

Human factors in nursing: The time is now

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ABSTRACT

Objective

To raise awareness for nurses about the differences between human factors, patient safety, and communication for safer process and system redesign.

Setting

Nursing service environments.

Primary argument

Nursing contributes at the sharp end of healthcare service provision. Communication is the most consistent pre-condition and consequence in any incident. Clarification of the role of Human Factors design in communication is critical to future research on process improvement in nursing. Human Factors is a key to the best practice management of system and process design as it builds-in the capabilities and limitations of humans in the workforce. Human Factors design is especially important for nursing as the 'caring' profession is vulnerable to high, unmonitored workloads directly and indirectly associated with the nurse's role and scope of practice. Patient Safety data and subsequent literature supports the aim of designing systems to fit better with humans, not humans working to suit systems. The question remains, how should nurses be doing this?

Conclusion

Health care service provision is complex, but understanding the underpinning human factors of the work environment and engaging in strategies to manage productivity fundamentally bound to human performance is paramount to higher-quality, safer care. Nurses need to recognise the precursory and antecedent human factors known to cause errors, and study their effect in redesigned systems using anterograde studies. Adoption of Human Factors research and proactively using the lessons learned from Patient Safety data into nursing systems and process design is best use of Evidence Based Practice.

INTRODUCTION

“Our greatest glory is not in never failing, but in rising up every time we fail.” Ralph Waldo Emerson (1803-1882).

Nursing is driven by supply and demand and contributes at the sharp end of healthcare service provision. Patient Safety and the safety of staff working within the environment are paramount and are underpinned by the principles of industrial democracy: worker contribution through consultation and liaison. Communication is the most consistent pre-condition and consequence present in any incident. Clarification of the role of human factors design in communication is critical to future research on process improvement in nursing. Human Factors is a key in the best practice management of system and process design that builds-in the capabilities and limitations of humans in the workforce. Human Factors design is especially important for nursing as the ‘caring’ profession is vulnerable to high, unmonitored workloads directly and indirectly associated with the nurse’s role and scope of practice. Introduction of patient safety and Productive Workplace (NHS 2011) initiatives are a significant step forward but to achieve the greatest efficiencies the next step is to build-in error-wisdom through managing for Human Factors. Patient Safety data and subsequent literature supports the aim to design systems to fit better with humans, not humans working to suit systems. The question remains, how should nurses be doing this?

BACKGROUND

“Evidence-based practice has been defined as using data and information, often from diverse sources, to guide practice.” Hughes, R., in Carayon and Gürses (2008 p.37).

Human factors, once limited to ergonomics, is a multidisciplinary field of learning with contributions from psychology, engineering, industrial design, statistics, operations research and anthropometry: the focus is on the elements of engineering, cognition, perception, and empiricism. It studies the ‘properties’ of human capability and limitation, focusing on engineering elements such as application design, development, distribution and categorisation of systems and services, and the integration of this knowledge into programs. It includes social interactions with an emphasis on the characteristics of humans, and the way humans operate within their environment. The aim is to improve operational performance, quality and safety by changing the way we design and create our systems (Kohn et al 2000). It is best applied to communications where the target audience and direction of information is clearly defined such as in single interface exchanges. Leading authors in the field include Wickens et al (1997), Carayon (2007), and Green (2004).

“Human factors research applies knowledge about human strengths and limitations to the design of interactive systems of people, equipment, and their environment to ensure their effectiveness, safety, and ease of use.” Henrickson et al (2008 p.84).

Human Factors is sometimes confused with Patient Safety, because it is rarely undertaken to explore aesthetic issues, process or workplace design, but rather the high profile or high priority issues such as adverse events. The Institute of Medicine defines Patient Safety as the prevention of harm to patients (Aspden et al 2004). Human Factors can take risk management and total quality management to another level, but to avoid getting lost in the maze of inference and jargon it is important to understand the language.

Patient Safety is the retrospective management of what went wrong, to prevent recurrence or mitigate damage. Error is an incorrect knowledge resulting from incorrect information which subsequently leads to a

wrong action¹, and can be due to inattention. An accident is a specific, identifiable, unexpected, unusual and unintended action, which occurs without apparent or deliberate cause. Accidents happen without the benefit of foresight or expectation; they are not reasonably foreseeable. Incidents unlike accidents are foreseeable. They appear minor in significance and occur by chance alongside an event or circumstance (and so are generally not causal on their own), or as a consequence of an event or circumstance. For example the incidental tasks related to the performance of a new duty. Violations, conversely, are “deliberate deviations from those practices (written rules, policies, instructions, or procedures) believed necessary to maintain safe or secure operations” (Carayon and Gürses 2008, p.8). It might be a relatively minor event that is incidental to or a consequence of others but which may cause an interruption, a crisis or an adverse event. Consequences as an endpoint are dependent on conditions. Patient Safety information therefore focuses on limitations identified on reflection.

Human Factors language on the other hand uses terms such as ‘fundamental surprise’ (Lanir 1986), which is the reaction a person has when something occurs to refute an assumption. It is borne from an error (incorrect assumption) and results in blame. “Humans,” says Green (2004 p.4), “have a strong bias to blaming people”, and he highlights nurses as assigning blame to minimize the impact of acknowledging an error; an action which defers responsibility from the people who created the system. This is called an ‘attribution’ error. Reason et al (2001 ii21, 23) described some organisations as having a cluster of pathologies which he termed Vulnerable System Syndrome (VSS). These organisations are at greater risk of adverse events. Central to this syndrome is blame, denial, and single-minded wrong-pursuit. The syndrome has three “interacting and self-perpetuating elements: blaming frontline individuals, denying the existence of systemic error provoking weaknesses, and the blinkered pursuit of productive and financial indicators.” Reason et al (2001) suggested going beyond immediate unsafe actions (active error) to the core underpinning assumptions (latent errors) about human fallibility, then begin to resolve the conditions that provoke it.

“There is always an easy solution to every human problem—neat, plausible, and wrong.” Mencken, H.L. (1917)

Inattention blindness, described by Green (2004), refers to our ability to adapt to our workplace and workloads by focusing our attention on the things that matter according to priority, but allowing other elements of the environment to go unnoticed. It is inattention blindness that is responsible for those slips and lapses (a result of preoccupation or distraction) that plague our everyday work life. It is about those items in one’s short-term memory that are prioritised frequently during the course of a day, allowing for some tasks to be dropped or forgotten (capture error). It is different to satisficing (‘good enough is enough’), which is the model of decision-making we use when we make choices selected from available options. Purchasing inventory is an example; the decision to buy is made on the best available option from the selection available.

Roles affect thinking behaviour also. For example a protocol might flow well for a Nurse Manager (NM), but not well at all for a frontline nurse. Time-critical roles (ward nurse) require mental rehearsal. That is, knowing what to do before it happens. A NM, on the other hand, has time to think through options, look for alternatives, and having a situational awareness different to the nurse due to the level of authority and access to information will influence the end decision. The NM optimises a response based on reflection and alternatives with more time to coordinate but the frontline worker responds based on protocol, conditions, and immediate options.

‘Situational Awareness’ is the ability to be aware of the local and meta-environment of the workplace while operating within it, allowing the operator to be more productive through enhanced workflow. For example, a nurse arranging for a patient to have a CT performed within an hour knows that the facility CT is not working

¹ Declarative (what to do), procedural (how to do it) or operational (when to do it).

and all emergency CT's must be arranged through the local private service. She is aware that she must contact this service, organise the transport and an escort, and that fortunately, the policy on external transport of critical patients has been ratified and so she must arrange through the new Patient Flow Coordinator to have this client moved as soon as possible, via the correct channels, using the current processes. Her situational awareness will assist her to tie-in all the relevant details required for success first time, in the least time.

PROPOSITIONS SUPPORTING THE ARGUMENT

Error and humans

"Experienced people develop expectations and mental models that permit pre-programming of behaviour and minimization of thought for routine, frequently performed tasks. ...One irony of medical error is that the most experienced and able people are likely to make the most egregious and unfathomable errors. They have the most experience, the greatest skill and the strongest expectations." Green, M. (2004, p.2).

Rasmussen's (1997) SRC Theory (Skill, Rule, Knowledge) applies to the experience of the human within the system, and refers to the way we process and manage information. The more experienced worker will rely on knowledge and commit more violations than the novice or the competent worker, who rely heavily on skill development or rules and tend to commit errors. The demarcation blurs when systems are dynamic and change rapidly and frequently, making expert workers vulnerable to all error types. Human Factors terms consistent with this theory include conspicuity, adaptation, automatic behaviour, cue generalising, top-down and bottom-up task relevance and hindsight bias. Two Patient Safety and Risk Management terms - consequences (dependent on prior events and especially relative to an individual), and conditions (a state or an assumption on which the validity or effect of something else rests) - often compete at the review table but have significantly different implications. We manipulate conditions and manage consequences.

Other terms of value are tautology and heuristics; repetition that detracts from the key message and the use of terms and rules to generalise or 'shorthand' information but which allows for misinterpretation and error. In a stable system these two behaviours have little impact, but this is reversed when the system is unstable.

Human Factors has been applied most frequently in nursing in the study and management of Patient Safety issues most notably medication safety, handover, hand washing, medical emergency early warning systems and in Root Cause Analysis (RCA). These are examples of the retrospective use of Human Factors knowledge by managing the consequence: revising the procedure or process to build-out the contributing factors. Hollnagel (2010) maintains the bias of RCA's is that they focus on predictable phenomena. Since healthcare systems are seldom stable, it is important to ensure human factors are being studied as contributing factors to prevent faults being built into the procedure or process. The resultant procedure or process should then be tested for reliability.

Communication

Human Factors is often referred to in Health, in terms synonymous with communication. This misnomer needs to be clarified. Communication (n) is a broad term that refers to the transfer of information from one entity to another, in terms of process or system. Processes are particular routine courses of prescribed action/s to achieve a particular result. Systems however, are a group of independent but interrelated processes comprising a unified whole. Systems are made up of methods and rules governing behaviour and provide an organised structure. They can be small or large, complex or simple, written and unwritten (for example, social systems). Human factors explores the elements present up to and at the point of breakdown of information involving a human and is empirical by default, allowing for the generalisation of knowledge learned for

specific interactions. For example, it is reasonable to generalise from empirical studies, that the capacity of our immediate memory limits the amount of information that we are able to receive, process, and remember. With this knowledge, we can design processes with instructions that meet the limitations of human memory, so decreasing the rate of errors and lapses.

“Accidents generally occur because of normal rather than aberrant behaviour. ..., human behaviour is the least malleable aspect of any system, such as a hospital, where people interact with a complex environment. It is futile to attempt error reduction by changing peoples’ cognition and behaviour...” Green (2004 p.37)

Communication in health is a patient safety concern (Carayon and Gürses 2008). It is cited with reference to the number of incidents directly related to a communication breakdown, and to how many incidents have communication breakdowns in the chain of evidence. Human factors specialists refer to communication in terms of prospective activity rather than a retrospective activity. Each discipline studying communication will have its unique perspective. Active issues of communicating (v), such as errors and execution failures tend to be temporal phenomena attributed colloquially with local tautology and ‘common sense’ rules. To change this behaviour and thinking, active communication techniques and strategies need to be studied using anterograde study designs, as a cause (either concomitant or isolated), for system-design improvements based on specific, measureable, repeatable foci.

The Mission

“Our systems and processes should make it difficult for staff to make mistakes and easy for them to do things correctly.” Ketrington and White in Reiling et al (2003 p.3).

The role of nurses in the development of Human Factors knowledge pertinent to the field of nursing is simply design modification. We need to *“... anticipate human cognition and to design systems that prevent the likely error”* (Green 2004 p.37). Active problems are faced by nurses at the frontline while the latent problems which often originate from the planning phases before production commences creep up on the nurse. Human Factors often present in strings or chains of events, circumstances, and phenomena where the active error or violation is the end product, but are equally present at the conception of latent errors. Individual psychological factors are the least manageable of all the links in the chain. Nursing research and quality improvement can focus on the development of work systems that mitigate or alleviate error as a starting point to expanding our skills in studying human factors for proactive management.

James Reason (1995), a leading author in error management believed people generally do not act in isolation, but that our behaviour is shaped by circumstance. He maintained that *“The likelihood of an unsafe act being committed is heavily influenced by the nature of the task and by the local workplace conditions. These in turn, are the product of “upstream” organisational factors.”* (Reason 1995 p.88). Humans reason in ‘causal series’ and this linear thinking reduces our ability to think in terms of networks or our side-effects on other parts of the system (Reason et al 2001 p.23). Most human factors work in nursing is done on safety critical tasks. An example of work being done to understand

A Human Factors’ solution shopping-list contains:

- reduce complexity,
- increase information processing capacity,
- automate wisely,
- use constraints,
- mitigate side effects,
- task analysis,
- assess likelihood,
- attach a reminder,
- use the five C’s (conspicuity, contiguity, context, count, and content),
- use heuristic evaluations,
- cognitive walkthroughs,
- protocol analysis, and
- reduce the number of competing tasks.
- Assess underpinning assumptions.

and manage the human factors is the handover project promoted by the Australian Commission on Safety and Quality in Health Care (2006) with development and testing of the ISOBAR (Western Australia Country Health Service 2009) handover tool. Its current weakness is the requirement for nurses to practice not just speaking the formulae but also actively listening to it. Another is the use of sharps-safe injection devices for both acute and community sectors. The use of needles that easily retract into a sheath has removed the human factor of re-sheathing, from the risk of needle stick injury by eliminating the ability to remove the needle.

Changes in one process, may lead to incidental changes in other processes within the same system, subsequently solutions come with varying levels of effectiveness. Only eliminating the situation completely will stop it recurring. Effective suggestions are physical design changes, usability testing before purchase for new devices, engineering control or interlock (forcing functions), simplifying processes by removing unnecessary steps, standardising equipment and processes, and tangible involvement and action by leadership in support of patient safety. Intermediate effect solutions only control the incident and are vulnerable to circumstance. For example increasing staffing and decreasing workload, software enhancement or modification, eliminate or reduce distractions, checklists and clinical pathways, eliminate look-and-sound-alike's, read-back, and enhanced documentation and communication. Double checks, warnings and labels, new procedures, memorandums, policies, and training are the least effective solutions as they only acknowledge awareness of the problem (Patient Safety Centre 2009).

Common solutions in the Human Factors literature are aimed at the systems, management, and individual level and include automation, equipment simplification, conspicuity improvement, simulation training, but education and in-service (Reason et al 2001 ii23), use of memory aids such as checklists (Etchells et al 2006) and enforcing vigilance (Simmons and Graves 2008) merely 'relocate' the focus of attention, compounding fundamental surprise. Team training has been demonstrated to work well (Tzeng and Yin 2010) for specific, time-limited, isolated functions such as Basic Life Support and Advanced Life Support or for day-surgery practices. But there are problems with this also – 'inattentional creep' is one of them.

PROPOSITIONS REFUTING THE ARGUMENT

Safety systems

Another common misnomer in nursing is that nurses are excellent 'on-the-spot problem solvers', which Mick et al (2007) coined as "good catch", a skill beneficial to the reporting of near-misses. It does illustrate however, valuable skills in risk identification. When nurses problem-solve on the spot, what is actually happening may be a violation – going around or shortcutting (workaround) the protocol or procedural pathway in order to complete a task. Regardless of the reason, the fact remains, that the process did not allow for a contingency, and needed redesign.

Exception handling refers to those things that happen but which aren't the intended pathway for example, client or patient calls. The system then is designed to provide a first and second response, and if the calls are not redirected, they may be ignored. Humans introduce the most exceptions into any system, but we are also the default exception handlers in any system. Exceptions are estimated to cause two thirds of system crashes (Shelton (1999) in Ye 2006). In health, nurses are predicted to intercept up to 60% of errors before they reach the patient (Jefcott 2010). Unlike fault-tolerance which absorbs error, exception handling prevents error propagation or snowballing. Nurses are the primary source of organisational resilience² through exception handling. Exception handling if excessive or not built into the workload, can lead to efficiency – thoroughness tradeoffs (ETTO) (Hollnagel 2010). For example if protocols are too onerous, workers will adjust their behaviour

² The four tenets of resilience are monitoring, anticipating, responding, and learning

to suit the perceived most important needs of the moment. Common trade-offs are occurring when we make a decision not to check supplies are adequate for the next day because we haven't time today. The same trade-offs that lead to success, also lead to failure.

Change management

Models and theories have evolved to facilitate or guide the implementation of system redesign. Rodgers (1963) described Diffusion Theory, principles to facilitate planned behaviour change. These principles include the adoption process, rate of adoption, category of adoption, and opinion leadership, and must go through the five stages of diffusion: knowledge, persuasion, decision, implementation and confirmation (Harder 2009). A Logic Model (Taylor-Powel and Henert 2008) is used based on situational analysis and 'needs' assessment. Ultimately the end user - the nurse at the sharp end, must own the solutions.

GENERALISATIONS SUPPORTING THE ARGUMENT

De-stigmatising error

Is it that excellent nurses commit no errors, or that excellent nurses commit, recognise and resolve errors?

Adapted from Lee, C.A (date unknown)

The culture of nursing has always been prescriptive and proactive as evidenced by nursing diagnosis, which focused on preventative management and quality of life. A lot needs to be done around de-stigmatising error. When things go wrong, it's a symptom of deeper system trouble, not nurses causing trouble. We shouldn't be looking for what a nurse did wrong (an act of commission), but how a mistake could be made. We need to consider in our system and process design the general human error probability data that exist in various operating conditions (Shelton 1999). Chedru and Geschwind (1972) demonstrated humans generally have a built-in error rate of 0.5-1.0% for every task. Sometimes, it's about the things we don't do (an act of omission (Reason 2002). Errors of omission outnumber errors of commission by 2:1 (Weingart et al 2000 p.775). Slips, lapses, forgetting, and not knowing lead to acts of omission, as do the opportunity losses built into the system by designs that focus on the known and targeted elements. Staff employed in unfunded positions may be an error of commission³, while not employing staff may be error of omission. Just as there are errors of detection, so there are errors of diagnosis: our systems and processes should be implementing incentive programs for error detection and recovery. Forward planning approaches build-in resilience to the effects of error through error-wisdom (Reason 2002).

Building-in error wisdom

"The best outcomes are from resilience from error, not from being error free." deLaval (2000) in Jeffcott et al (2009 p.258)

Failure mitigation goes beyond design, into maintenance. Currently our systems have a level of fault-tolerance: absorbing the incidents without serious impact. But adverse event data shows that isn't enough. We need to build system maintenance into our protocols. For example, regular competency checks can be likened to having your car's tires checked. Ensuring meal breaks are built into the appointment booking program means failure due to hunger is mitigated via scheduled mealtimes and maintained by forcing functions built into the system (eg. the program will not allow booking patients into scheduled meal-break times). 'Hard conditions' are failure modes that are known to fail after a certain amount of operation with a high degree of

³ Guttman's (1983) in Lee (undated) four error types: omission, commission, sequential and timeliness.

certainty. Each individual maintenance item has a contribution to safety and can be given a numerical value. In procedure and systems design today, it is assumed if the process flow is consistent with ideal workflow, then that is all that's required. Human Factors engineering suggests instead that we should be taking the next step and evaluating the workflow for points of failure or fault. This may require adding 'redundant sensors' to the process / procedure / system. NASA technologies have demonstrated that the safety of a system (in terms of successful performance without incident) is related to the number of redundant modes available: the more redundant modes the safer the system. These modes operate silently in the background, and are only noticed when an incident occurs – they come into play, and prevent the incident from progressing, ensuring only the desired procedural flow occurs.

"The system approach concentrates on the conditions under which individuals work and tries to build defences to avert errors or mitigate their effects. High reliability organisations—which have less than their fair share of accidents—recognise that human variability is a force to harness in averting errors, but they work hard to focus that variability and are constantly preoccupied with the possibility of failure" Reason, J. (2000 p.768)

What's on the Horizon

Human Factors knowledge is growing in the nursing world. We need to focus on the role of Human Factors in nursing research. This focus needs to be on conditions and pre-conditions as independent variables. Interruptions have been studied most recently in nursing, demonstrating via 'cognitive pathway' mapping the shifting of a nurses' attention from patient to patient and of each interruption, while 'Stacking' is the number of tasks a nurse 'balances' concomitantly. In Wolf et al's (2006) study, nurses averaged ten or more activities stacked and experienced 3.4 interruptions/hr. Papers on attentional errors currently focus on medication management and the surgical patient journey.

Current Studies

Nursing workload studies (Carayon and Gürses 2005) are breaking-down the division of work into four levels: unit level in terms of nurse-patient ratios, job level as the amount of work routine to the job, including degree of difficulty and level of attention required (Holden et al 2011), patient level in terms of acuity, and situation level in terms of performance obstacles and facilitators (Carayon and Gürses 2005). With demand, supply, staffing, and length of stay issues a constant tension in healthcare service delivery, nurses must look at how human factors engineering can improve the workflow and efficiencies (Zolnieriek and Steckel 2010). Situation level issues include the physical work environment, models of care that match workflow and layout, supplies and availability, complexity of logistical systems, the extraneous needs of clients, patients and carers, communication styles (Thomas et al 2003), flows and conformity, the number of 'redirections' in any workplace structure and the similarities and familiarity between parallel programs within the same organisation. Studies of human factors on workload are mostly American, and refer to the acute sector (Cho et al 2003; Kovner et al 2002). What is missing specifically in the nursing literature on Human Factors management in nursing is the community nursing perspective.

RECOMMENDATIONS

Human Factors methodology allows nurses to study the 'properties' of human capability and limitation in the workplace. The language of Patient Safety is largely reflective and attaches socially constructed value-loaded labels, while the language of Human Factors is descriptive and focuses on the conditions that lead to a consequence. We manipulate conditions and manage consequences. Rassmussin's SRC Theory contributes to understanding human diversity in dynamic and rapidly changing environments, such as the

health workplace. Communication as it relates to the transfer of information in terms of processes or systems needs to be examined using Human Factors methodology to allow us to generalise knowledge learned for specific interactions. This can in turn assist nurses to manage-out some of the conditions (such as unwritten 'common sense' rules) that lead to incidents of active communication. As our behaviour is shaped by conditions, nurses must focus therefore on process and procedure design modification, using automation, equipment simplification, conspicuity improvement, team and simulation training, and the development and use of critical language in context. Nurses are well placed to report near misses and actively engage in process and system redesign, as the organisation's exception handlers. All this means revisiting our professional culture – not just the organisational culture - to include de-stigmatising error to allow nurses to build-in error wisdom (Reason 2004) into our practice, workflow and the organisations we work in.

CONCLUSION

Health care service provision is complex, but understanding the underpinning human factors evoked within the work environment and engaging in strategies to manage productivity fundamentally bound to human performance is paramount to higher-quality, safer care. Nurses need to recognise the precursory and antecedent human factors known to cause errors, already being studied by many other disciplines, and study their effect in redesigned systems using anterograde studies. The effective adoption of Human Factors research into nursing systems and process design is best use of Evidence Based Practice enhancing our Safety Culture and Total Quality.

REFERENCES

- Aspden, P., Corrigan, J., Wolcott, J. and Erickson, S. 2004. *Patient Safety: Achieving a new standard for care*. Washington: The National Academies Press.
- Australian Commission on Safety and Quality in Health Care (ACSQHC). 2012. *Safety and Quality Improvement Guide Standard 6: Clinical Handover (October 2012)*. Sydney. ACSQHC, 2012.
- Carayon, P. 2007. *Handbook of Human Factors and Ergonomics in Health Care and Patient Safety*. Hillsdale: Lawrence Erlbaum Associates.
- Carayon, P. and Gürses, A. 2005. A human factors engineering conceptual framework of nursing workload and patient safety in intensive care units. *Intensive Critical Care Nursing*, 21(5):284-301.
- Carayon, P. and Gürses, A. 2008. *Patient Safety and Quality: An Evidence Based Handbook for Nurses*. Volume 2. Rockville: Agency for Healthcare Research and Quality.
- Chedru, F. and Geschwind, N. 1972. Writing Disturbances in Acute Confusional States. *Neuropsychologica*, 10(3):343-353.
- Cho, S-H., Ketefian, S., Barkauskas, V. and Smith, D. 2003. The effects of nurse staffing on adverse events, morbidity, mortality, and medical costs. *Nursing Research*, 52(2):71-79.
- Etchells, E., Bailey, C., Bason, R., DeSousa, S., Fowler, L., Johnson, K., Morash, C. and O'Neill, C. 2006. Human Factors in Action: Getting "Pumped" at a Nursing Usability Laboratory. *Healthcare Quarterly*, 9:69-74.
- Green, M. 2004. Nursing Error and Human Nature. *Journal of Nursing Law*, 9:37-44.
- Harder, A. 2009. Planned Behaviour Change: An Overview of the Diffusion of Innovations. University of Florida IFAS Extension. Department of Agricultural Education and Communication, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. First published: July 2009 <http://edis.ifas.ufl.edu/pdf/FILES/WC/WC08900.pdf> (Accessed 27/1/11).
- Henriksen, K., Dayton, E., Keyes, M., Carayon, P. and Hughes, R. 2008. Chapter 5. Understanding Adverse Events: A Human Factors Framework in Carayon, P. and Gurses, A. 2008. *Patient Safety and Quality: An Evidence Based Handbook for Nurses*. Volume 2. Rockville: Agency for Healthcare Research and Quality.
- Holden, R., Scanlon, M., Patel, N., Kaushal, R., Hamilton Escoto, K., Brown, R., Alper, S., Arnold, J., Shalaby, T., Murkowski, K. and Karsh, B. 2011. A human factors framework and study of the effect of nursing workload on patient safety and employee quality of working life. *British Medical Journal Qual Safety* 2011;20:15e24. doi:10.1136/bmjqs.2008.028381
- Hollnagel, E. 2010. The ETTT Principle: Efficiency –Thoroughness Tradeoff – Why things that go right sometimes go wrong. *Risk Analysis*, 1(1):153-154.
- Jeffcott, S. 2010. *Errors of Omission: what we are missing when trying to keep patients and residents safe*. Centre of Research Excellence in Patient Safety. Monash University: Melbourne.

- Jeffcott, S., Ibrahim, J. and Cameron, P. 2009. Resilience in Healthcare and Clinical Handover. *Quality and Safety in Health Care*, 18(4):256-260.
- Kohn, L., Corrigan, J. and Donaldson, M., (eds). 2000. To err is human: building a safer health system. A report of the Committee on Quality of Health Care in America, Institute of Medicine. Washington: National Academy Press.
- Kovner, C., Jones, C., Zhan, C., Gergen, P. and Basu, J. 2002. Nurse staffing and post surgical adverse events: an analysis of administrative data from a sample of U.S. hospitals, 1990-1996. *Health Services Research*, 37(3):611-629
- Lanir, Z. 1986. *Fundamental Surprise*. Eugene Oregon. Decision Research.
- Lee, C.A. Undated. Human Error in Aviation <http://carrieelee.net/pdfs/HumanError.pdf> (Accessed 27/1/11)
- Mencken, H. 1917. "The Divine Afflatus" New York Evening Mail 16 November 1917.
- Mick, J., Wood, G. and Massey, R. 2007. The good catch program: increasing potential error reporting. *Journal of Nursing Administration*, 37(11):499-503.
- NHS Institute for Innovation and Improvement. 2011. The Productive Ward – Taking Time to Care. Coventry: NHS Institute for Innovation and Improvement.
- Patient Safety Centre. 2009. *RCA: A guide for Root Cause Analysis Teams*. Herston: Queensland Health.
- Rasmussen, J. 1997. Risk management in a dynamic society: a modelling problem. *Safety and Science*, 27(2/3):183-213.
- Reason, J. 1995. Understanding adverse events: human factors. *Quality Health Care*, 4:80-89
- Reason, J. 2000 Human Error: Models in Management. *British Medical Journal*, 320:768–70
- Reason, J. 2002. Combating omission errors through task analysis and good reminders. *Quality and Safety in Health Care*, 11(1):40-44.
- Reason, J. 2004. Beyond the organisational accident: the need for 'error wisdom' on the frontline. *Quality and Safety in Health Care*, 13(Sup2):28-33.
- Reason, J., Carthey, J. and de Leval, M. 2001. Diagnosing "vulnerable system syndrome": an essential prerequisite to effective risk management. *Quality in Health Care*, 10(Suppl II):ii21–ii25.
- Reiling, J., Breckbill C., Murphy, M., Mccullough, S. and Chernos, S. 2003. Facility Designing and Patient Safety and Its Effect on Nursing: Human Factors. *Nurse economist*, 21(3):143-147.
- Rogers, E.M. 1963. The adoption process: Part I. *Journal of Cooperative Extension*, 1(1):16-22.
- Shelton, C. 1999. Exception Handling. Carnegie Mellon University: Pittsburgh. http://www.ece.cmu.edu/~koopman/des_s99/human/ (Accessed 27/1/11)
- Simmons, D. and Graves, K. 2008. Tubing Misconnections - A Systems Failure with Human Factors: Lessons for Nursing Practice. *Urological Nursing*, 28(6):460-464.
- Taylor-Powell, E. and Henert, E. 2008. *Developing a logic model: Teaching and training guide*. Madison: University of Wisconsin-Extension-Cooperative Extension.
- Thomas, E., Sexton, B. and Helmreich, R. 2003. Discrepant attitudes about teamwork among critical care nurses and physicians. *Critical Care Medicine*, 31(3):956-959.
- Tzeng, H. and Yin, C. 2010. *Nurses' response time to call lights and fall occurrences*. Medical Surgical Nursing, Retrieved 20/1/11 from http://findarticles.com/p/articles/mi_mOFSS/is_5_19/ai_n55833316
- Weingart, P., McL Wilson, R., Gibberd, R. and Harrison, B. 2000. Epidemiology of medical error. *British Medical Journal*, 320:774-777
- Western Australia Country Health Service. 2009. Isobar – A handover 'how-to'. Isobar promotional material. WA Dept. of Health: Perth. Retrieved from [http://www.health.gov.au/internet/safety/publishing.nsf/content/com-pubs_CH-IHPT/\\$File/iSoBAR-PromoMatls.pdf](http://www.health.gov.au/internet/safety/publishing.nsf/content/com-pubs_CH-IHPT/$File/iSoBAR-PromoMatls.pdf) at 27/1/11 1102hrs.
- Wickens, C., Lee J., Liu, Y. and Becker, S. 1997. *An Introduction to Human Factors Engineering*, 2nd Edition. Prentice Hall. ISBN 0321012291.
- Wolf, L., Potter, P., Sledge, J., Boxerman, S., Grayson, D. and Evanoff, B. 2006. Describing nurses' work: combining quantitative and qualitative analysis. *Human Factors*, 48(1):5-14
- Zolnierek, C. and Steckel, C. 2010. Negotiating safety when staffing falls short. *Critical Care Nursing Clinics of North America*, 22(2):261-9.