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Weak Signals in Healthcare: A Case study on Community-Based Patient Discharge

Eva-Maria CARMAN\(^a\), Mike FRAY\(^a\), and Patrick WATERS\(^a\)

\(^a\)Human Factors in Complex Systems Research Group, Loughborough Design School, Loughborough University, Loughborough, UK

ABSTRACT
To adjust performance to ensure the success of a task and prevent error, it is necessary to anticipate, identify and respond to variations in the work system. The objectives of this study were to develop a framework for the analysis of signals, which provide an indication of variations in the system, in the healthcare environment and qualitatively investigate signals in the context of community-based patient discharge. In addition to the signals, both traditional (Safety-I) and proactive safety (Safety-II) elements were investigated with six expert groups, from the field of community-based patient discharge. The signals identified and the safety elements were analysed using the SEIPS 2.0 model. The sources of the signals were identified as originating from work system elements. The proposed framework and method provide a preliminary basis for the investigation of signals and assists in highlighting the role that these can play in safety behaviour.

KEYWORDS
Sensemaking; Health; Weak Signals; SEIPS; Safety-II.

INTRODUCTION
Healthcare can be described as a complex socio-technical system (Braithwaite, Clay-Williams, Nugus, & Plumb, 2013; Buckle, Clarkson, Coleman, Ward, & Anderson, 2006; Carayon & Friesdorf, 2006; Janowitz, Gillen, Ryan, Rempel, Trupin, Swig, Mullen, Rugulies & Blanc, 2006), which due to the rapidly changing and dynamic environment, exhibits properties of emergence, adaptation and self-organization (Braithwaite et al., 2013). Emergent behaviours result as numerous tasks require a more improvised response due to the unpredictable nature and the unanticipated events that comprise the daily routine in this field (Braithwaite et al., 2013; Kerfoot, 2004). As a result of the work and system nature of the healthcare environment, safety in this context not only refers to the safety of the workers but more predominantly to the safety of the patients. Patient safety can be effected by errors (Ahmed, Adam, & Al-Moniem, 2011), which can then potentially lead to adverse incidents or events (Brown, Hofer, Jhol, Thomson, Nicholl, Franklin & Lilford, 2008). Additionally numerous factors, including organisational factors (Johnson, 2004) affect patient safety and therefore it is key to look at patient safety from a system’s perspective.

Research in healthcare will benefit from adopting not only the traditional definition of safety but the more recently developed definition of Safety-II. The concept of safety has recently been expanded to include both a definition of an absence of harm, whereby the number of adverse events is as low as acceptably possible labelled as Safety-I (Hollnagel, 2014), as well as a definition that focuses on the ability to succeed under varying conditions, labelled Safety-II (Hollnagel, 2014). One element of Safety-II is the ability to adjust performance to ensure success of the task and this requires anticipating, identifying and responding to signals indicating changes in the system (Hollnagel, 2014). Signals can be defined as sensed information regarding emerging events (Ansoff & Mcdonnell, 1990), and include indicators or cues from the environment (Rasmussen, 1983) which require interpretation and sense-making (Weick, 1995). The strength of these signals can vary resulting in different requirements regarding interpretation and abilities of sense-making. Strong signals provide a specific indication and are more readily recognized (Guilhaune, 2011) whereas weak signals are often vague in nature (Ansoff & Mcdonnell, 1990), and need to be actively sought out and created by processing interrelated existing events, prior knowledge and future expectations in order to understand the information they provide (Macrae, 2014a). Through the early detection of unexpected events, they may be addressed in a more cost-effective and timely manner (Vogus & Sutcliffe, 2007), but failure to notice the warning signs may result in the risks being normalised, and remaining dormant until an adverse event occurs (Macrae, 2014a, 2014b).

Weak signals may provide an opportunity to achieve proactiveness through the required awareness, monitoring and constant vigilance needed for the identification of these signals and the up-to-date information regarding ongoing operations they provide (Vogus & Sutcliffe, 2007). Effective risk management requires continuous identification and addressing the problems that threaten safety (Macrae, 2014b) and identifying weak signals may offer means of reducing risk and responding to hazards earlier. This highlights the role that weak signals can play in safety behaviour. Despite accident reports increasingly stating signals were present prior to an
incident that would have altered the course of the event if they had been acted upon, research exploring weak signals and the role they may play in safety, especially in healthcare, is limited.

The aims of this research were two-fold, namely develop a conceptual framework for the investigation of weak signals in the healthcare environment and to explore both Safety-I and Safety-II elements in the environment. The results in this paper include the developing conceptual model as well as the results from the first case study.

**METHOD**

**Framework**

To develop an integrated framework, literature was drawn from different fields to develop a conceptual framework for the investigation of weak signals to be assessed in upcoming case studies. The framework was developed for the analysis of weak signals in the context of the work, actions and events in the system in which they occur, specific for the healthcare context. This framework was developed based on literature from strategic management theory (Ansoff & Mcdonnell, 1990), systems ergonomics (Holden et al., 2013; Karsh et al., 2006), naturalistic decision making theory (Zsambok & Klein, 1997), the work on weak signals by Macrae (2014a), as well as the work on error by Rasmussen (1983) and Reason (1991). It is aimed through the use of different case studies conducted within the healthcare context, that the model will be verified and expanded on. The aim of the framework is to enhance the understanding of signals, specifically where they may originate and how they may be manifested specifically in healthcare, which will aid the development of training and tools utilising weak signals.

**Research Design**

An explorative qualitative method was adopted to investigate aspects that lead to performance failure and success as well as weak signals within the community-based patient discharge field using a focus group methodology. This qualitative approach was adopted due to the fuzzy nature of weak signals and as the field of Safety-II is still emerging. The focus groups drew upon the experience of the staff involved in the discharge process for patient discharge into the community to investigate why discharges fail, could the failure be prevented and the characteristics that ensure that the discharge is a success. A total of 6 focus groups across three directorates of the Nottinghamshire Healthcare NHS Foundation Trust were conducted.

**Participant Characteristics**

A total of 39 participants to part across the six focus groups. For five of the six focus groups, seven participants partook in the focus groups with the sixth focus group having a total of four participants. The mean total number of years involved in patient care across all six focus groups was 16.6 years (±10.6) and the mean number of years in the current position was 3.6 years (±3.6). The current positions held by the participants in the focus groups included community and district nurses, locality managers, community physiotherapists and occupational therapists, assistant practitioners, and a team leader of a care home team.

**Protocol**

Each focus group comprised of two consecutive components, where the focus of each component was on aspects and system structures that promote success (in line with the Safety-II definition) and aspects that could go wrong, influencing factors and possible weak signals present (in line with the Safety-I definition). Each component was approximately 45 minutes in duration with a 20-minute break between the two sessions. Prior to the start of the focus group, the project was described to the participants and the project information sheet, the informed consent sheet, as well as demographic information sheet was distributed among the participants, and returned before the start of the first component in the focus group.

The emphasis of the first component in the focus group was on the elements of the discharge process that work well and improve patient safety. These questions were developed using the SEIPS 2.0 model by incorporating the work system elements (Holden et al., 2013) and based on literature on Safety-II. During the main discussion, the group was encouraged to develop a definition of a good discharge from the perspective of the staff as well as that of the patient. Participants were encouraged to discuss how stable their work conditions are, if their work requires a high degree of improvisation and how predictable the work situation is. Following the development of the definition, the discussion was guided by one of the researchers through the following series of questions:

- What is the best way or optimal way to perform your work? What personal elements ensure a good discharge? (Person-related) What needs to be in place (requirements)?
- What can happen unexpectedly during the task and how do you prepare for it? (Task-related)
- Are tools in place that assist with this? (Tool-related)
- What do you require from your team/unit for the discharge to be a success? (Team/group/unit/department)
- What organizational elements assist in ensuring the discharge is a success? (Organizational factors)
The emphasis of the second component in the focus group was on the potential elements for error recovery and identification of weak signals. The main discussion was guided through the following series of questions by one of the researchers:

- What could go wrong with this task? (Error)
- What external factors would influence this task? (External Factors)
- How do you know the task is going wrong? (Signals)
- When you know it is going wrong, how do you correct yourself? Can you pre-empt the task? (Reaction/Monitoring)
- Do you use this knowledge next time you do this task? (Learning)

All focus groups were conducted using the question structure described above. The questions for the two components were used to loosely guide the discussion, but the participants were encouraged to freely discuss any topics that arose as a result of these questions. The discussions for both components of the focus groups were recorded using two audio recorders and one researcher recording field notes. During both discussions, one of the researchers compiled a summary of the key points raised by the group in the discussion on a white board or flip chart. The results were qualitatively analysed using a thematic analysis approach (Braun and Clarke, 2006) by identifying common themes across the groups and the signals identified were categorised using the SEIPS 2.0 model. Ethical approval for this project was granted by the Loughborough University Ethics Approval (Human Participants) Sub-Committee and the Nottinghamshire Healthcare NHS Foundation Trust.

RESULTS

Framework
This work draws on research from numerous fields, including human factors, strategic management theory, natural decision making theory as well as the concepts of safety-I and safety-II to expand the knowledge and understanding of weak signals. The framework was developed for the analysis of weak signals in the context of the work, actions and events in the system in which they occur specific for the healthcare context and the preliminary framework is depicted in Figure 1.

![Figure 1: A conceptual framework for the investigation of weak signals within the healthcare context.](image)

The work by Ansoff (1975) on weak signals in strategic management theory and the work by Macrae (2014a) on weak signals in aviation were used to provide the basic definition and premise for the conceptual framework developed for the investigation of weak signals. The left aspect of the framework included the Input-
transformation-output model of healthcare professional performance (Karsh et al., 2006) in order to determine the aspects of the system from which the signals could originate. This model was selected as it provides a general multi-level model of a work system, as well as having considered open systems theory. The framework was then further expanded to incorporate more specific elements from the second version of the Systems Engineering Initiative for Patient Safety (SEIPS) model (Holden et al., 2013). The SEIPS 2.0 model was selected as it provides a framework for the analysis of processes and the relationship of various elements that occur in healthcare specifically (Carayon et al., 2006).

The forms of the signals have been described in the framework as either being internal or external. An external signal may also generate an internal signal, but the external source or signal that causes the experience of an internal signal may not always be present or known. The external signals include visual, haptic, verbal, auditory or olfactory cues. The internal signals include the experience of a “hunch”, “vibe” or a general sense of “something going wrong”. Signal detection theory (Green and Swets, 1966) was included in the framework as it provides possible factors that may influence how a signal is perceived. These include the strength of the signal and the individual’s bias in perceiving the signal (McLeod, 2015). Theoretical concepts and models included to explain possible interpretation processes and mechanisms in the framework consist of the concepts of situation awareness (Endsley, 1995), sensemaking (Weick, 1995), naturalistic decision making (Zsambok & Klein, 1997), emotional attunement (Benner, Tanner, & Chesla, 1996) and the skill-rule-knowledge model of behaviour (Rasmussen, 1983). The skill-rule-knowledge model of behaviour (Rasmussen, 1983) was included as it may explain the processing and influence signals may have on performance. Signals can affect outcomes in that as a result of fixation (Reason, 1991) no action may be taken or alternatively a recovery strategy is implemented which may either result in an appropriate or inappropriate outcome. By considering the source and type of information, these signals provide insight regarding the status of the system and areas of risk may be revealed (Macrae, 2014a).

**Weak Signals**

In the second component of the focus group, participants were asked to discuss how they knew the discharge may not be going as expected and the signals that indicated this. Additionally, it was discussed how they would respond to this and make an adjustment or adaptation they thought was necessary. These signals, if they are acted upon, have the potential to change the progression of the task and may assist in ensuring a successful outcome.

The identified signals were analysed using the SEIPS 2.0 model by identifying from which element in the sociotechnical work system they originated. The sources of the signals could be categorized as the following elements from the work system: “person”, “tasks”, “tools” and “internal environment”. Examples identified in the focus groups and the categorization of these examples is presented in Table 1.

<table>
<thead>
<tr>
<th>Example given</th>
<th>Source (Sociotechnical Work System)</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient’s physical state</strong></td>
<td>Work system: Persons</td>
<td>Examples consist of external forms of signals including visual cues and olfactory cues, as well as internal forms such as cognitive cues.</td>
</tr>
<tr>
<td><em>For example:</em> Patient does not look well</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient is not at the anticipated level</td>
<td></td>
<td></td>
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<tr>
<td>Patient’s behaviour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanliness of Patient</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>State of patient’s home</strong></td>
<td>Work system: Internal environment</td>
<td>Examples consist of external forms of signals including visual cues and olfactory cues</td>
</tr>
<tr>
<td><em>For example:</em> Untouched medication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluttered environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanliness of home environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family’s response</strong></td>
<td>Work system: Persons</td>
<td>Examples consist of external forms of signals including visual cues and auditory cues</td>
</tr>
<tr>
<td><em>For example:</em> Numerous phone calls</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family is intense or disengaged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family/Carers look as if they are not coping</td>
<td></td>
<td></td>
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<tr>
<td>Family’s expectations</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Patient documentation</strong></td>
<td>Work system: Tools</td>
<td>Examples consist of external forms of signals including auditory cues, as well as internal forms such as cognitive cues.</td>
</tr>
<tr>
<td><em>For example:</em> Prior phonecall</td>
<td></td>
<td></td>
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<tr>
<td>Referral</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Patient history</strong></td>
<td>Work system: Tasks</td>
<td>Examples consist of internal forms of signals including cognitive cues.</td>
</tr>
<tr>
<td><em>For example:</em> Previous experience with the patient</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Known psychological disorder</td>
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</tr>
</tbody>
</table>

Examples of signals originating from “person(s)” in the system included the patient’s physical state and feedback from the patient and their family. This is highlighted by the following quote from one participant: “they’re [the patient] telling you they are not coping”. Additionally, the indicators from feedback from the

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Table 1. Examples of the signals identified in the focus groups and their classification with regards to the sociotechnical work system and from
family are highlighted by the following quote: “Just to add to that, the patient might tell you their fine, but then you might get a family member go... into the kitchen... and ‘can I have a word’. They will tell you they are fine but they are not”. Signals originating from the “internal environment” included the state of the patient’s home. Signals originating from the “tools” included the signals generated as a result of patient documentation such as the referral form. The referral form may contain information that could possibly act as a warning signal to community staff prior to them visiting the patient, for example if the patient is a “high volume service user” with a history of failed discharges.

Following this, the examples were classified into the different forms of signals according to the framework depicted in Figure 1. The examples related to the patient’s physical state that could be categorised as external included visual cues, for example seeing the patient does not look well, olfactory cues which would provide an indication of if the patient is not coping with tasks of daily living, such as personal hygiene. Internal signals identified included cognitive cues, for example the patient not being at the anticipated level of recovery. This type of signal was classified as internal, as it would have originated based on information processing from other external cues such as the documentation of the current state of the patient and the external visual cue that would then highlight the discrepancies between the two sources of information.

The participants mentioned that they felt that the identification of these signals is a necessary component of their current work as their work requires them to adapt the patient’s treatment plan accordingly so that a readmission would not occur. In response to these signals, several participants mentioned that they would restructure their time, delegate work to other staff members and link in with other services to address the emerging issues. Additionally, they mentioned updating documentation, reporting back to the care teams, and setting up follow-ups as possible response to the signals. In the groups, it was also mentioned that it was not always possible to respond to the signals identified. The final aspect discussed during the focus groups considered the potential learning opportunities and how one would pass the knowledge regarding signal identification on to more junior members. These included the need for reflection with different staff members, regular meetings to allow for feedback, team handovers to share best and worst practice, clinical supervision, and sharing experiences and information with different occupational groups.

Safety I and Safety II Aspects

The safety aspects discussed in the focus groups included aspects which could go wrong including errors, influencing factors and the various system elements that aid in task success. Common errors identified included errors relating to inappropriate or missing equipment, missing medication and inadequate packages of care. Error producing conditions identified by the groups consisted of a lack of communication between the different services involved in the process, and missing or incomplete information or documentation. An example of the effect and resulting problems a lack of communication can cause is highlighted in the quote: “patients gone home to a different place, can’t find your patient but you know they are out”.

Potential factors that would influence the task and task-related behaviour identified by the groups included patient-related factors, time-related factors, and organizational factors. The organizational and managerial factors identified may not only influence the worker and task but also may affect an individual’s ability to adapt and adjust their performance. The elements that assist in promoting a good discharge were categorized according to the SEIPS 2.0 model, and the results for the different elements are depicted in Figure 2. Examples of work system elements that promote a good discharge categorized as person-related, included experience, open communication, ability to improvise, and having the confidence in asking questions. An example of open communication and the importance of it is highlighted by the following quote by one of the participants: “where there’s been some level of communication between where they’re coming from to where they’re going to ensure that there’s a smooth transition of care”. Additional examples categorized as person-related included utilizing all available resources, understanding the job-roles of the individuals involved in the process, good team work and being proactive, for example by “chasing” discharges for that day in the morning. This is highlighted by the one participant: “I think for me its chasing up that discharge early in the morning, making sure its planned for that day. So now when we have future discharges I will ring in the morning to make sure all the plans are done and that they’ve not moved ward.”. Examples of task-related elements included the information provided during the task being up-to-date and accurate, effective cooperation and coordination between the services involved, good timing of tasks, for example other services are timely informed about the discharge and ensuring cut-off times are considered and maintained to ensure patient safety, as well as the necessary and appropriate equipment being in place prior to the patient being discharged. Examples of tool-related elements included well completed documentation forms including referrals, therapy forms and discharge letters, having access to computer records to access the latest information on the patient, and standard operating procedures. The standard operating procedures were described as an aid in specific cases in that it eased the discharge process across localities, which is explain in the following quote: “but sometimes you need to fall back on standard operating procedures so that you can kind of, everyone is going from the same sheet across the localities”. Examples of organization-related elements included organizational structures such as integrated teams, good intra-organizational communication and designated staff members, such as having a key contact person within the acute hospital. An example of how integrated teams promote a good discharge is highlighted in the following quote: “I think we all support each other and be in integrated teams and working with the
physios and OTs. You have got access to people, sending them [the patient] back into hospital is always going to be the last resort, it would be a visit of what can we get into place, what equipment can we get, who can we get involved to try keep them at home”.

CONCLUSION
The method above qualitatively investigated Safety-I elements, signals as well as other Safety-II elements. The Safety-I elements addressed in this study included specific potential errors and error producing conditions related to the discharge process that may result in adverse events whereas the Safety-II elements investigated included signals, learning opportunities and work elements that may assist in task success. These Safety-II elements may aid in rendering a system more resilient by improving the ability to succeed under varying conditions (Hollnagel, 2014). Additionally, weak signals may also provide a means for effective risk management in that they provide an opportunity to be proactive and identify aspects that threaten safety (Macrae, 2014a), and consequently one can respond to hazards earlier.

The proposed method provides a preliminary basis for the investigation of signals and work elements that may aid in task success. The ramifications and practical implication of this research is that it provides a basis for developing work processes so that current aspects that staff feel work well are incorporated into new procedures. Additionally incorporating Safety-II aspects when designing an intervention, whether it is a tool, training or redesigning a work process, by incorporating aspects staff feel work well, it may promote greater ownership of the intervention. The model on weak signals may assist in the development of a possible tool to triage and maybe highlight discharges that may be particularly difficult sooner rather than later.

The participants provided positive feedback regarding the focus groups as a source of sharing ideas and as a platform to discuss task aspects that work well. Further investigations are required to identify additional elements that aid in task success as well as the factors that promote or inhibit signal identification.

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