Outbreak column 17: Situational Awareness for healthcare outbreaks

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Abstract

Outbreak column 17 introduces the utility of Situation Awareness (SA) for outbreak management. For any given time period, an individual or team's SA involves a perception of what is going on, meaning derived from the perception and a prediction of what is likely to happen next. The individual or team's SA informs, but is separate to, both the decisions and actions that follow. The accuracy and completeness of an individual or team's SA will therefore impact on the effectiveness of decisions and actions taken. SA was developed by the aviation industry and is utilised in situations which, like outbreaks, have dynamic, i.e. continuously changing problem spaces, and wherein a loss of SA is likely to lead to both poor decision-making and actions with potentially fatal consequences. The potential benefits of using SA for outbreaks are discussed and include: (1) retrospectively to identify if poor decision-making was a result of a poor SA; (2) prospectively to identify where the system is weakest; and (3) as a teaching tool to improve the skills of individuals and teams in developing a shared understanding of the here and now.

Keywords

Outbreak, Situation Awareness, error

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Introduction

Outbreak Column 16 discussed effects and biases that can result in poor decision-making when people are trying to work optimally. How these effects and biases could manifest during outbreak prevention, preparedness and management (PPM) was also debated (Curran, 2015). Additionally, insights were given as to how we as infection prevention and control teams (IPCTs) might recognise and avoid them. On reflection, in Outbreak Column 16 the term Outbreak PPM was used; this should have been Outbreak PPDM: Prevention, Preparedness, Detection and Management. This is because detection (like prevention and preparedness) is sufficiently distinct from outbreak management and arises before outbreak management commences. Further arguments supporting this change will be discussed later. For clarity, Table 1 provides definitions of Outbreak PPDM.

Outbreak Column 17 introduces and illustrates the potential utility of Situation Awareness (SA) during outbreak management. SA is about an individual or IPCT's perception, understanding and prediction of what will happen next in a dynamic (continuously changing) problem

space within a given time period. During an outbreak the information regarding the mode(s) of transmission, the number of persons affected, the locations where transmission can arise may all change; as a consequence, the prediction as to what will, and what needs, to happen next also changes. To maximise the utility of SA during outbreaks the IPCT needs to be goal-driven; this column will begin a brief explanation as to why this should be the case.

IPCTs' sub-goal: detect an outbreak if one is present

In previous work it was suggested that IPCTs should be 'data-driven' (Curran and Wilson, 2008); however again on

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Table 1. Definitions of Outbreak PPDM – and activities to achieve.

	Definition
Outbreak Prevention	Ways of working which include the availability of resources, negation of risks and the operationalisation of policies that minimise cross-transmission and cross-infection risks in care settings.
Outbreak Preparedness	Ways of working which achieve a state of system readiness for outbreaks achieved through: alertness, training, exercising, surveillance, organisation, communications, policy and other resources.
Outbreak Detection	The identification from clinical, microbiological or surveillance data of alert signals or unnatural variation(s) that suggest an outbreak.
Outbreak Management	The use of investigations, control measures and communications to halt transmission, care for affected people, remedy systems and share information.

reflection and following further reading for this column, it is clear that the IPCT should, as advocated by Endsley (2000), be ‘goal-driven’. Data create an argument for actions, indicate progress and goal failure or achievement, but they only form part of our SA. Everything IPCTs do is about reducing the impact and incidence of outbreaks – even if this is not explicitly stated, e.g. teaching Standard Infection Control Precautions is about minimising the risk of cross-transmission, not just to individual patients, but collectively to all patients to prevent outbreaks. It could be argued therefore that the primary goal of IPCTs should be: To prevent, prepare for, detect and manage outbreaks. Within this primary goal there are several sub-goals, e.g. every time an ICN is referred new patients with alert organisms one (of many) sub-goals is: detect an outbreak if one is present. Now that this primary and sub-goal are explicit, our SA and follow on decisions / actions can be measured robustly as either achieved or not. The next section will explore SA and how using, measuring and analysing this construct can improve our Outbreak PPDM capabilities.

Situation Awareness (SA)

SA is a critical component of decision-making (Wright et al., 2004). It has been described simply as ‘knowing what is going on’ (Endsley, 1995b; Wickens, 2008) and formally 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, 1995b). SA is a construct of these three elements (perception, comprehension and projection) which form three hierarchical levels (Endsley, 1995b). Level 1 is the lowest level of SA and is about what is perceived – literally, what is happening. There is no understanding or context to what is happening; the dots are seen as individual dots, but they are not joined up to make an outbreak picture. For example, consider a nurse on the ward who is aware that three patients have diarrhoea and vomiting but does not consider that the symptoms in different patients are related to the same infectious pathogen – in such a situation the IPCT

will not be called. At a Level 2 SA, the dots have been seen and been joined. There is meaning and understanding to what has been perceived – an outbreak has been identified. Finally at Level 3, the highest level of SA, from what is known to exist, and what is understood about the situation, a prediction is made as to what is likely to happen next. In the example given it could be this: without control measures this outbreak will spread to other people in this ward and perhaps to other wards. The levels are important because there are different ways to address each of them when they fail (Wickens, 2008). Referring to earlier work by Endsley, it was reported that loss of SA was a critical factor in 88% of commercial aircraft incidents resulting from human error (Kaber and Endsley, 1998). Figure 1 shows how SA could be applied to outbreak decision-making.

It is important to note that SA is only about the extent of ‘knowing’; SA does not include the decisions and actions that follow from on from the awareness (Wickens, 2008). It is argued that good decisions can follow poor SA ‘if only by luck’ and conversely bad decisions can follow good SA (Endsley, 1995b). Although, good decisions are much more likely if they follow an accurate and complete SA (Endsley, 1995b).

Dynamic problem spaces necessitate accurate SA

As stated, SA is more commonly used in high-risk occupations such as the aviation industry where the environment involves a rapidly dynamic problem space, i.e. situations like outbreaks where the information is constantly changing, and SA can be lost in an instant with fatal consequences (Wickens, 2008). Although the elements of SA vary widely between different domains (e.g. between aviation and healthcare), the mechanisms can be generically described and relate to different professional settings (Endsley, 2000). The use of SA as a training aid has already proven useful in anaesthesiology (Wright et al, 2004). Outbreaks also present in dynamic problem spaces and although they change less rapidly than say, cockpit indicators in a phantom jet,

Figure 1. Outbreak example of Endsley's (2005b) 3 levels of situation awareness.

they still require an accurate and complete SA, which needs to be updated as the dynamic problem space evolves. It has been argued that wherever there is a dynamic problem space there is a need to track the data sources and update SA (Stanton et al., 2001). In aviation this would include altitude, speed, wind, etc., during outbreaks this would include the standard epidemiological information of time, places, persons and mode(s) of transmission.

Outbreaks necessitate a continuously updated, accurate and complete SA

This column is in the main using the example of SA at the critical earliest point of possible outbreak detection. The sub-goal as stated already is: detect an outbreak if one is present. Once an outbreak is detected other sub-goals will commence which also necessitate concurrent tasks being performed (Table 2). Figure 2 shows that following a SA Level 3 (prediction), regardless of its accuracy and completeness, decisions will be made and actions taken (or omitted). As a consequence the dynamic problem space evolves and results in the need for the individual to update their SA. SA can therefore be lost at the beginning of an outbreak and result in delayed detection, as well as at various points throughout the outbreak's duration resulting in its prolongation with more cases than necessary arising. For each of the sub-goals that arise during an outbreak, tasks will be performed which can be measured as achieved or not achieved (Table 2). The overall outbreak management success will be dependent on the accuracy and completeness of SA being maintained, while the dynamic problem space evolves, by each of the people involved. It is now possible in mid-outbreak to confirm whether there is a shared SA among IPCT members. Finding out where and why there are differences in SA among an IPCT, could reveal that some individuals have access to more accurate data, or that an individual's perception, understanding and prediction from the same data are erroneous. Recognising

where an individual's SA is inaccurate could also lead to the identification of specific training needs. From this limited discussion it should be obvious that IPCTs now have an excellent framework with which to assess outbreak detection and monitor goal attainment throughout the outbreak.

The next sections will look at how SA can be useful in Outbreak PPDM for teaching, prospectively to identify system weaknesses, but first the retrospective utility of SA will be examined.

Retrospective SA loss in large outbreaks

The erroneous assumption of safety held by key people in the organisation during major healthcare incidents can be summarised thus: if there was an outbreak somebody would find it and somebody would tell me, they have not told me therefore there is not an outbreak. Such erroneous assumptions are reliant on passive reporting rather than the much safer active reporting; passive reporting in these instances can be considered a Level 1 organisational SA failure. One example of a passive reporting failure leading to a non-healthcare disaster is the 1980s ferry, the *Herald of Free Enterprise*. The *Herald* had set sail with her bow door open; she capsized shortly thereafter with the loss of many lives. Her captain erroneously assumed that the bow door must be closed as he had not heard that it was open (Department of Transport, 1987) (12.3). The standing instruction for those noticing a problem or failure was to call the captain – no call came, no problem was identified and water came in the bow door to capsize the vessel. Recommendations were subsequently made for positive confirmatory indications that ships were safe (doors are closed) pre-departure (Department of Transport, 1987). Similarly, it is much safer if hospital managers are provided with active reporting to confirm where outbreaks are and are not present. There needs to be a shared complete and accurate SA within the IPCT and between the IPCT and the organisation. Such a recommendation is included in the Vale of Leven Report

Table 2. Examples of sub-goals and tasks once an outbreak is detected.

Sub-goals once outbreak detected	Task(s)
Stop new cases by ensuring control measures are correctly applied.	Advocate control measures and confirm HCWs know how to apply them; monitor adherence of application.
Inform everyone who needs to know about the outbreak.	Follow outbreak communications chain SOP and update by phone key people. Confirm outbreak email group is current. Produce and issue SBAR email to the outbreak email group.
Track the outbreak's progress.	Produce an epi curve and time line of all known cases and update as new cases come to light.
Identify all cases.	Undertake a laboratory look-back; consider looking for additional cases in recently discharged or transferred persons. Arrange for specimens to be taken from all symptomatic and exposed persons.

Figure 2. The dynamic problem space showing how deterioration in outbreak data changes the Endsley's 3 levels of SA resulting in different predications and actions.

states that: ‘Reporting [of outbreaks] should include positive reporting in addition to exception reporting.’ (MacLean, 2014, p. 369; Recommendation 55).

For IPCTs dealing with patients who have newly identified alert organisms, an accurate SA is required throughout the day. If there is an increase in the data on new alert organisms, the IPCT should perceive the number of cases, comprehend that this number is a change and represents a (possible) outbreak and predict that unless outbreak control measures are implemented the situation will deteriorate further (Figure 1). By retrospectively analysing outbreak reports it can be seen that, although the term ‘the IPCT lost SA’ was not specifically used, there are examples of poor SA being identified in a couple of very large outbreaks that led to major enquiries:

Maidstone-Tunbridge Wells Report: (Healthcare Commission, 2007, p. 24)

‘Before April 2006 figures on *C. difficile* were not reported in a way that would easily enable the trust to detect outbreaks.’ ‘The significant outbreak in the autumn of 2005 was missed and the trust has acknowledged it should have detected the rise in cases at that time.

Vale of Leven Report: (Maclean, 2014, p. 307)

‘Mr Divers (CEO) quite rightly could not understand how despite: “The evidence in front of their eyes (they) somehow managed to conclude there wasn’t an outbreak”.’

The Maidstone-Tunbridge Wells report suggest that there was a Level 1 SA failure, i.e. the surveillance systems was so poor that the increase in the number of cases could not be perceived in real-time. In contrast, the Vale of Leven Report suggests a Level 2 SA failure, i.e. the increase in cases was perceived but this increase was not understood to be indicating an outbreak.

In the Vale of Leven outbreak, the evidence ‘in front of their eyes’ was a colour-coded T card surveillance system which showed more yellow cards indicating more *Clostridium difficile* cases than usual; but the IPCT was unable to perceive the increase and determine that there was an outbreak present. Statistical process control chart (SPCs) use statistical theory to identify when the data represent the IPC system functioning normally (data exhibiting natural variation) or the IPC system being awry (data exhibiting unnatural variation) (Benneyan, 1998a, 1998b; Curran et al., 2002). However, SPCs were not in use in the outbreak hospital. The inquiry considered that ‘had SPC charts been in place in 2007, an increased level of awareness would have been generated in relation to rates of CDI and the Vale of Leven Hospital [and] it is likely the problem would have been discovered sooner’ (Maclean, 2014, p. 345). Highlighted but not heeded within one of the reports was a lesson learned from the Stoke-Mandeville outbreak (Healthcare Commission, 2006): ‘Crucial for outbreaks is the need for ... rapid identification and notification of outbreaks’ (p. 89). It may seem inexcusable to fail to detect a large outbreak – but did you spot the gorilla?

Did you see the gorilla?

For those who know nothing of the gorilla and basketball passes, please stop reading and look at the following website: www.youtube.com/watch?v=IGQmdoK_ZfY (accessed 8 December 2014). Basically, a team at the Smithsonian Institute have demonstrated that up to 50% of people cannot see what is staring them in the face – even if it is wearing a gorilla outfit and thumping its chest (Simons, 2014). This ‘inattention blindness’ is a recognised phenomenon and for IPCTs it shouts loud and clear – our systems need back-up. No IPCT should have a system where a single person / small team is responsible for assessing data that could be hiding outbreaks. There must be recognition that the IPCT sub-goal of: detect an outbreak if one is present, is not a single discrete task. Rather it is a task that is being undertaken in many different clinical settings each and every day. Perhaps the sub-goal would be more accurately stated as: from all the data on patients with alert organisms in multiple clinical areas – detect outbreak(s) if and where they are present.

Missing the gorilla is a Level 1 SA failure, whereas failing to see an outbreak from a detected increase in cases is a Level 2 SA failure. This does not mean that inattention blindness could not influence outbreak detection. In addition, Endsley (2000) summarises interesting work which found that ‘highly experienced air traffic controllers developed quite elaborate stories to explain away conflicting information that was inconsistent with the mental model created by earlier information’. Although experienced practitioners are more able than novices to recall familiar patterns and therefore recognise problems, such as outbreaks,

what Endsley’s (2000) work shows is that regardless of experience, as humans we are reluctant to let go of early-formed wrong opinions even when faced with a mountain of evidence that indicates we are wrong. This bias has been discussed previously in Outbreak Column 16 and is of course ‘Confirmation Bias’ (Curran, 2014; Reason, 1990). Given that experienced-operators can go awry when trying to perform optimally, what hope is there for operators who have never experienced an outbreak with a particular organism? Apparently, due to problems of available memory, very little chance at all (Endsley, 1995b). Having previously discussed the availability heuristic (mental shortcuts used for decision-making) and effects such as the ‘Black-swan effect’ (Kahneman, 2011; Kahneman et al., 1982), i.e. believing what has not been experienced does not exist / will not happen, there can be little expectation or guarantee that an inexperienced practitioner would have an accurate and complete SA and detect a novel to them outbreak presentation; outbreak detection could be late.

Today the IPCT can be inundated with data; however, this does not necessarily mean that as a consequence they will be able to extract more intelligence from it and more easily detect outbreaks. More data can in effect mean that operators are less likely to see the dots – let alone join them up (Endsley, 2000). As stated, IPCTs need back-up. Let’s consider whether a double-check would be a good place to start.

Double-checking (two opinions are better than one, right?)

Under the title of ‘hazards of consensus in inspection’ (Deming, 2000) explains the pitfalls of relying on a second person. If there is a difference in the grades of the people doing the assessment, a junior assessor with a contradictory view may, fearing the consequences of contradiction, agree with the superior’s assessment and withhold any reservations. Thus such a ‘double-check’ may actually represent only the superior’s opinion (Deming, 2000). There can also be a false comfort with double-checking if individually both assessors consider that, as there is a second assessor, they themselves do not need to apply as much attention as they would if they knew they were the only detection defence. Both assessors may consider that their colleague will detect an outbreak if one is present; in reality no one will detect an increase (Level 1 SA failure) or detect an outbreak (Level 2 SA failure) because they are not diligently looking for it. Deming (2000) considers independent assessment by two people is a better and a safer approach; this is also recommended in most medication calculation checks even if time constraints make it difficult to achieve (White et al., 2010). Therefore the sub-goal of detect an outbreak if one is present, is more likely to be achieved if two ICNs independently review SPCs and then exchange their written assessment of the data variation being

exhibited (natural or unnatural). Such a process could also optimise learning and would determine if there is a shared SA between team members. In summary IPCTs are vulnerable to poor outbreak detection if they:

Level 1 SA Failure

- Are not goal driven, i.e. specifically set out to detect an outbreak if one is present.
- Describe data using non-numerical terms, e.g. 'some, more than usual, about the same, bobbing along'.
- Fail to accurately attribute patients' alert organism acquisition to clinical areas.
- Do not have alert organism attribution data by clinical area over periods of time.

Level 2 SA Failure

- Cannot distinguish between natural and unnatural variation / triggers for action.
- Are experiencing 'inattention blindness' to outbreak data due to encysting / fixation or other competing priorities.
- Have little independent back-up or oversight.

Level 3 SA Failure

- Have not previously experienced an outbreak and cannot predict how it will progress.
- Have early and wrong ideas about the presence of an outbreak and how it will progress.

Prospective SA: where are we vulnerable to inaccurate SA and poor outbreak detection?

Prospectively, the above summary can be used as an assessment tool to determine how vulnerable an IPCT is to having an inaccurate and incomplete SA during outbreak detection. Even with sufficient training and qualifications, the IPCT needs to be a goal-driven and have access to high-quality numerical data from which they can perceive changes, derive meaning and predict events. This should involve a shared SA among the team involving independent back-up. The presence or absence of these critical elements (experience/back-up and goal/data quality) which are in addition to standard qualifications are the basis for an assessment of the IPCT's capability and resources. So it is not the presence of a specific number of ICNs or a surveillance system that indicates sub-goal capability, but the quality of the data available, how the data are used, as well as how the individual team members operate to create resilience should confirmation bias or inattention blindness take hold. Once prospective assessments of the capabilities and resources to

achieve the sub-goal are complete, plans to improve ways of working can be devised.

IPCT SA and SA within the organisation

Organizational cybernetics is the science of effective organisations and is based on the assumption that complex systems are recursive in nature (Jackson, 2004). This refers to the system existing in natural hierarchies – the perimeters of which in healthcare are described succinctly as 'from board to ward'. In addition to this recursive structure, as NHS boards and trusts have become larger there is also hierarchical and recursive nature within the IPCT structure, e.g. several small teams, a few geographical leads reporting into a single overarching control centre. The overarching IPCT control system once assured the sub-goals have been accurately achieved (outbreaks have been detected if they are present) must feedback to all clinical areas and feed forward to each recursive layer of the organisation with relevant intelligence to enable others to have organisational SA on a par with the IPCT. The Chief Executive does not need to see the SPC for every clinical area, but does need assurance as to whether, how many, and in which clinical areas outbreaks have been detected. Graphical representation of the data fed back and fed forward to various recursive layers of the organisation should be produced by the IPCT and approved of by the organisation and its layer representatives.

Since outbreak management is a team pursuit, the question arises as to whether SA should be considered and assessed at the level of an individual or a team. The WHO personalise the Endsley (1995) definition which starts with the 'individual's perception...' (Anon, 2009). But in any given situation outbreak situation SA may be about individuals working independently and as a team. Different people within the team may have a different SA based on access to separate data, different perceptions, different comprehension and different projections based on their personal experiences. That an outbreak is identified will be based on the sharing of an individual's SA within the IPCT to generate a team SA (TSA). The question arises: is that important? The answer is, of course, yes. Individual colleagues may have a more accurate and a more complete SA than others. Differences between individuals' SA may make team decision-making more difficult and team decisions less optimal. Given that TSA is so important the next logical question is how is SA measured during an outbreak?

Measuring real-time SA

Although there are tools for measuring SA in anaesthesia, critical care (and the aviation industry) has yet to be developed for IPC professionals (Crozier et al., 2015; Endsley, 1995a; Wright et al., 2004). However, just as the mechanisms used in SA are useful across different professions, it

is likely that the mechanisms used to measure SA can similarly also be used across different professions.

Endsley (1995a) has set out the requirements for a valid SA measure:

- Measures the construct and not a reflection of other processes
- Provides the required insight on the form of sensitivity and diagnosticity
- Does not substantially alter the construct in the process of measurement
- Is predictive of performance and sensitive to manipulations in workload and attention.

There are a variety of techniques being developed to measure the SA of people while they are carrying out their duties. These techniques include: physiological techniques (the use of electroencephalographic measurements to show if information is registered cognitively), performance measures (assessed by computer), global measures (end of task assessments), external task measures (artificially changing the data and determining how long it takes people to respond) and imbedded task measures. The latter method shows promise and potential utility for IPCT training. It involves interrupting simulation procedures to ask the participants questions and to relay what they have perceived (Endsley, 1995a). It has been shown that the interruptions do not result in memory decay nor did the interruptions negatively affect performance (Endsley, 1995a). Similar methods for outbreak training could be developed and tested with relative ease. Clinical colleagues (and pilots) do significant amounts of training in simulators: clearly IPCT outbreak training may also benefit from such an approach.

The ubiquitous cry from people personally affected by major disasters (within or outwith healthcare) is that 'it must not happen again'. What the public needs is assurance on is that all levels of care organisations have a shared and as complete and accurate SA as it is possible to have with regard to the sub-goal(s): detect outbreaks if they are present. This review of the utility of SA shows that IPCTs can use the construct retrospectively and prospectively to identify what wrong and where the weakest link in their system are. Further research is needed to determine the full utility of SA measures during outbreak simulation to boost TSA.

Concluding comments

It has been argued that IPCT's primary goal is to attain optimal Outbreak PPDm. Likewise the most important sub-goal is to detect an outbreak if one is present. The ingredients necessary for outbreaks are present every day in every clinical setting. Reports of major outbreaks although small in number are too many and thus necessitate prospective and continuous assurance of system capability. IPCTs can use the SA construct to determine their systems strengths

and weaknesses in outbreak detection. During outbreaks they can also determine if there is a shared TSA, which is a necessity for optimal outbreak management decision-making.

The use of SA by IPCTs is clearly at present a promising tool but the construct shows great promise to enable the development and maintenance of safe systems.

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