49 minutes per shift while searching 23 times on average for the access keys to the narcotics cabinet, delaying treatment of patients.[4]

In the manufacturing industry, about 70–80 per cent of cost is determined during the product design stage.[5] In addition, the quality of the product and the yield and complexity of its processing are largely decided during this early phase. Few opportunities are left to cut costs, defects and processing time during production when design changes are impractical or infeasible. Similarly, the design and layout of a hospital and its facilities will largely decide the flow of people, material and information and how they would interact with one another. It would be difficult to improve safety, quality, efficiency and timeliness once these facility decisions have been made. High capex assets such as buildings, bulky equipment and their unique support infrastructures are difficult to change or reconfigure once procured, installed, constructed or bolted to the ground. Many healthcare organisations are improving patient safety, patient care and patient flow and are cutting operating costs long after the facilities have been procured. The usability of facilities is often an afterthought. Hospital management is alerted only after a facility-related or device-related incident or failure directly or indirectly causes an adverse event. The consequences of deficiencies in facility design could be higher costs not only in financial terms but also in terms of injuries and lives lost or put at risk. Correcting usability problems at the end is much costlier and more difficult than fixing or designing them at the beginning during the facility planning and selection stages.

LONG-TERM IMPACT OF FACILITIES

Facilities are permanent or semi-permanent tangible assets that may be fixed or mobile. Unlike drugs, medical supplies and other consumable resources, facilities have much longer lives and have a longer-term and larger impact on operational performance and efficiencies. In healthcare, facilities include the permanent structures like buildings, patient rooms, emergency room, OR, intensive care unit, common areas like hallways and elevators and semi-permanent assets like medical equipment, beds, furniture and fixtures. Facilities are repaired and maintained regularly because of normal wear and tear. Those with shorter lives like equipment may be replaced or upgraded more frequently than the more permanent structural ones like buildings and rooms. The longer the life of a facility, the longer its impact on hospital performance. The adverse effects of a facility with poor usability or design will persist until it is fully depreciated or removed at the end of its useful life or replaced when the investment has been recovered. A hospital building and its service components like plumbing may be depreciated 40 and 20 years respectively, although in reality many hospital buildings last 50–100 years.[6] Hospital management should view investments in facilities not only as a financial decision but also as a strategic decision because of their long-term impact on operating performance.

FACILITY DESIGN FOR PATIENT SAFETY

Human-centred facility design is one of the foundations of patient safety. Facilities can

help or hinder the critical flows in hospitals — process flow, workflow, patient flow, staff flow, material flow and information flow. Facility design can influence how staff and patients will interface with the facilities as users. Poorly designed and configured facilities can directly or indirectly induce errors by causing confusion, ambiguity, stress, clutter and congestion. Over time, even competent, vigilant staff can misuse a facility or equipment with poor usability. One study indicated that 'unfamiliar equipment' along with 'haste' and 'fatigue' is among the leading causes of adverse events during anaesthesia.[7] Another study estimates that 60 per cent of medical errors in the United States is due to usability problems, with X-ray, radio frequency devices, infusion pumps as the most error-prone equipment.[8] On the other hand, ergonomically designed facilities can improve patient safety and quality of care. Studies have shown, for instance, that the single-bedroom design creates a safer environment for patients and staff. It reduces adverse events like falls, cross-infections and stressors such as noise.[9] Another study showed that the acuity-adapted patient room that combines intensive care and step-down care improves patient safety. With this integrated design, patient falls are significantly cut, patient transfers are reduced by 90 per cent and medication errors are cut by 70 per cent.[10]

Hospital facility design must consider the frequent movement of people, material and equipment as well as their sensitive nature or condition. These movements may not be commonplace in other industries and could easily be overlooked during hospital facility planning. Patients are often transported and transferred in numerous handoffs. Multitasking overworked medical staff move around often with fragile patients, critical supplies or sensitive equipment. Facilities must be designed to facilitate these movements and minimise inconvenience, distraction and risk of injury to people as well as loss or damage to the material being transported. Facilities should not slow down or delay these movements as timeliness is critical in the delivery of healthcare services. Examples of deficient designs are narrow door openings, narrow hallways, insufficient elevator dimensions and steeply sloping floors and walkways that can hamper movements of both people and equipment such as beds and wheelchairs. Facilities like toilets, chairs and handrails with insufficient load-bearing capacities can fail and injure patients and visitors. Facility dimensions should be sufficient to provide for adequate, safe space allowance between people and equipment they are designed to accommodate.[11] For instance, the recommended spacing between incubators is 2.4m to allow for doctor's rounds, access of mobile equipment and prevent infection due to overcrowding.[12] The following are examples of best practices based on mistake-proofing principles to address people movement: placing the bathroom near the bed to reduce walking, putting sinks in visible places convenient for handwashing and painting lines on floors or walls to guide patients to frequently visited locations like the pharmacy, X-ray and payment centres.[13]

The design of the workplace environment is also critical to safety. A study of pharmacists noted a 16 per cent reduction in errors in reading prescriptions with higher intensity light and a 24 per cent reduction in errors in order entry with the use of prescription holders on monitors.[14] It is established that an illumination level of about 1,460lx significantly reduces the dispensing error rate compared with baseline illumination of about 450lx.[15] The right temperature, humidity and noise levels are also critical considerations in workplace design.[16] The recommended temperature for staff health and safety should be more than 16°C.[17] The humidity in ORs should not be more than 50 per cent to prevent infection.[18] Hospital noise levels should not exceed 40–45db (A) in the daytime and 35db (A) at night according to World Health

Organisation/Environmental Protection Agency standards.[19] Attention must be paid to these detailed ergonomic specifications during facility planning to avoid unnecessary stressors and ensure a safe working environment.

A new facility must be field tested with its users in the actual environment within the expected range of operating conditions. Testing equipment in a controlled, laboratory or showroom setting may not reveal the actual risks and potential usability issues it may have. A new piece of equipment must be checked for any adverse effects if placed near another facility such as another piece of equipment, windows, hallways, patient rooms or nursing units. Its installation should not cause narrowing of working space and cluttering, especially that of its cabling and wiring that can cause tripping and accidental misconnection or disconnection. New equipment can transfer heat, moisture, noise, vibration and other unwanted emissions to an existing adjacent facility and compromise the latter's operations. Conversely, for the same reason, existing equipment or facilities can inadvertently and adversely affect the performance of a new piece of equipment installed adjacently. New equipment and facilities must also be stress tested with their users in their actual physical and mental condition. Equipment operators are often multitasking, overworked and frequently distracted and interrupted in their work. A facility must have sufficient fail-safe features to ensure safe operations in a wide range of working environments and working conditions.

FACILITY DESIGN FOR PATIENT AND STAFF SATISFACTION

Facility design can affect the quality of care and of user experience. The deficient design and capacity of a hospital facility can lower both patient and staff satisfaction. Without careful planning, new facilities can inadvertently disrupt or complicate existing processes and patient flows. Studies have shown that the physical or built environment of the hospital influences the patient's comfort, privacy and perception of independence and control. For example, the acuity-adapted room improved patient satisfaction. Another study noted that facility design and the work environment it creates improved nurses' satisfaction and co-worker relationships.[20] A hospital in Asia had to move its laboratory facility outside after realising that outpatients, the laboratory's major user, were adding to inpatient overcrowding inside the hospital. The outpatients' entry into the hospital also unnecessarily exposed them to hospital infection. The costly relocation closer to the lobby and visitors unloading areas decongested the hospital. The more convenient location improved the outpatient experience. Billing and payment for laboratory services were also integrated into the relocated facility as a one-stop shop. Diagnostic facilities like X-ray and pharmacies, which serve mostly outpatients, are still located inside many hospitals, exposing them to unnecessary inconvenience and risks. Another cause of great inconvenience and stress to patients and visitors are long queues and long waits in front of slow or inadequate elevators. Elevators, like computed tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography (PET) imaging centres, are examples of 'monuments', or large facilities that are practically immovable and unmodifiable once installed. The features, capacity, location and speed of these facilities cannot be changed or improved once bolted to the ground. Existing hospital buildings typically do not have provision for additional elevators and other 'monuments'. Care and foresight must be exercised in the planning of these 'monuments' for they can become persistent dissatisfiers to patients and staff and act as permanent bottlenecks in patient flow and visitors flow.

FACILITY DESIGN FOR PRODUCTIVITY AND EFFICIENCY

The difficulty of operating and maintaining poorly configured and designed facilities increases their operating costs. Their poor usability also reduces the productivity and efficiency of users. More man-hours and manpower are needed to operate and monitor these facilities. Utilisation of facilities that are not user-friendly tends to be lower as users may use them less often or avoid using them at all, in effect, turning them into 'white elephants'. Studies show that facilities design and their physical and spatial configuration can pose structural obstacles, inefficiencies and constraints to staff while carrying out their tasks. Nurses consume more hours as their make more trips between medical units, spend more time searching for supplies and equipment and experience more fatigue. Centralised and decentralising nurse stations have different impacts on nursing productivity in providing patient care, including patient surveillance.[21]

Ergonomically designed patient rooms, working areas and medical equipment are easier to use and operate, requiring minimal efforts and less man-hours. For example, the single bedroom is a cost-effective design that reduces readmissions, length of stay and patient transfers. The acuity-adapted room significantly cuts clinician handoffs, reduces the budgeted nursing hours per patient day and increases the available nursing time for direct patient care without additional costs.[22] Placing floor markers around drug preparation areas improves the staff efficiency and accuracy in preparing medicine as distraction and interruption are minimised.[23] Hand- or foot-activated medical equipment whose reach does not exceed the arms or limbs of the smallest user are efficient and require less time to operate.[24]

FACILITIES SELECTION CRITERIA

The usability of facilities will be determined by the knowledge of ergonomics of the facility planners and decision-makers. Existing policies, perceptions, practices and paradigms that prevail in the organisation may also influence their decisions or choices. In a survey of more than 700 decision-makers, 60 per cent considered better clinical outcomes in the purchase of hospital equipment, while about 50 per cent considered lower costs. Usability did not count as a major criterion. The study also showed that physicians are the top influencers and also the top decision-makers in the purchase decision, outnumbering hospital CFOs and chief executive officers (CEOs). In this study, the equipment operators and technicians, the direct users, did not come out as important influencers or decision-makers in the hospital equipment purchase.[25]

The following is a more comprehensive list of criteria that hospitals and other healthcare organisations may currently be using in facility planning and procurement:

Economic criteria

- The one with the lowest price by the lowest bidder
- The one with the highest return on investment or shortest payback
- The one with the lowest operating cost
- The one with the lowest cost of ownership
- The one with the best value for money
- The one within the approved budget

Time criteria

- The most available in stock
- The fastest to source or import
- The easiest to set up or install within the given time frame
- The one with the shortest learning curve to operate
- The one most users are familiar with

Technical criteria

- The one with the best clinical outcomes
- The latest model with the latest technology
- The fastest and most efficient

- The one with the most features
- The one with the best after-sales service
- The one most compatible with current facilities
- The one that can fit the available space and other limited resources

Reputation criteria

- The industry standard
- The most popular model
- The ones offered only by accredited suppliers or brand
- The most recommended by doctors or 'what the doctor ordered'
- The most preferred by hospital executives, for example CEO or CFO
- The one used by the hospital group and its member affiliates
- The one mandated by a regulatory agency or central governing body like Ministry of Health (MOH)

While each criterion is valid and may have its own merit, it may not necessarily meet the standards of usability or expectations of the actual users. Most likely, it would not since usability is not the primary consideration and is given less weight. Regardless of the criteria or set of criteria used by management in facility selection, the direct users must the consulted or be made co-participants in the decision-making process to ensure usability.

FACILITY USERS

All possible stakeholders, users and non-users, present and future, regular and casual, direct and indirect, who will engage with the facility during its life cycle in different ways for different reasons must be taken into account in designing or selecting facilities. For healthcare facilities, they include equipment operators, patients and their families, doctors, nurses, maintenance technicians, visitors, passers-by and even unauthorised users, whether intentional or inadvertent. Facilities must be designed for both convenient and safe use. Facility life cycle covers selection, sourcing, procurement, delivery, installation or construction, operations or usage, maintenance and repairs, upgrade or expansion, dismantling or removal and disposal. The different users, decision-makers, process owners and other stakeholders during each stage must be considered and consulted in choosing facilities. Usability must consider the viewpoint not only of the users of the facility's output but also of their direct operators. For example, doctors may recommend or influence the choice of diagnostic equipment. They will use the output and reports generated by this equipment but not necessarily operate them directly. Those who would have to cope with any usability issue and shortcoming, if any exist, would be the equipment operators and technicians themselves who are often not part of the selection or procurement process.

Most hospital facilities have multiusers whose unique needs have to be met. Equipment may be used by both staff and patients who have different expectations, different touchpoints and varying levels of knowledge. They have to be designed to be staff-friendly and patient-friendly. Staff includes those who will operate the facility and those who will install, maintain and repair it. Hospital facilities should therefore be patient-friendly, operator-friendly, maintenance-friendly and visitor-friendly if visitors are allowed to access them.

USER INVOLVEMENT IN FACILITY DESIGN

User involvement in facility design decisions will ensure usability. To avoid problems in the production and marketing of new car models, leading car manufacturers practise concurrent engineering or parallel design, whereby all stakeholders from design, engineering, production, marketing, procurement, suppliers and customer representatives design the car together or in parallel in virtual meetings using computer-aided design (CAD)/computer-aided manufacturing

(CAM) technology. In the traditional sequential design process, designers and engineers design the product and parts. The next process owners such as manufacturing and suppliers, who were not involved in design, would then be tasked to make these efficiently. The buyers and customers are then expected to use them to their satisfaction although they were not directly consulted to validate the new design. Often, design flaws, like poor manufacturability and usability, are discovered after the product is mass produced and mass marketed. Defect reduction, rework and design changes at this stage are costly. Early and concurrent involvement of all stakeholders ensures that all potential problems and pain points are identified, addressed and removed during the design phase.

Hospitals and other healthcare establishments can adopt these proven concurrent engineering principles in facility design by involving users and other process owners early in design decisions. User involvement includes participation, consultation, validation, recommendation, suggestions and feedback. The highest form of user involvement is the user's or user representative's sign off on new facility design, layout, request for proposals (RFPs), request for qualification (RFQs) and terms of reference (TOR) before proceeding to sourcing, final contracts or purchase orders (POs), procurement and construction. Important facility decisions in which users should be involved or at least consulted are:

- design specifications
- facility configuration
- procurement technical criteria
- facility capacity and quantity
- facility brands and models
- vendors, suppliers and other service providers
- facility installation site
- facility's physical position and orientation

Direct observation and analysis of the simulated use or actual use of a proposed new facility can help gauge its usability. A time and motion study can measure cycle times of tasks and identify usability issues that could slow down users or induce errors. Feedback from test operators of new medical equipment can be gathered to determine its user friendliness and intuitiveness of controls and interface design. New beds must be tested with nurses for ease of bed preparation and helping patients get into and out of it. These facilities must also be tested with geriatric patients to ensure minimal risk of bed falls. The housekeeping staff must be consulted with new patient room and facility design to check for ease of cleaning and collection and disposal of garbage and hospital wastes. The maintenance staff must also be consulted with new patient room designs to confirm whether it is easy to spot and fix any plumbing leaks or electrical problems or pull down air conditioners for disinfection. Before new bathroom designs and fixtures are finalised, test patients must be observed using a prototype bathroom to ensure there are no risks of slips due to poor water drainage and scalding due to faucet controls that lack intuitive and fail-safe features. To evaluate a proposed hospital layout, a walk-through of nurses transporting patients in wheelchairs or beds must be conducted and observed between important stations like the patient room and X-ray department or to ensure seamless transport. A walk-through of nurses carrying or transporting medication, supplies, documents or equipment must also be conducted to confirm there are no delays, difficulties or long waits encountered. A simulation of the response of a code blue team with a new hospital layout must be done to check if it can reach the patient within the stipulated time. During this emergency simulation, the hospital's new public address system can also be checked for audibility and clarity. Visitors' flow especially that of the patients' families must be simulated to ensure they are not lost inside the hospital and they could easily and conveniently reach their destination. Through

good hospital design and adequate signage, visitors should easily and intuitively find their way. Transport of patients' meals must be simulated from the dietary section to the patients' rooms to confirm timely serving. A spaghetti diagram may be used to trace the actual flow of people or materials to uncover any potential backtracking, circuitous flows, congestion, clogging and build-up.

DIMENSIONS OF USABILITY

Facility usability can be organised into four major areas (4Fs): friendliness, flexibility, fail-safe and future-proof.

Friendliness

User-friendly facilities incorporate human-centred design. They are patient-friendly, staff-friendly or visitor-friendly. They are convenient to use or experience by their authorised or intended users. Their user interface is intuitive. Users do not experience stress, inconvenience, discomfort, confusion and ambiguity during normal usage. Well-designed facilities do not require constant and intense vigilance. They support simplicity of workflow and allow for easy reach and access by users. They are transparent in all areas where user knowledge or awareness of facility status and condition are critical to proper use. Ergonomic facilities have high visibility, readability and traceability for accountability. They protect users from distraction and interruption and other sensual stress like glare, noise, scent, vibration, extreme temperatures, humidity and dust. Their learning curves are short and simple, especially for commonly used facilities like elevators and bathrooms. They do not tax the users' memory nor overload and overwhelm them with information.

Flexibility

Well-designed facilities are flexible, offering sufficient options for personalisation or customisation. They do not force users into a one-size-fits-all design or configuration like size, posture and reach. Users are not induced to do stressful or unsafe workarounds. Users with force-fitted facilities can experience inconvenience and loss of focus on the job. Ergonomic facilities are user-adjustable to suit the user's physical and intellectual characteristics and limitations. For instance, for readability and easy reach by users, the facility's height, width, position, orientation and illumination are fully adjustable to suit the individual user's requirement. User interface is available from simple to complex formats to accommodate different user backgrounds and knowledge. Facilities used in different areas of the hospital should be conveniently transportable but can be securely locked in place for stable operations. The facility's set-up or preparation between users or usage is simple, short and seamless.

Fail-safe

Fail-safe features must be incorporated in facility design and considered a top criterion in facility selection. Medical device-related incidents and injuries are often attributed to human errors. Common examples are malfunctioning defibrillators and anaesthesia equipment. Operators are often blamed for lack of skill or vigilance or both. The maintenance staff may also be held responsible for improper repair or calibration. A well-designed facility has sufficient fail-safe features to protect its users — operators and patients — from harm in case of any device failure or misuse. It is mistake-proof to prevent injury or damage to property in case of human error, both commission and omission, due to lack of familiarity or alertness. The fail-safe feature also alerts and prevents anyone from using the device or facility in case it is not usable or ready for normal use for any reason.

Facilities must be safe for all types of users and even non-users in case of unintended or unauthorised usage. Facilities in common areas must also be childproof

and visitor-proof, in light of the increasing number of paediatric patients and visitors in most hospitals. A typical hospital, private or government-owned, is an open public area with minimal security that allows the easy ingress and egress of visitors and other non-patients. Yet it is a high-risk, accident-prone area where dangerous materials and equipment are regularly transported and stored, high-risk and fragile patients are transported, and staff often hastily move around. Facilities should be designed to protect the public, patients and non-patients from the facilities themselves as well as to protect the facilities from the public. The facility should be able to withstand tampering and unwanted intrusion. If necessary, it should revert immediately to its safe mode or non-operating mode in case of unauthorised use or access. Facilities should be designed to be fault-tolerant. In case of breakdown or malfunction, facilities should revert to its safe or safest mode. After a system override, the facility should clearly indicate its override mode or status to all current and future users. If necessary, after a prescribed time after its system is overridden, the facility should revert to its normal or default state. Facilities should be robust enough to operate normally within the expected extreme range of its operating environment like temperature, humidity, moisture, pressure, load, vibration, noise and dust.

Future-proof

Facilities must be designed not only for current use or operations but also for the entire duration of their lives. They should be easy to maintain, repair, replace, calibrate, clean and service. Parts must be easy to identify, replace, source and install. Facilities should be upgradable for better performance and scalable to higher capacities if needed in the future. They should have compatibility, connectivity and interoperability with existing systems. They should be downward compatible with legacy systems after an upgrade. The lack of upgradability, compatibility and connectivity of facilities with other parts of the system can lower their usability, the efficiency of users and the quality of output. At the end of their lives, facilities should be easy to replace, disassemble, dismantle and dispose of. As much as possible, in keeping with socially responsible design principles, hospital facilities, equipment and devices, in particular, must be designed for reuse, remanufacturability or recyclability to reduce their carbon footprint and other environmental impact at the end of their lives.

DESIGN AREAS

The critical design areas of any business, including healthcare establishments, are:

- Business model design — the system that determines how the business creates value to achieve its mission or goal such as generating income
- Organisational design — the structure that determines how people work together and relate to each other to achieve common objectives
- Facilities design — the structures, fixed assets and resources that provide the platform and capacity for processing and servicing
- Process design — the workflow that determines how people and materials pass through the system and facilities as they are processed, transformed or serviced
- Workplace design — the man–machine platform in which a task or set of tasks is repeatedly accomplished
- Job design — the procedures and steps to accomplish a specific task or set of tasks by a specific person or team
- Product design — the configuration, features, characteristics of products, including their packaging, to satisfy users and meet their specific needs

- Information design — the channels and routes through which information flows across the organisation, and the format and speed at which it is transmitted and received.

Facility design must fit or harmonise with other design aspects of the establishment. These design areas interact and influence each other. The business model guides the capital investment strategy and direction. The organisational structure determines the decision-makers in investment and procurement decisions. The planned process flow design will initially decide facility design and requirements. But the actual facilities installed can alter or affect the final process flows — both people and material. Facilities, through their design and usability, can directly or indirectly influence the final design of the workplace, jobs, products and information.

CONCLUSION

The design and configuration of facilities can significantly affect hospital performance in terms of safety, quality of care and service, productivity and cost-efficiency. Hospital management should view facility selection and sourcing as long-term strategic decisions and give importance to usability. In facility planning, there must be early and concurrent involvement and consultation of all stakeholders, including all users and process owners from the beginning to the end of the facility's life. There must be transparency and sharing of information that may materially impact users. Decision-makers should design errors out, design waste out, design costs out, design inconvenience out and design long waits out during facility planning.

References

1. Hughes, R. (ed.) (2008) 'Patient Safety and Quality: An Evidence-Based Handbook for Nurses', Agency for Healthcare Research and Quality, Rockville, MD, p. 701.
2. Duffy, V. (ed.) (2011) 'Advances in Human Factors and Ergonomics in Healthcare', CRC Press, Boca Raton, FL, p. 49.
3. *Ibid*., p. 28.
4. Spear, S. (September 2005) 'Fixing healthcare from the inside today', *Harvard Business Review*, Vol. 83, No. 9, pp. 78–91, 158.
5. Whitney, D. (July 1988) 'Manufacturing by design', *Harvard Business Review*, pp. 83–91.
6. Holmes, J. R., Felsenthal, D. (October 2009) 'Depreciating and stating the value of hospital buildings', *Healthcare Financial Management*, Vol. 63, No. 10, pp. 88–90, 92.
7. Nocera, A., Khursandi, D. S. (1998) 'Doctor's working hours: Can the medical profession afford to let the courts decide what is reasonable?' *Medical Journal of Australia*, Vol. 168, No. 12, pp. 616–618.
8. *Ibid*., ref. 2 above, p. 34.
9. *Ibid*., ref. 1, p. 702.
10. *Ibid*., p. 707.
11. *Ibid*., ref. 8 above, p. 93.
12. Donchin, Y., Gopher, D. (eds.) (2014) 'Around the patient bed – Human Factors and Safety in Health Care', CRC Press, Boca Raton, FL, p. 87.
13. Grout, J. (2007) 'Mistake-Proofing the Design of Health Care Processes', Agency for Healthcare Research and Quality, Rockville, MD, Publication No. 07-P0020, available at: https://archive.ahrq.gov/professionals/quality-patient-safety/patient-safety-resources/resources/mistakeproof/mistakeproofing.pdf (accessed 2nd February, 2019).
14. Cohen, M. (2007) 'Medication Errors', American Pharmacists Association, Washington DC, p. 208.
15. National Patient Safety Agency. (2007) 'Design for patient safety – A guide to the design of the dispensing environment', Edition 1, available at: www.williamsprimarycare.co.uk/uploads/Dispensing-EnviromentReport.pdf (accessed 20th February, 2019).
16. *Ibid*., ref. 15 above.
17. *Ibid*.
18. *Ibid*., ref. 12 above.
19. Carayon, P. (ed.) (2012) 'Handbook of Human Factors and Ergonomics in Healthcare and Patient Safety', CRC Press, Boca Raton, FL, p. 228.
20. *Ibid*., ref. 1 above, pp. 703–705.
21. *Ibid*., pp. 702–703.
22. *Ibid*., pp. 704–707.
23. *Ibid*., ref. 13 above.
24. *Ibid*., ref. 19 above, p. 221.
25. Think Insights. (May 2013) 'The doctor will see you now: How hospital administrators make purchase decisions', available at: https://think.storage.googleapis.com/docs/how-hospital-administrators-make-purchase-decisions_research-studies.pdf (accessed 1st March, 2019).