Resilient Health Care in the use of intravenous insulin infusions

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ABSTRACT

Variable rate intravenous insulin infusions (VRIIIs) are used to treat elevated blood glucose in severely ill hospitalised patients and those with diabetes missing more than one meal. VRIIIs can cause serious harm to the patient if used incorrectly. Conventional approaches to increasing safety have focused on linear thinking by first identifying errors, then finding solutions to prevent future recurrence. Resilient Health Care proposes improving patient safety by understanding the variability in everyday clinical work in order to realign 'Work as Imagined' (WAI): what people say, or think they do, with 'Work as Done' (WAD): what people actually do in practice. This study aimed to explore resilience in the use of VRIII in adult inpatients by comparing WAI with WAD. WAI was explored by analysing VRIIIs guidelines and focus groups with different stakeholders involved in the process of using VRIIIs. WAD was explored by first videoing healthcare practitioners while using VRIII, selecting video clips and discussing them with participants in reflexive meetings, then transcribing and analysing the reflexive meeting discussions. Two hierarchical task analyses (HTA) were developed to systematically represent WAI and WAD. Although most of the tasks in WAD HTA generally aligned with WAI HTA, some misalignments were observed. Misalignment was identified in different type of tasks including emergent, complex tasks as well as simple and complicated tasks. The majority of the observable adaptations used to respond to emergent tasks were forced adaptations or temporary workarounds where ideal solutions were not possible at that time.

KEYWORDS

Resilient Health Care, variable rate intravenous insulin infusion, safety.

Introduction

Controlling blood glucose level is an important aspect of inpatient care. VRIIIs are considered the cornerstone treatment and might be the only appropriate option for controlling elevated blood glucose in some situations such as patients with diabetes missing more than one meal, critical illnesses e.g. sepsis, perioperative period and stroke (George et al., 2015). VRIII is a high-risk medication with a narrow therapeutic index, meaning that both underdosing and overdosing may cause severe life-threatening side effects such as hypoglycaemia, rebound hyperglycaemia or ketoacidosis (Sampson et al., 2018).

Healthcare systems are regarded as complex adaptive systems (CAS), in which "the system's performance and behaviour changes over time and cannot be completely understood by simply

knowing about the individual components" (Braithwaite, 2018). Traditional safety approaches (Safety-I) to enhance safety in CASs have predominantly based on the assumption of human culpability, with errors and adverse events being caused directly by things going wrong whether through incompetence, negligence, personal deficiency, or deliberate deviation from standard procedures (Hollnagel, 2014). Although great strides have been made in enhancing patient safety in the use of VRIII, to date, major investments to increase patient safety using VRIII have not convincingly shown to reduce risk, error or mortality rates (NHS Digital, 2018). Dealing with this situation has proved remarkably difficult. A new way of safety thinking, termed Safety-II, aims to strengthen everyday work by ensuring that the number of intended and acceptable outcomes is as high as possible (Hollnagel, 2014).

Resilient Health Care (RHC), which adopts the Safety-II approach, proposes a balanced approach to safety by understanding the successes as well as failures in everyday work (e.g. see Iflaifel et al., 2019). RHC and the Human Factors and Ergonomics field are clear that healthcare practitioners are not a problem to be solved or standardised. Instead, they are viewed as resources and assets that can anticipate, monitor, respond to, learn from and adapt to threats - all fundamental features of a resilient safety system (Hollnagel et al., 2019; Carayon et al., 2014). A recent systematic review highlighted the importance of exploring WAI and WAD for each system level to form a robust understanding of the work system and to understand complexity and variability in everyday clinical performance (Iflaifel et al., 2020). Several studies have shown that there are gaps or misalignments between WAI and WAD (Clay-Williams et al., 2015; Back et al., 2017). In practice, patient safety and outcomes could be enhanced by understanding how everyday work is done to explore the gap between WAI and WAD. This understanding can direct efforts to realign WAI with WAD by enabling stakeholders at different system levels to better appreciate how work is assumed to be accomplished and how it unfolds in practice. In this study, alignment was identified if the task illustrated in the WAD HTA was accomplished as it was presented in the WAI HTA. Misalignment was identified if WAD was accomplished in a way that was different from the one described in WAI HTA. The present study aimed to compare WAI with WAD and to explore alignments and misalignments in the tasks observed and presented in the WAD HTA compared with WAI HTA.

Methods

This study was conducted between December 2018 and March 2019 in a Vascular Surgery Unit in a UK tertiary, acute National Health Service (NHS) teaching hospital.

The study involved three phases:

• Phase I explored WAI. Two sources of data (VRIII guidelines and related documents, and three focus group meetings with different stakeholders/users from within the hospital and in different professional roles), were used to explore WAI. Based on our definition of WAI, the perspectives of different stakeholders on how they thought and assumed others and themselves work was used as a data source complementary to that presented by the guidelines, in order to give a comprehensive understanding of WAI. A purposive sample of guideline developers, managers and healthcare practitioners, involved in treating elevated blood glucose using VRIIIs, were recruited. Transcripts and documents were analysed using inductive and deductive thematic analysis.

- Phase II explored the feasibility of using video reflexive ethnography (VRE) methodology along with quantitative data to explore WAD. Qualitative VRE involved videoing healthcare practitioners using VRIIIs, after which video clips were selected and discussed with participants in reflexive meetings. Reflexivity emerged through making sense of everyday work; healthcare practitioners analysed their own existing taken-for-granted work and explored new insights with a view to improving patient care delivery as well as contextualising their perspective on their work. The video recordings were transcribed, quantitative data were collected from electronic patient records, and the qualitative and quantitative data were used to provide a clear view of the observed outcomes and tasks. Audio-recordings from the reflexive meetings were transcribed and analysed using inductive thematic analysis.
- Phase III compared WAI and WAD, using HTA. HTA, a core ergonomics approach, was used to represent the use of VRIIIs as an overall goal with a hierarchy of subordinate subgoals and plans. The analysed data from phases I and II were used to develop a WAI HTA and a WAD HTA respectively. Goals, sub-goals and plans in both HTAs were compared systematically to explore alignments and misalignments in the use of VRIIIs. The data from phases 1 and II were also used to analyse the resultant outcomes and the permanence status of the practices/adaptations where misalignments were identified. The permanence status of the identified adaptations was categorised into permanent (performed as part of regular everyday work) or temporary (arranged provisionally to respond to present challenges) adaptations. This categorisation is crucial to differentiating between work that has long-term or short-term success. Systems can share learnings from long-term successes and identify indicators for short-term success in order to proactively prevent their occurrence by providing practical and more sustainable interventions.

Findings

In phase I, four guideline developers, three managers and four healthcare practitioners participated in three separate focus group meetings. In phase II, two patients treated with VRIII and ten healthcare practitioners caring for these patients over a four-month period, were recruited. Two HTAs, one representing WAI and another WAD were developed and compared. The comparison between WAI HTA and WAD HTA revealed that most of the tasks in the WAD HTA were aligned with those described in the WAI HTA. Such activities included: prescribing a flushing solution, assembling and administering insulin and intravenous fluids via an infusion pump, and treating hypoglycaemia. Misalignment in the tasks found in the WAD HTA was mapped on the WAI HTA (see Figure 1). The misalignment between WAI and WAD tasks is summarised in Table 1.



Figure 1: A HTA showing similarities and differences between WAI and WAD

Misalignments were primarily found in assembling components of a VRIII, prescribing intravenous fluids, continuing long-acting subcutaneous insulin alongside the VRIII, and monitoring and confirming suitability to stop the VRIII.

Table 1: WAI tasks and their execution *in situ*. Key: (D) Done; (PD) Partially Done; (ND) Not Done; (NA) Not Applicable; (NO) Not Observed.

Tasks in the WAI- HTA	Status	Evidence from WAD	Observable outcome	Adaptations' Permanence Status		
3.1.5 Prescribe						
3.1.5.3 Prescribe intravenous (IV) insulin, fluids and antidote using the relevant electronic prescribing proforma	PD	The VRIII and the antidote were prescribed but the IV fluids were not prescribed.	The nurse found out that the IV fluids were not prescribed and went to the specialist registrar (SpR) and asked him to prescribe it.	Temporary		

3.1.5.4 Continue long-acting subcutaneous insulin if previously prescribed and suspend all other medications for diabetes.	PD	The SpR did not suspend the regular prescription for subcutaneous intermediate-acting insulin when initiating the VRIII.	The nurse did not administer the intermediate-acting insulin to the patient.	Temporary			
3.1.6 Assemble components of IV insulin infusion							
3.1.6.4 Follow Aseptic Non-Touch Technique guidelines	ND	The Aseptic Non-Touch Technique guidelines were not followed.	NO	NA			
3.1.6.4.1 Clean hands with alcohol rub or soap and water	ND	The nurse did not clean hands with alcohol rub or soap and water, but applied non-sterile gloves, before checking the Electronic Patient Record (EPR).	NO	NA			
3.1.6.4.12 Scrub the needle free port tip with chlorhexidine and alcohol wipe for 15 seconds and allow 30 seconds to dry.	ND	The nurse attached the insulin and fluids to the patient cannula without wiping the needle free port tip.	NO	NA			
3.1.7 Administer							
3.1.7.1 Perform two-staff independent verification of prescription, patient, pump, blood glucose, VRIII initial rate and for each rate change.	PD	Patient case 1: a senior nurse changed the infusion rate of VRIII, then told a second nurse that the rate had been changed, asking for the nurse to sign as a witness on the EPR. Patient case 2: The independent verification before administering VRIII was not done as the second nurse was busy with another patient and the nurse chose to	The VRIII rate was changed and the second nurse signed on the EPR without checking the changed rate. The nurse administered the VRIII and IV fluids to the patient without delay. Following this the second nurse checked and signed on the EPR.	Permanent Temporary			

		proceed with the task.					
3.1.8 Monitor							
3.1.8.5 Take action based on the results of monitoring as per relevant the Medicines Information Leaflet	D	In the hospital guidelines there is no clear description on how to clean the planned skin puncture site before checking blood glucose. However, instructions are provided in the CBG monitoring training to wipe the planned skin puncture site with damp cotton wool.	Two different practices were observed; one nurse used dry cotton wool and a second used wet cotton wool dampened with tap water.	Permanent			
3.1.10.1.4.1 Stop VRIII if blood glucose < 4 mmol/L							
3.1.10.1.4.2 Administer antidote (20% glucose IV infusion)	D	Sometimes the nurses proceeded with administering the antidote and checked in retrospect that it was prescribed. In other cases, the nurse asked for a verbal order before administering the antidote.	Hypoglycaemia was treated without delay.	Permanent			

Discussion

Although misalignments were identified in some tasks, most of the tasks illustrated in the WAD HTA were aligned with the tasks presented in the WAI HTA. This result may be accounted for by the fact that, as guideline developers in the study hospital explained, the production of the hospital-specific VRIII guidelines drew on various resources. Such resources included, the relevant Joint British Diabetes Societies for Inpatient Care guidelines, local incident reports, feedback, audits and consulting the Think Glucose Group i.e. local inpatient diabetes operational group, the inpatient specialist nursing team and junior doctors.

Misalignments were identified not only when emergent, complex tasks were carried out, but also in some simple and complicated tasks. Based on Glouberman and Zimmerman (2002) and Johnson et al. (2019), the differentiation between simple, complicated and complex tasks is essential if effective means of safety measures are to be identified. Simple tasks, such as Aseptic Non-Touch Technique, are best investigated by cause-and-effect methods to identify the cause of non-compliance (Johnson et al., 2019). Standardisation is considered a useful tool in monitoring these tasks, entailing the use of protocols, checklists and policies that make the tasks easier to

carry out correctly. Complicated tasks such as routine use of electronic systems to prescribe VRIII and intravenous fluids need tools such as clinical guidelines and Lean Six Sigma approach to ensure the required clinical work is delivered with minimal variations (Johnson et al., 2019). It is widely accepted that it is irrelevant to use the above tools in highly complex or unpredictable tasks (Johnson et al., 2019). Dealing with a deteriorating patient needs flexible and goal-oriented tools rather than rigid and process-oriented ones. Here, safety tools tend to support healthcare practitioners in dealing with challenges and making decisions in unexpected situations. Such tools include VRE methodology, used to explore the leadership enactment at a micro-level in a healthcare setting (Gordon et al., 2017); Functional Resonance Analysis Method (FRAM), used to understand sources of performance variability in intravenous infusion administration in an intensive care unit (Furniss et al., 2020); and the Resilience Analysis Grid, used in an urban emergency department as a learning stimulus to identifying gaps, facilitating awareness of everyday performance and taking actions to increase capacity for manoeuvre (Hunte et al., 2019). The previous studies used goal-oriented tools which improved healthcare practitioners' understanding of their everyday work in different clinical environments and provided suggestions to enhance clinical work. In this study, classifying tasks into simple, complicated and complex, was not easy as the study explored the use of VRIII on two patients over a short period of time. Task classification needs to be approached from a complex lens which takes into account the whole case scenario within a wider complex system.

In the present study, some of the permanent adaptations were planned adaptations that aimed to proactively improve patient care, as when an assistant nurse used cotton wool dampened with tap water to clean the planned puncture site before checking blood glucose, in order to prevent interference with blood glucose measurements. By contrast, most of the observed adaptations were temporary workarounds that preserved the resilience of the system. Although these did not resolve the underlying system problems (lack of knowledge of how to use the electronic system to prescribe IV fluids, staff shortages, etc.), they depended on healthcare practitioners' creative responses demonstrating healthcare practitioners' adaptive capacity. One example was when the specialist registrar had not suspended the regular subcutaneous intermediate-acting insulin, the nurse did not blindly administer it, as this would have likely caused hypoglycaemia. Such adaptations were temporary workarounds that had a purely localised effect; they brought no permanent improvement to the system as they were not reported or escalated for action, which might have led to sustained improvement.

The resulting WAD sample size was small by the reason that phase II was a feasibility study which focused on providing snapshots of WAD in the clinical environment using VRE methodology.

Conclusion and study impact

To the best of our knowledge, this is the first study to have systematically compared WAI with WAD in the use of VRIIIs. The study results provided a detailed method for finding where misalignment occurs and identifying the effect of observable adaptations on the patient care process while using VRIIIs. This study also identified the permanence status of the adaptations required that might be used to co-create and design interventions based on how work is performed using VRIIIs. Designing interventions could be achievable by engaging different stakeholders/users to cultivate new skills learned from adaptations that have had positive

outcomes and proactively use the adaptations that lead to negative outcomes to explore where the system is liable to fail in order to anticipate realistic and more sustainable interventions.

References

Back J, Ross A, Duncan M, Jaye P, Henderson K, Anderson J. (2017). Emergency Department Escalation in Theory and Practice: A Mixed-Methods Study Using a Model of Organizational Resilience. Ann Emerg Med. 70:659-71.

Braithwaite J. (2018). Changing how we think about healthcare improvement. BMJ. 361:k2014.

- Carayon P, Wetterneck T, Rivera-Rodriguez A, Hundt A, Hoonakker P, Holden R, et al. Human factors systems approach to healthcare quality and patient safety. Appl Ergon 2014;45(1):14-25.
- Clay-Williams R, Hounsgaard J, Hollnagel E. (2015). Where the rubber meets the road: using FRAM to align work-as-imagined with work-as-done when implementing clinical guidelines. Implementation Sci. 10:125.
- Furniss D, Nelson D, Habli I, White S, Elliott M, Reynolds N, et al. Using FRAM to explore sources of performance variability in intravenous infusion administration in ICU: A non-normative approach to systems contradictions. Appl Ergon. 2020;86:103113.
- George S, Dale J, Stanisstreet D. (2015). A guideline for the use of variable rate intravenous insulin infusion in medical inpatients. Diabet Med. 32:706-13.
- Glouberman S, Zimmerman B. (2002). Complicated and complex systems: what would successful reform of Medicare look like? ; Ottawa: Commission on the Future of Health Care in Canada.
- Gordon L, Rees C, Ker J, Cleland J. Using video-reflexive ethnography to capture the complexity of leadership enactment in the healthcare workplace. Adv Health Sci Educ Theory Pract. 2017;22(5):1101-21.
- Hollnagel E, Braithwaite J, Wears R. (2019). Delivering Resilient Health Care. Abingdon, Oxon: Routledge.
- Hollnagel E. (2014). Safety-I and Safety-II : The Past and Future of Safety Management. Farnham, UK: Ashgate Publishing Ltd.
- Hunte G, Marsden J. Engineering resilience in an urban emergency department. In: Hollnagel E, Braithwaite J, Wears R, editors. Delivering Resilient Health Care. Abingdon, Oxon: Routledge; 2019.
- Iflaifel MH, Lim R, Ryan K, Crowley C, Iedema R. (2019). Understanding safety differently: developing a model of resilience in the use of intravenous insulin infusions in hospital in-patients-a feasibility study protocol. BMJ Open. 9:e029997.
- Iflaifel MH, Lim R, Ryan K, Crowley C. Resilient Health Care: a systematic review of conceptualisations, study methods and factors that develop resilience. BMC Health Serv Res. 2020;20(1):324.

- Johnson A, Clay-Williams R, Lane P. (2019) Framework for better care: reconciling approaches to patient safety and quality. Aust Health Rev. 43:653-5.
- NHS Digital. (2018) The 2017 National Diabetes Inpatient Audit (NaDIA) annual report England and Wales.
- Sampson M, Jones C. (2018). Joint British Diabetes Societies for Inpatient Care: clinical guidelines and improving inpatient diabetes care. Diabet Med. 35:988-91.