Situation Awareness in Midwifery Practice

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ABSTRACT

Situation Awareness (SA) is commonly defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (Endsley, 1995:36). From this cognitive perspective, SA is synonymous with perception or attention, and involves a continual monitoring of the status quo for changes that might require action by frontline operators (Flin et al 2008). Within the midwifery literature, "loss of situation awareness" has been cited as a contributory factor to adverse events and unwanted clinical outcomes (HSIB 2020; Knight et al 2014; RCOG 2017). This operationalisation of SA is problematic for multiple reasons which are explored in this discussion paper.

The paper begins by exploring the transferability of human factors lessons between safety critical industries such as aviation and healthcare. Different theoretical perspectives on SA are evaluated, highlighting that the theoretical concept has been misapplied in midwifery, with distinct differences from Endsley's original model in how it is defined and measured. The paper provides an overview of the difficulties in measuring SA, which limit the prospective utility of the construct. Furthermore, retrospective identification of loss of SA is value laden and subject to hindsight bias. This stands in opposition to the Human Factors systems approach where "human error" should be viewed as a symptom of systemic problems within an organisation, rather than a causal factor (Amer-Wahlin and Dekker, 2008; Shorrock and Williams 2016).

This paper proposes that a more holistic perspective is required which considers the individual clinician within the context of the wider sociotechnical system, rather than focus solely on the performance of individuals. It is vital to identify the system factors which may lead to loss of situation awareness, in order to redesign the work environment to minimise patient harm and maximise safety (Singh et al 2006). Opportunity also exists for further research to investigate whether an alternative model of SA may be more appropriate for use in the healthcare context generally, and maternity care specifically, better reflecting the complex system in which clinicians work.

KEYWORDS

Situation Awareness, midwifery practice, maternity safety, Human Factors.

Background

Labour and birth are a time of great physiological change, with the potential for rapid deterioration in health of the mother and baby. During this time, the role of the midwife is to monitor maternal and fetal wellbeing to detect deviations from the expected course and act promptly to access emergency care where necessary (International Confederation of Midwives (ICM) 2017). However, Safety in UK maternity services is currently a high profile concern, with the Ockenden (2022) and the Kirkup (2015) reports identifying significant failings in care at two NHS Trusts, and several other Trusts under investigation or rated inadequate by the Care Quality Commission (CQC)(2022). Concerningly, it has been reported that improvements in care may have changed the outcome in 37% of cases of maternal death (Knight, 2021). Within the midwifery literature, "loss of situation awareness" has been cited as one contributory factor to adverse events and unwanted clinical outcomes in maternity care (Draper, Kurinczuk and Kenyon 2017:47; HSIB 2020; Knight et al 2014; RCOG

2017). However, the operationalisation of SA is problematic for multiple reasons, which will be explored below.

Learning lessons from other industries

The infamous American Institute of Medicine (1999) report To Err is Human: Building a Safer Health System, report cited alarming figures for avoidable patient deaths, referring to this as an "epidemic of medical errors" (Institute of Medicine 1999a:1). Their revolutionary conclusion was that medical errors are not due to poor practice by individual "bad apples" but result from system failures and conditions that cause people to fail (Institute of Medicine 1999b:49). Consequently, they recommended a move away from a punitive system of attributing blame, to redesigning work systems to support practitioners to do the right thing and recommended that human factors lessons be learnt from other safety critical industries to minimise errors and thus improve patient safety (Institute of Medicine 1999b).

Situation Awareness (SA) is an example of a human factors issue that has been highlighted in safety critical industries such as aviation, military, nuclear, and the oil and gas sectors, which has now been widely accepted in healthcare (Flin et al 2008; Gluyas and Harris 2016). Sharing learning between industries would seem logical in the pursuit of improving safety, however, concepts should not be indiscriminately transferred from one context to another (Powell-Dunford et al 2017). Concerning the application of situational awareness to healthcare generally, and midwifery specifically, it is important to consider the similarity or dissonance with aviation from whence the concept appears to have derived.

In a comparative review of aviation and healthcare, Kapur et al (2015) describe multiple differences between the industries. Some are obvious, such as that the focus of the work in healthcare is human bodies as opposed to inanimate aircraft, the relative lack of automation in healthcare and the fact that pilots will usually fly a specific type of airplane, whereas health professionals use a large range of different pieces of equipment to care for patients with a wide variety of different clinical presentations. Other less obvious differences are particularly relevant to situation awareness such as the small number of consistent crew members on an airplane, rather than large numbers of health professionals within a frequently changing team due to shift changes and work areas. Staff change-overs present an opportunity for information to be lost or may alter the team dynamics which could affect SA. Dekker (2011) uses a jet plane as an example of a complicated system, which are predictable, controllable, and stable when the correct procedure is followed. Complex systems such as midwifery on the other hand, are never fully "knowable", they cannot be definitively mapped or measured because of the number of variables and dynamic interactions between elements (Dekker 2011:214). Complex systems are ones in which there are multiple interrelated components or agents, and the interaction between the components and the environment are continually in flux (Dekker 2011). Not only are there multiple practitioners involved in maternity care, but also, as Fioratu et al (2010) explain, the situation itself is not static, it is affected by the actions taken in response to the situation. Thus, the individual clinician is an integral part of the system, both responding to changes in the environment and also causing further change in a continuous cycle (Stanton et al 2010). This presents a clear obstacle to the study of SA in midwifery, where so many unknowable variables exist which may affect both individual clinicians and the system functioning as a whole. Furthermore, Kapur et al (2015) highlight hierarchical boundaries and cultural differences in healthcare, where aviation has a more embedded safety culture, free from blame. Acknowledging these differences is not to say that human factors principles, such as SA should not be applied to midwifery. Indeed, Fore and Sculli (2013:2619) argue that "SA needs to be examined in a theoretical context, studied systematically and openly recognised as a universal factor in patient safety". However, the theoretical and practical relevance of SA to midwifery should be ascertained, and implementation ought to be tailored to the context (Powell-Dunford et al 2017).

Situation Awareness as a theoretical concept

Situation awareness is widely cited as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future"

(Endsley 1995:36). Within this cognitive perspective, SA is synonymous with perception or attention, it involves a continual monitoring of the status quo for changes that might require action (Flin et al 2008). This requires an "internalized mental model of the current state of the operator's environment" (Jones et al 2011:227), meaning that the practitioner integrates all of the available information into a picture of the current situation upon which decisions can be made. In this way, SA is contained within the mind of the individual practitioner. A key criticism of this perspective is that situating SA within the cognitive processing of the individual cannot account for behaviour of the system beyond that individual (Stanton et al 2010). As Fioratu et al (2010) explains, it is necessary to examine the interaction of the individual within the context of their environment, analysis should not focus solely on the individual.

Salmon et al (2009a) present an alternative social view of SA whereby Distributed Situation Awareness is the collective awareness of a whole system, with the cognition being shared across the system, within the interactions between system elements such as people and technology. Both Endsley's (1995) and Salmon's (2009a) models pertain to an awareness of the current state, where they diverge is upon where that awareness is held; in the mind of the individual practitioner, or somewhere between the elements of a socio-technical system. The DSA perspective aligns more closely with the human factors principle of systems thinking, whereby SA is distributed throughout the system, and viewed as a collaborative activity, rather than a largely individualistic one. Carayon et al (2014) highlight the importance of taking a systems approach to consider all aspects of the work system which may impact upon patient safety. Although Endsley's (1995) model does allude to external factors which may affect SA, such as system capability, interface design, complexity, and automation, these are extrinsic to situation awareness, rather than integral to it as in the DSA model by Salmon et al (2009a).

A third perspective exists, which situates SA purely within the devices that humans use as sources of information (Stanton et al 2010). It is questionable as to whether this perspective is actually describing SA or merely information availability. Indeed Stanton et al (2010) argue that more information does not necessarily lead to more situation awareness. Furthermore, this engineering perspective may hold weight in a purely technological system, however, is less applicable to healthcare and specifically to midwifery which as a socio-technical system, involves a large degree of human interaction, therefore SA cannot be contained only within devices in this context.

Measurement of Situation Awareness

It is important to note that irrespective of the debate between conceptual models, SA itself is a contentious issue. Within the human factors community, some authors have questioned whether SA exists as an entity (Salmon et al 2009b). Significant debate exists as to whether SA is an operational or representational concept (Endsley 2015; Dekker 2015) and indeed, viewing SA as a cognitive activity, as in Endsley's model, is fraught with issues when it comes to proving it exists in the world, beyond being a theoretical construct. Firstly, it is not possible to directly observe SA, therefore proxies must be used which are thought to demonstrate externally the processes that are going on in the mind of the individual (Flin et al 2008). For example, Abbott et al (2012) reported observable features of teamwork such as cooperation, co-ordination, leadership, monitoring and communication, and narratively equated these with levels of Team SA. Consequently, SA may be a subjective judgement imparted by the observer. Endsley (1988) has developed a measurement technique that is identified as an objective measure. The Situation Awareness Global Assessment Technique (SAGAT) uses a freeze-probe technique designed for use in simulated settings where the activity can be paused, and questions asked of participants (Endsley 1988). The generalisability of SAGAT findings to real world settings is limited given the complexity of clinical care environments with multiple other patients and the inability to freeze activity whilst clinicians consider the facets of the situation evolving in front of them. Additionally, the questions that are asked during the freezes of the SAGAT test knowledge rather than the cognitive processes used to obtain that knowledge (Chatzimichailidou et al 2015). Therefore, it could be argued that it is recall that is being tested moreover situation awareness. The Situation Present Assessment Technique (SPAM) technique is an alternative to SAGAT, which has been designed to be used in real time, without the need to freeze situations

(Durso et al 1998). However, this may not be practicable in midwifery practice because the SA probe questions could be disruptive to patient care or bias the results if clinicians choose to delay answering the probes until workload permits (Endsley 2021). Alternatively, Zhang et al (2020) provide a useful review of various physiological measures of situational awareness, such as eye tracking, cardiovascular changes and brain activity. Regardless of questions over the validity of these techniques given that physiological measures could be affected by environmental factors, the practicality of implementing the physiological measurement technologies whilst providing clinical care limits their use (Zhang et al 2020).

The implication of these difficulties in measuring SA are that we cannot be sure that the mental processes occur as depicted in the theoretical model, and if the depiction is accurate, then what distinguishes these activities as Situation Awareness rather than features of another theoretical construct such as attention or decision making for example. Endsley (2000) vehemently denies that decision making is synonymous with SA, SA is considered a precursor to it. Nonetheless, many of the barriers to SA identified in the literature pertain to cognitive limitations such as limitations of working memory capacity, attentional tunnelling, information or task overload, stress, fatigue, distraction and mind wander (Flin et al 2008; Gluyas and Harris 2016; Endsley 2015). Distributed Situation Awareness is more observable, as it is concerned with the interactions between elements of the system, however this is also subject to the same critique, that these interactions could be labelled communication or information sharing for example. It is debatable whether these interactions necessarily provide awareness to the clinician or simply information which must then be processed and acted upon. Fore and Sculli (2013) conclude that SA may be an amalgamation of similar terms. Therefore, the label given to the process could be considered semantic and may have little bearing on the day-to-day practice of clinicians. What is important is how the concept is applied in practice.

Use of Situational Awareness in Midwifery

A scoping review was undertaken to understand how the concept of SA is understood and used within the midwifery context. The review found that within midwifery, situation awareness is universally viewed as a person-level cognitive construct, dominated by Endsley's (1988) three step model. However, the theoretical concept has been misapplied in midwifery, with distinct differences from Endsley's original model in how it is defined and measured. For example, Rayfield et al (2017) define SA as a cognitive process, where Edozien (2015) concurs with Endsley (1995) that SA is a cognitive state. Endsley (1995: 36) refers to the process of acquiring SA as "situation assessment". This important because it determines how SA should be measured; by process or outcome measures, if indeed cognitive functions can be measured (Salmon et al, 2009a). Only two out of the six primary research studies included in the scoping review attempted to quantitatively measure SA. Both studies cited the SAGAT devised by (Endsley 1988), however the implementation of their methods deviated (Cooper et al, 2012; Morgan et al 2015). Two studies used qualitative methods which justifiably did not measure SA, yet made inferences about the levels of SA observed (Abbott et al 2012; Mackintosh et al 2009). Meanwhile, SA was a finding, rather than a prospective measure of the qualitative document analysis of delivery suite co-ordinator job descriptions by Bunford and Hamilton (2019). Interestingly, situation awareness did not feature in the job descriptions verbatim, this was an outcome of the logic modelling which was employed by the researchers. The final study measured participants' knowledge about the topic of SA pre- and post- training, without measuring SA itself (Sonesh et al 2015). Irrespective of the debate around the validity of measuring knowledge of the construct rather than participants' ability to demonstrate SA, the study found that knowledge was not improved by the training programme anyway (Sonesh et al 2015).

Prospective utility of Situation Awareness

Training has historically taken the form of either theoretical teaching about SA, or simulation-based practice using a crisis/ crew resource management approach of managing a clinical situation with factors that threaten SA added into the scenarios to challenge participants (Gordon et al 2012). However, given the difficulties in measuring SA, it is difficult to assess whether training is effective at improving individuals' SA. Furthermore, SA training does not appear from the literature to be linked to improved clinical outcomes (Fore and Sculli 2013). Endsley (2000) explains that the link between SA and performance is difficult because Clinicians can

still make poor decisions even with good situation awareness. This rather questions the relevance of SA and the justification for attempting to teach it.

SA training is not appropriate when SA is viewed as a socio-technical construct, as the focus is the system and not the individual. The goal of Distributed Situational Awareness (DSA) is to improve the design of systems and technology to enable better human performance (Salmon et al 2009a). However, this is also challenging given that the DSA model describes SA but does not measure it (Chatzimichailidou et al (2015). Consequently, it is difficult to quantify any improvement in system performance in terms of SA, and impossible to attribute causation of any observed improvements to SA interventions. In this sense, the inability of the DSA model to measure SA renders itself practically impotent. This may be symptomatic of what Shorrock and Williams (2016: 97) call *"the inherent contradiction between human factors' pragmatic orientation and the systems approach it tries to build upon"*, in that a systems approach tries to look at problems holistically, but this means that the results are inevitably descriptive and less causal than those produced by a traditional reductionist approach which studies variables in isolation, in controlled environments. However, if the issue cannot be reduced to a single identifiable cause, then it is impossible to "fix the system" when elements of the system are interconnected and interdependent.

Retrospective assessment of Situational Awareness

The discussion thus far has demonstrated that SA is difficult to measure, difficult to teach with any real-terms effect, and too descriptive to be of use in quality improvement activities. Thus, there is limited prospective utility of SA theory. Within the midwifery literature, the concept of SA has been applied retrospectively, by citing loss of situation awareness as a contributory factor to adverse events and poor clinical outcomes (HSIB 2020; Knight et al 2014; RCOG 2017). This operationalisation of SA is problematic for a number of reasons.

The first issue is validity. If SA is a cognitive activity, then we cannot know what was occurring in the mind of the individual that led to the outcome under investigation. As outlined previously, measurement of SA is challenging in the present, therefore even more so in retrospect. In the case of retrospective identification of loss of SA, the assessment is made on the basis of observed decisions and actions, however this does not illuminate the cognitive process that was undertaken by the clinician to decide upon the ensuing actions. This raises another issue which is that SA is measured against a normative ideal which assumes that there was one correct understanding of the situation and therefore one course of action (Stanton et al 2017). However, there is not necessarily a "correct" course of action in Midwifery, there may be multiple routes to arrive at the same understanding or diagnosis (Singh et al 2006). Therefore, it is subject to expert opinion as to whether the clinician made appropriate decisions in any particular case. This is not necessarily a valid measure of the clinicians SA, moreover an appraisal of their decision making.

Furthermore, judging SA retrospectively is clearly subject to hindsight bias. With the benefit of hindsight, the eventual outcome is predictable, however at the time clinicians may not have had all of the information, or there may have been misleading symptoms that allude to an alternative pathology for example. Dekker (2015:159) suggests, *"'loss of situation awareness' is analytically nothing more than a post hoc judgment that says we know more about the situation now than other people apparently did back then"*. The human factors principle of local rationality says that people make decisions that make sense to them at the time. Although in retrospect an expert can judge that a decision was wrong, it must be assessed, based on the knowledge the practitioner had at the time and in the context that the decision was made. Furthermore, the human factors principle of performance variability suggests that people create safety by varying their practice to defend against potential threats within the system (Amer-Wahlin and Dekker 2008). What might superficially appear to have been a poor decision, may have been made with good reason, to compensate for inadequacies elsewhere within the system. Therefore, it is important to look at the systemic factors which ordinarily keep the organisation running safely, to understand why an adverse outcome may have occurred on this occasion (Dekker 2011).

The final concern with assessing SA retrospectively, it that there is an embedded value judgment. To assert that someone lacked SA, inherently implies a failure on the part of the clinician; that they got it wrong, that there was some form of negligence (Dekker 2015). This perspective stands in opposition to the human factors approach of systems thinking where human error should be viewed as a symptom of systemic problems within an organisation, rather than a cause (Amer-Wahlin and Dekker 2008). Blaming individuals, whether overtly or implicitly, is not helpful in bringing about solutions. Indeed, Shorrock and Williams (2016) argue that labelling errors retrospectively with broad terms such as loss of SA, removes context and so hinders our understanding of the system factors that were at play at the time. Therefore, identifying the reasons why someone may have lost SA could enable system redesign to reduce the risk of errors in the future (Singh et al 2006).

Conclusion

This paper has presented a theoretical critique of situation awareness as an academic concept, outlining the main perspectives that exist to explain this construct. A scoping review has demonstrated that despite heavy criticism of Endsley's (1988) cognitive model of SA, it appears that this perspective has been unquestionably implemented in midwifery settings, without consideration of alternative perspectives. Additionally, there are inconsistencies in the midwifery application of SA theory from Endsley's (1988) conceptual model, and how SA can be measured. Alarmingly, whilst assertions were made about levels of SA in the midwifery literature, only two studies attempted to measure it. Difficulties in measuring SA are a stumbling block for meaningful operationalisation of this concept in practice. If SA cannot be measured, then it cannot be taught because there it is impossible to evaluate whether the teaching has been effective. Furthermore, teaching SA does not appear from the literature to be linked to improved clinical outcome, therefore the benefit of teaching SA is debatable. In conclusion, SA may be an interesting and potentially useful theoretical concept, but the practical utility of it is limited. What is clear, is that applying "loss of situation awareness" post hoc as a cause or contributory factor in incident investigations and safety reports such as HSIB (2020), Draper et al (2017) and RCOG (2017), is not helpful in bringing about solutions (Shorrock and Williams 2016). Amer-Wahlin and Dekker (2008:936-7) argue *that "the greatest risk to safety in the delivery room is not the technology, nor the human. It is the oversimplification: the idea that there are simple explanations for adverse events and single silver bullets that can resolve the situation is an illusion"*. In line with the Institute of Medicine (1999b) recommendations set out at the beginning of this paper, which called for a move away from a punitive system of attributing blame, to redesigning work systems to support practitioners to do the right thing, it is vital to identify the system factors which may lead to loss of situation awareness, in order to redesign the work environment to minimise patient harm and maximise safety (Singh et al 2006).

References

Abbott, S., Rogers, M. and Freeth, D. (2012) 'Underpinning safety: Communication habits and situation awareness', British Journal of Midwifery, 20(4), pp. 279-284. doi: 10.12968/bjom.2012.20.4.279.

Amer-Wahlin, I. and Dekker, S. (2008) 'Fetal monitoring—a risky business for the unborn and for clinicians'. BJOG : an international journal of obstetrics and gynaecology, 115(8), pp. 935–937. doi:10.1111/j.1471-0528.2008.01758.x.

Bunford, D. and Hamilton, S. (2019) 'How delivery suite co-ordinators create situational awareness in the multidisciplinary team', British Journal of Midwifery, 27(8), pp. 497-505. doi: 10.12968/bjom.2019.27.8.497.

Carayon, P., Wetterneck, T.B., Rivera-Rodriguez, A.J., Schoofs Hundt, A., Hoonakker, P., Holden, R. and Gurses, A. P. (2014) Human factors systems approach to healthcare quality and patient safety. Applied Ergonomics, 45, pp 14-25.

Care Quality Commission (CQC) (2022) Find and compare services. https://www.cqc.org.uk/search/all?query=maternity&location-query=&radius=10&display=list&sort=relevance&last-published=&filters[]=archived:active&filters[]=lastPublished:all&filters[]=more_services:all&filters

[]=overallRating:Inadequate&filters[]=services:hospital&filters[]=specialisms:all (Accessed 14/07/2022).

Chatzimichailidou, M.M., Protopapas, A. and Dokas, I.M. (2015) Seven Issues on Distributed Situation Awareness Measurement in Complex Socio-technical Systems. In: Boulanger F., Krob D., Morel G., Roussel JC. (eds) Complex Systems Design & Management. Springer, Cham. https://doi.org/10.1007/978-3-319-11617-4_8 (Accessed 03/02/2022).

Cooper, S., Bulle, B., Biro, M.A., Jones, J., Miles, M., Gilmour, C., Buykx, P., Boland, R., Kinsman, L., Scholes, J. and Endacott, R. (2012) 'Managing women with acute physiological deterioration: Student midwives performance in a simulated setting', Women and Birth, 25(3), pp. e27-e36. doi: 10.1016/j.wombi.2011.08.009.

Dekker, S. (2011) Patient Safety: A Human Factors Approach. Taylor & Francis Group, ProQuest Ebook Central. http://ebookcentral.proquest.com/lib/staffordshire/detail.action?docID=726851 (Accessed 02/02/2022).

Dekker, S.W.A. (2015) The danger of losing situation awareness. Cogn Tech Work, 17: pp159–161.

Draper, E.S., Kurinczuk, J.L. and Kenyon, S. (2017) MBRRACE-UK Perinatal Confidential Enquiry. Term, singleton, intrapartum stillbirth and intrapartum-related neonatal death. https://www.hqip.org.uk/wp-content/uploads/2018/02/mbrrace-uk-perinatal-confidential-enquiry-report-2017.pdf (Accessed 28/02/2022).

Durso, F.T., Hackworth, C.A. and Truitt, T. et al (1998) Situation awareness as a predictor of performance in en route air traffic controllers. Air Traffic Quarterly, 6(1): 1-20.

Edozien, L. (2015) Situational Awareness and Its Application in the Delivery Suite. Obstetrics & Gynecology, 125, (1): 65-69.

Endsley, M.R. (1988) Situation awareness global assessment technique (SAGAT). Proceedings of the IEEE 1988 National Aerospace and Electronics Conference, pp. 789-795 vol.3, doi: 10.1109/NAECON.1988.195097. https://ieeexplore.ieee.org/document/195097 (Accessed 12/01/2022).

Endsley, M.R. (1995) Toward a Theory of Situation Awareness in Dynamic Systems. Human Factors Journal, 37(1), 32-64.

Endsley, M. (2015) Situation awareness: operationally necessary and Scientifically grounded. Cogn Tech Work, 17:163–167. DOI 10.1007/s10111-015-0323-5.

Endsley, M.R. (2000) Theoretical Underpinnings of Situation Awareness: A Critical Review. In: Endsley, M. R. and Garland D. J (Eds.) (2000) Situation Awareness Analysis and Measurement. Mahwah, NJ: Lawrence Erlbaum Associates.

Endsley, M.R. (2021) Systematic Review and Meta-Analysis of Direct Objective Measures of Situation Awareness: A Comparison of SAGAT and SPAM. Human Factors, 63(1) 124-150.

Fioratu, E., Flin, R., Glavin, R. and Patey, R. (2010) Beyond monitoring: distributed situation awareness in anaesthesia. British Journal of Anaesthesia, 105 (1): 83–90 (2010). doi:10.1093/bja/aeq137.

Flin, R., O'Connor, P. and Crichton, M. (2017) Safety at the Sharp End A Guide to Non-Technical Skills. 1st edition. London: CRC Press.

Fore, A.M. and Sculli, G.L. (2013) A concept analysis of situational awareness in nursing. Journal of Advanced Nursing, 69(12), 2613–2621. doi: 10.1111/jan.12130

Gluyas, H. and Harris, S-J. (2016) Understanding situation awareness and its importance in patient safety. Nursing Standard, 30(34): 50-58.

Gordon, M., Darbyshire, D. and Baker, P. (2012) Non-technical skills training to enhance patient safety: a systematic review. Medical Education, 46: pp1042–1054.

Healthcare Safety Investigation Branch (HSIB) (2020) Delays to intrapartum intervention once fetal compromise is suspected. Independent report by the Healthcare Safety Investigation Branch I2019/020. https://www.hsib.org.uk/investigations-and-reports/delays-to-intrapartum-intervention-once-fetal-compromise-is-suspected/ (Accessed 17/01/2022).

Institute of Medicine (1999a) To Err is Human: Building a Safer Health System. Brief Report. https://www.nap.edu/resource/9728/To-Err-is-Human-1999--report-brief.pdf (Accessed 02/02/2022).

Institute of Medicine (1999b) To Err is Human: Building a Safer Health System. Full book. https://www.nap.edu/download/9728 (Accessed 03/02/2022).

International Confederation of Midwives (2017) Core Document: International Definition of the Midwife. https://www.internationalmidwives.org/assets/files/definitions-files/2018/06/eng-definition_of_the_midwife-2017.pdf (Accessed 02/03/2022).

Jones, R.E.T., Connors, E.S. and Endsley, M.R. (2011) A Framework for Representing Agent and Human Situation Awareness. 2011 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support (CogSIMA), Miami Beach, FL. https://ieeexplore-ieee-org.ezproxy.staffs.ac.uk/stamp/stamp.jsp?tp=&arnumber=5753450&tag=1 (Accessed 03/02/2022).

Kapur, N., Parand, A., Soukup, T., Reader, T. and Sevdalis, N. (2016) Aviation and healthcare: a comparative review with implications for patient safety. Journal of the Royal Society of Medicine Open. DOI:10.1177/2054270415616548. (Accessed 03/02/2022).

Kirkup, B. (2015) The Report of the Morecambe Bay Investigation. An independent investigation into the management, delivery and outcomes of care provided by the maternity and neonatal services at the University Hospitals of Morecambe Bay NHS Foundation Trust from January 2004 to June 2013. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/408480/47487_MBI_Accessible_v0.1.pdf (Accessed 24/01/2022).

Knight, M., Kenyon, S., Brocklehurst, P., Shakespeare, J. and Kurinczuk, J.J. (2014) Saving Lives, Improving Mothers' Care. Lessons learned to inform future maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2009-2012. MBRRACE Report. https://www.npeu.ox.ac.uk/assets/downloads/mbrrace-uk/reports/Saving%20Lives%20Improving%20Mothers%20Care%20report%202014%20Full.pdf (Accessed 10/02/2022).Powell-Dunford, N., Brennan, P.A., Peerally, M.F., Kapur, N., Hynes, J. and Hodkinson, P.D. (2017) Mindful Application of Aviation Practices in Healthcare. Aerospace Medicine and Human Performance, 88 (12): pp1107-1116.

Knight, M., Bunch, K., Tuffnell, D., Patel, R., Shakespeare, J., Kotnis, R., Kenyon, S. and Kurinczuk, J.J. (Eds.) (2021) MBRRACE-UK. Saving Lives, Improving Mothers' Care Lessons learned to inform Maternity care from the UK and Ireland Confidential Enquiries into Maternal Deaths and Morbidity 2017-19. https://www.npeu.ox.ac.uk/assets/downloads/mbrrace-uk/reports/maternal-report-2021/MBRRACE-UK_Maternal_Report_2021_-_FINAL_-_WEB_VERSION.pdf (Accessed 24/01/2022).

MacKintosh, N., Berridge, E.-. and Freeth, D. (2009) 'Supporting structures for team situation awareness and decision making: Insights from four delivery suites', Journal of evaluation in clinical practice, 15(1): 46-54. doi: 10.1111/j.1365-2753.2008.00953.x.

Morgan, P., Tregunno, D., Brydges, R., Pittini, R., Tarshis, J., Kurrek, M., DeSousa, S. and Ryzynski, A. (2015) 'Using a situational awareness global assessment technique for interprofessional obstetrical team training with high fidelity simulation', Journal of Interprofessional Care, 29(1):13-19. doi: 10.3109/13561820.2014.936371.

Ockenden, D. (2022) Findings, Conclusions and Essential Recommendations From the Independent Review of Maternity Services at the Shrewsbury and Telford Hospital NHS Trust. https://www.ockendenmaternityreview.org.uk/wp-content/uploads/2022/03/FINAL_INDEPENDENT_MATERNITY_REVIEW_OF_MATERNITY_SERVICES_REPORT.pdf (Accessed 14/07/2022).

Powell-Dunford, N., Brennan, P.A., Peerally, M.F., Kapur, N., Hynes, J. and Hodkinson, P.D. (2017) Mindful Application of Aviation Practices in Healthcare. Aerospace Medicine and Human Performance, 88 (12):1107-1116.

Rayfield et al (2017) Rayfield, M., Ansari, S. and Prosser-Snelling, E. (2017) Seeing the bigger picture. https://www.rcm.org.uk/news-views/rcm-opinion/seeing-the-bigger-picture/ (Accessed 06/01/2022).

Royal College of Obstetricians and Gynaecologists (RCOG) (2017) Each Baby Counts. 2015 Full Report. https://www.rcog.org.uk/en/guidelines-research-services/audit-quality-improvement/each-baby-counts/ebc-2015-report/ (Accessed 17/01/2022).

Salmon, P.M., Stanton, N.A., Walker, G.H., Jenkins, D., Ladva, D., Rafferty, L. and Young, M. (2009a) Measuring Situation Awareness in complex systems: Comparison of measures study. International Journal of Industrial Ergonomics, 39: 490–500.

Salmon, P.M., Stanton, N.A., Walker, G.H. and Jenkins, D.P. (2009b) Distributed Situation Awareness. Theory, Measurement and Application to Teamwork. London: CRC Press.

Shorrock, S. and Williams, C. (2016) Human Factors and Ergonomics in Practice: Improving System Performance and Human Well-Being in the Real World. Taylor & Francis Group, ProQuest Ebook Central, http://ebookcentral.proquest.com/lib/staffordshire/detail.action?docID=5185433. Accessed 09/02/2022)

Singh, H., Petersen, L.A. and Thomas, E.J. (2006) Understanding diagnostic errors in medicine: a lesson from aviation. Qual Saf Health Care, 15:159–164. doi: 10.1136/qshc.2005.016444.

Sonesh, S.C., Gregory, M.E., Hughes, A.M., Feitosa, J., Benishek, L.E., Verhoeven, D., Patzer, B., Salazar, M., Gonzalez, L. and Salas, E. (2015) 'Team training in obstetrics: A multi-level evaluation', Families, Systems, & Health, 33(3): 250-261. doi: 10.1037/fsh0000148; 10.1037/fsh0000148.supp (Supplemental).

Stanton, N.A. , Salmon, P.M., Walker, G.H. and Jenkins, D.P. (2010) Is situation awareness all in the mind? Theoretical Issues in Ergonomics Science, 11:1-2: 29-40. DOI: 10.1080/14639220903009938.

Stanton, N.A., Salmon, P.M., Walker, G.H., Salas, E. and Hancocke, P.A. (2017) State-of-Science: Situation Awareness in individuals, teams and systems. Ergonomics, 60(4):247-258.

Zhang, T., Yang, J. and Liang, N. et al. (2020) 'Physiological Measurements of Situation Awareness: A Systematic Review', Human factors, pp. 1872082096907–18720820969071. DOI:10.1177/0018720820969071. Available at: https://doi.org/10.1177/0018720820969071.