The Communication Patterns in the Context of Error in an Intensive Care Unit in a Malaysian Hospital

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Abstract. This paper describes a study that was carried out in an Intensive Care Unit at a hospital in Malaysia. The objective of our work was to define *what constitues the context of error* during the ward round practice of patient care management considering how artifacts are used during the communication. Thus the work focused on the analysis of communication patterns. As research method, we have applied the ethnography method and used situated cognition as an analytical perspective to synthesize the communications patterns. In this paper we focus on reporting the empirical analyses of the communication patterns in which errors had occurred. The analyses had highlighted how a clinician team conceptualized information and what majorly constitutes the context of error was that the clinical information on the artifacts were represented 'without a context'.

Keywords: Context and communications · Situated cognition · Medical error · Health information technology · Patient safety

1 Introduction

In the intensive care unit (i.e., ICU) setting, the frequent need for urgent critical and life-saving decision-making potentially creates an environment within which medical errors may happen. In our work we refer to [10] on the definition of medical error, which is defined as the failure of a planned action to be completed as intended or the use of a wrong plan to achieve an aim. Due to the nature of the patient group (i.e., the most critically ill) present within the ICU, the ICU is an environment in which there is less margin for error and less favorable circumstances exist for error recovery [8, 9]. The basic assumption is that error arises within highly complex medical care systems of *people, information systems, workflow, and clinical procedures* and follows a flow of work practice pattern that can be uncovered [6]. Uncovering these patterns of errors would allow clinicians to eliminate or recover from them as soon as possible before the

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errors turn into an actual adverse event[1] [6]. It has been reported that health information technology (HIT) can reduce the risk of serious injury for patients during hospital stays [6]. However, its true potential for *preventing errors* remains only partially realized and, as has been demonstrated in a recent article [7], some systems may even give rise to hazards of their own. Thus, the critical care setting is a uniquely complex field for which computing technology needs to be developed according to novel and often unprecedented design principles [6]. How well the design of the system complements its intended setting and purpose is critically important for patient safety [6]. Patient safety has been defined as "the prevention of harm to patients." Its emphasis is placed on the system of care delivery that: (1) prevents errors; and (2) learns from the errors that do occur [3].

Thus we put forward the following research question - *how can the patient safety element in our use of HIT translate into a design principle*? To begin with, the objective of our research is to study the patterns of *what constitues context of error, that is, the work system context in which errors occur* during patient care management. By studying the context of error, it will reveal the limitations of the system. A well-defined modeling and representation of *context of error* will reveal specifically how and when artifacts in work practice frequently lead to error. This would enable us to identify safety elements which are required in the design principles that can reduce or eliminate those erroneous situations that may lead to adverse events.

Therefore, we have carried out an ethnography study in an ICU in a studied hospital in Kuala Lumpur, Malaysia for several weeks. Communication exchanges were recorded during the morning ward rounds and analysed using situated cognition theory to synthesize the medical staff communication patterns. The ward rounds involved a clinician team that reviews the patients' cases in the morning to make decisions on the patient care management for the rest of the day.

In this paper we focus on reporting the empirical analyses of the communication patterns in which errors had occurred. The analyses had highlighted how a clinician team conceptualized information. We found that what majorly constitutes the context of error was that the current information on the artifacts were represented 'without a context' (absence for what the patient is being treated for). Thus this paper is organized as follows. We discuss related work, followed by research methods. Then we will illustrate the empirical findings. We summarise the paper with discussion and perspective on future work.

2 Related Work

There are various approaches to studying the use of HIT in improving the patient care management in the ICU and can be mainly divided into two major viewpoints. The first viewpoint looks into the existing clinician work practice to mainly understand the nature of their work practice to derive and/or improve methodologies and theories.

[1] Any injury due to medical management, rather than the underlying disease. Example of an injury would be a rash caused by an antibiotic [10].

For example, the work of Abraham et al. [2] looked into conceptualizing a communication model during handoffs in critical care handoffs as communication failure has been reported as the leading cause of medical errors and adverse events. Meanwhile the authors Vimla et al. [8] investigated what are the natural constraints in the ICU environment imposed on error detection and correction during team's decision-making process in patient care management planning.

The second viewpoint looks into the study of the information technology used as part of the work practice in the ICU for the purpose of designing better information system. The work of Thursky and Mahemoff [11] explored the use of user-centered design techniques for developing the requirements for an antibiotic decision support system in ICU. Meanwhile the authors Gibson et al. [5] looked into how general practitioners interact both with their patients and computers with the aim of facilitating the detailed understanding of how GPs use their computers while in consultation with patients.

Our work intertwines both viewpoints. First we would like to understand and capture how the HIT in the studied ICU is used during the clinician team ward rounds. Secondly to uncover what *constitues context of error during the ward rounds*.

2.1 Study Site, Participants and Data Collection

The data was collected at a 30-bedded post-operative adult intensive care unit in a large hospital in Kuala Lumpur. It looks after approximately 2000 admissions per year. A decision support system and paper records were concurrently used for patients care documentation in the unit at the time of study. Three clinicians team from the ICU were included in this study during our 3-day study. Each team consisted of a resident doctor, an intensivist, a nurse, and the ICU clinical director (with once or twice a week participation). This is the common composition of a clinical team participating in the morning handover ward rounds. A total of 10 individuals participated in the 3-day study.

Data was collected during the morning ward rounds, where the patient care planning sessions were done in the ICU. The ward rounds are held twice daily during medical staff shift rotation (0745 and 1800 h) in addition to a more formal morning (0900). The first author followed the team on their formal ward rounds. During these sessions, the clinical team discussed each patient's health status. The resident doctor or the clinical director will lead the ward round to review and decide collaboratively on the patient care management for the day. Each round lasted approximately 3 to 4 h and the first author spent 3 h a day for 3 days consecutively shadowing and observing the clinical teams. Team interactions were video-recorded. Field notes, photographs of artifacts, and interviews with the clinicians and support staff complemented the video recordings. The video interaction records of the morning ward rounds amounted to a total of 9 h.

2.2 Data Transcription Annotation and Coding

We have developed the following steps for relating the clinical communication to the context of error, which was analysed together with the second author.

1. Selected transcriptions were analysed using discourse analysis. An utterance is marked with who is the speaker and listener and the medium (i.e., paper, decision support system) used to mediate their communication, and the topic of their communications [1].
2. The analysed utterances are then applied with a high-level coding of case management and error coding [8] to capture the clinical content. For example, "Klebsiella esbl…..must be carbopenum….carbopenum..where is the carbopenum" is coded as 'information loss'. Details to follow in the next section.
3. Situated cognition theory was applied to synthesize and explain the clinician team communication analysis and patterns [4].

For data coding, we have applied a high-level coding process using codes from the work of Patel et al. [8]. The authors [8] applied an open coding process, where each clinically relevant utterance exhibiting common strategies used during case management was coded for content (e.g., information interpretation). Furthermore, the authors [8] had also developed a coding of errors in communication (including clinical content). If an utterance contained or was related to an error, the authors categorized it as either "generated error", "resolved error" etcs. Please refer to the Appendix for the complete coding definitions. The coding developed however did not look specifically into the *notion of context*. Thus in our work we have incorporated a contextual analysis to relate how artifacts are used during the ward rounds and *how it constitutes part of the work system context in which error had occurred.* The coding were applied to capture the kind of actions that the clinician team formulated in context of errors, and using the contextual analysis to capture how artifacts are used during these contexts.

2.3 Analysis of Context – Conceptualization

In situated cognition [4] context for a person is viewed as a mental construction studied from the notion of *conceptualization* and *contextualization,* and is studied from a moment-by-moment analysis.

Conceptualization is considered from both a social and neuropsychological perspective. In our work, we first focus on the notion of context from the perspective of social psychology. 'Context' from this perspective is explained by conceptualization i.e.: how a person conceptualizes his role considering his situation, and activity - 'What I am Doing Now'. For example, a resident doctor on the ward round is conceptualising what he is doing now: 'making decision whether the patient has a heart failure' in constructing his behavior. From a neuropsychological perspective, the notion of conceptualization involves a composition of higher-order categorization processes at the perceptual-conceptual level that is responsible for our coordinated activity in time. For example, at the perceptual level, a resident doctor at the ICU when he is situated in a context, the way he perceives the context is always through categorizing the details. As an example the resident doctor categorises the details from 'the patient's skin color, blood test results on paper and the nurses speaking about the wounds' in the environment. These categorized details are then given a description or semantic label, as an example 'patient is improving'. At the conceptual-memory level, which is a higher-order categorization process – the details, which are also given descriptions, are then conceptually categorized, as an example ‘these are clinical evidence’. Thus, conceptualizing can be viewed as a dynamic process of reconstructing a person’s action relating perceptions to higher-level concepts in memory as part of how experiences are formed. Thus physical re-coordination such as taking a paper chart, and reading from it while speaking about is viewed as part of the basis in speaking and comprehending text. The notion on conceptualization is used as a method to synthesize the communication patterns.

3 Results –Communication Analysis

In this paper, we will illustrate the results from our communication analysis of a specific event between the resident and the ICU clinical director in which errors were *generated and unresolved* for about 15 min. The errors (of information) were subsequently revealed and managed appropriately but only after a period of time deliberating and discussing the erroneous points. First we will describe the work setting, followed by the artifacts in use and a brief background of the event. Figures 1 and 2 shows an example of a bedspace at the studied ICU and the mock design of the decision support system correspondingly.

Fig. 1. ICU bedspace.

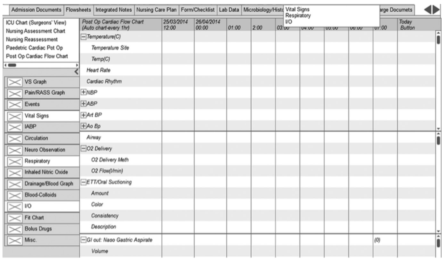
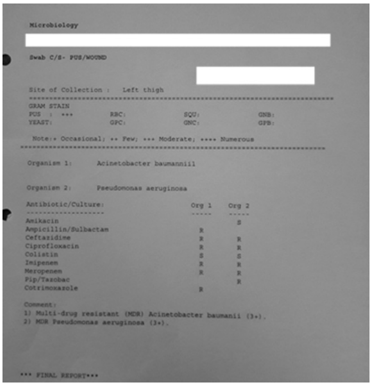


Fig. 2. Mock up of the decision support system

The computer is located on the left hand side at the end of the bed (not shown in Fig. 1), facing away from the bedspace. The system (see Fig. 2) allows users to enter the ICU daily plan, and view the progress of the post-operative vital signs in a time based flow chart. The flow chart shows the reading at different time intervals of the haemodynamic (blood pressure, heart rate, etc.) variables, itemized input and output of the patient (fluids, medications, etc.). The clinical team also refers to an X-ray system, which will include the most recent as well as previous radiological (i.e., X-ray) investigations. Other artifacts in use are the blood gas report, pathology report and microbiology paper record. Figure 3 is an example of a microbiology paper report while Fig. 4 shows an example of the prescription chart.

We give a brief background of the event. The resident doctor had committed an error when referring to the patient record from the decision support system and thus the resident doctor was presented with two contradicting information about his patient. One



Microbiology

Swab C/S- PUS/WOUND

Site of Collection : Left thigh

GRAM STAIN
PUS : *** RBC: SQU: GNB:
YEAST: GPC: GNC: GPB:

Note:* Occasional; ** Few; *** Moderate; **** Numerous

Organism 1: Acinetobacter baumannii

Organism 2: Pseudomonas aeruginosa

Antibiotic/Culture:	Org 1	Org 2
Amikacin		S
Ampicillin/Sulbactam	R	
Ceftazidime	R	R
Ciprofloxacin	R	R
Colistin	S	S
Imipenem	R	R
Meropenem	R	R
Pip/Tazobac		R
Cotrimoxazole	R	

Comment:
1) Multi-drug resistant (MDR) Acinetobacter baumanii (3+).
2) MDR Pseudomonas aeruginosa (3+).

*** FINAL REPORT***

Fig. 3. Microbiology report

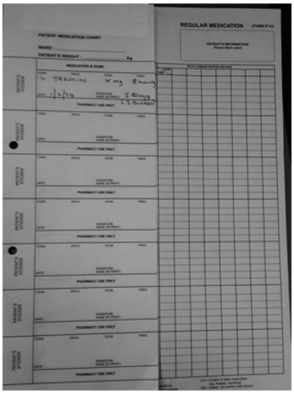


Fig. 4. Prescription chart

was about the patient in the next room viewed on the decision support system, and another is of the correct patient at that bedspace presented on the paper documents (i.e., microbiology lab result).

We shall refer to the next room patient as patient B, and the correct patient as patient A. Patient B has been diagnosed with an infection "extended-spectrum beta-lactamase (i.e., ESBL) bacteria". Patient A's medical treatment did not indicate that he was diagnosed with the ESBL bacterial infection. Patient A actually had "e-coli bacteria" identified in a healing wound and was being treated with an antibiotic for "corynebacterium bacteria" identified in his sputum. However these facts were not mentioned in the artifacts but instead the drug prescribed for Patient A was mentioned, which was tazocin. For the next 15 to 20 min, the resident doctor and the consultant doctor were engaged both in trying to reconcile the contradictory information by communicating and recalling their clinical knowledge about the ESBL diagnosis, and what's being taught about its medical treatment. Based on their medical knowledge, tazocin is not usually the preferred choice of treatment for an ESBL infection. We show an excerpt of the transcribed communications below:

> *Resident doctor: "Klebsiella esbl..must be carbapenem, carbpenem, where (looks at the blue folder of drugs prescription) is the carbapenem?"*

> *Resident doctor: "This patient..surgeon request to extubate but still has op-pneumonia..klebsiella pneumonia isolate before //"*

> *ICU clinical director: "//When was the last positive culture?" (continues)…*

Applying step 1 (refer to section on Data Transcription and Annotation Coding), the transcribed communications has been annotated with the turn taking, including gestures, artifacts, and the details that the doctors were focused at during the communications. Details could refer to the artifacts, or a concept in the mind (e.g., focused at the detail in the mind about ESBL). Notation such as "//" indicates overlapping of utterances between speaker and listener. The Table 1 below depicts correspondingly at each utterance: (i) the activity-artifact (i.e., paper, computer) referring to which patient's information; (ii) the high-level coding of the actions coded by the categories of the case management, and (iii) if and what are the categories of error that had occurred during the different 'actions'. Situated cognition was applied to give a moment-by-moment account of the communications considering the relationship of details in the artifacts.

Table 1. The annotated utterances applied with case management and error coding.

Ln_n, Spk_x	Utterances	Activity-Artifact	Details	Comment	Case management	Error
1, H	Klebsiella esbl.. must be carbopenem.. where is the carbopenum..	Looked at microbiology report on system (Patient B) Flipping through - Paper chart (Patient A)	Carbopenum (a drug) and ESBL (a type of bacteria)	H verbalising outloud looking for the bacteria culture report and its treatment on the chart pages by pages	Information loss type of failure to follow up	Generated error
2, H	This patient surgeon request to extubate but still has op-pneumonia klebsiella pneumonia isolated before//	Assessing -X-ray and the paper chart (Patient A)	Condition of patient's lung	H refers to historical evidence consisting of the X-ray to look at the lungs, and to the paper chart on reported test results	Information interpretation	Generated error
3,Sh	//when was the last positive culture?	Standing and looking – computer report (Patient A)	ESBL, shadows in the lung field	SH is listening to H's assessment of patient's history	Additional information	N/A
7, Sh	this is 19, this is today	Looking- X-ray (Patient A)	ESBL, shadows in the lung field	Shared representation	Information aggregation	N/A
8, H	slightly better (nodded)	Looking -X-ray (Patient A)	ESBL, shadows in the lung field	Shared representation	Information interpretation	Generated error
9, Sh	not much	Looking -X-ray (Patient A)	ESBL, shadows in the lung field	Shared representation but SH did not agree with the assessment	Information interpretation	Corrected error

The case management coding allowed us to identify the kinds of actions (i.e., information interpretation) that the clinician team formulated in the context of error. At Ln_1, the resident doctor was referring to the microbiology report on the decision support system indicating Patient B had ESBL, at the same time flipping through the prescription chart of Patient A to look for carbopenum, a drug treatment for patients that have ESBL. His action was coded with case management 'information loss' of type 'failure to follow up'. Previously he was inquiring about the patient's A diagnosis, however it was not followed up. Thus he went to look for details of carbopenem that would indicate that the patient A does have ESBL. At this time, it had led to 'error generated' in which the result of his seeking of information was still not being followed up. Thus it has led him *to continue to believe* that the patient A had an ESBL infection.

At Ln_2, the case management was ‘information interpretation’ to find evidence from the information loss that the patient A does indeed have ESBL (to confirm his diagnosis). Based on the x-ray results, historical records, and the prescription chart he interpreted that the patient A had klebsiella, a bacteria that can have the ESBL property. This led to further ‘error generated’ because the resident doctor made assumptions that the patient A had a klebsiella infection, which was incorrect still. At Ln_3, the ICU clinical director had applied ‘additional information’ case management strategy after listening to the resident doctor’s interpretation of the patient’s A drug treatment and assessing the X-ray. At this moment, the ICU clinical director would like to get past information on how long the infectious disease (i.e., ID) team have isolated the organism, as this would inform him what the patient actually has. From Ln_7 onwards until Ln_9, the resident doctor and the ICU clinical director were both referring to the X-ray, which becomes a shared representation for both. Both of them were focused at analyzing the *details* of the ‘shadows in the lungs’ that would indicate physiologically that the lungs of patient A have improved.

3.1 Patterns of the Communication Analysis – a Clinician Team’s Context

In the previous section we have illustrated how the clinician team formulated actions during a specific event where errors had occurred. Specifically the term *action* in our work encompasses the coordination and communications on the use of the artifacts. In this section, we will discuss the communication patterns that had emerged from our analysis. From the communication analysis, we have found that the “error generated” occurred during two types of case management categories: information loss type ‘failure to follow up’ (3 times) and information interpretation (2 times), shown in Table 2 below. Thus in total we had identified 5 occasions in which a context of errors had occurred.

Refer to Table 2, we identified the general patterns that has emerged from the category ‘information loss’ of type failure to follow up:

- The prescription chart (i.e., paper artifact) was used to *get historical information* on the kind of drugs that have been prescribed to the patient, this was followed by;
- X-ray which (i.e., digital X-ray) was used to get clinical evidence that the lung *has physiologically improved*.
- *Microbiology full report on the paper artifact* was used to get the complete results, i.e., full sensitivity report for the microorganism, which is the *reaction of the microorganism with different types of antibiotics*.
- *Microbiology quick report on the decision support system* was used to get the report on *the name of the microorganism that is grown*.

The category ‘information interpretation’ that is interpreting evidence in hand exhibits the following pattern:

- Digital X-ray which was used to interpret if the lungs had improved and;

Table 2. Type of case management categories in relationship to errors.

Ln_n	Categories	Activity-Artifact	Information	Details
1	Information loss	Prescription chart on paper (Patient A)	Shows list of drugs prescribed to patient	Carbopenum (a drug) and ESBL (a type of bacteria)
20	Information loss	Microbiology lab results on paper (Patient A)	Shows results on the microbiology, hematology and biochemistry	Drug (tazocin)
36	Information loss	Patient, ventilator, microbiology lab report on the decision support system (Patient B), X-ray system (Patient A)	Patients demonstrate clinical evidence of health, ventilator, decision support system window showed the microbiology report, X-ray shows lung evidence (improving or not)	Improvements in patients – drug dosage, lungs, clinical evidence (skin, alertness in patient)
2	Information interpretation	X-ray system, prescription chart on paper (Patient A)	X-ray shows lung evidence (improving or not), shows list of drugs prescribed to patient	Drug (tazocin)
8	Information interpretation	X-ray system (Patient A)	X-ray shows lung evidence (improving or not)	Shadows, drugs

- Prescription chart on the paper was used to interpret if the drug treatment have indeed improved the lungs, thus would help clinicians to infer the patient's infectious disease.

The X-ray is used as a 'physiological evidence' that the lungs has improved and the prescription chart is used as an evidence that the drug treatment is indeed the correct one that is improving the lungs.

4 Discussion and Future Work

The objective of our study has been to study *what constitues context of error*. In the previous sections we have illustrated at a moment-by-moment analysis how the clinician team used the artifacts during the context in which error had occurred. To synthesize the conceptualization process, we refer to situated cognition notion [4] of conceptualization. Thus, in this section we will discuss our synthesis of the findings.

The findings had revealed a very complicated work practice interaction among the decision support system, ventilator setting, paper records, and the clinician team clinical knowledge and procedure in conceptualizing "*what is the patient being treated for and is he/she improving*?". The conceptualisation process demonstrated an act of 'coupling' in the coordinating of using the artifacts *while* speaking about the drugs, and their knowledge on the medical treatment. The coordination here refers to how the actions of *assimilating, interpreting and aggregating* information are used to coordinate the team's decision-making process on the patient's care management.

At the coordination-artifacts coupling level, the clinicians access the information, which was represented on the artifacts as different levels of details to conceptualise their next actions (i.e., what does this information represent and where do I go next to seek evidence?). At the artifacts-speaking coupling level, the details from the artifacts were formed conceptually in the mind (e.g., the patient has EBSL) and the details from the environment were also constructed (e.g., seeing the physical signs on the patient) while speaking. These actions had demonstrated that the clinicians were 'trying to fit' what is being presented as information, and interpreting and aggregating it (model of what is represented in the world) with what they have learned as 'clinical knowledge' and from their experiences on the treatment (model in their mind). This has further revealed that the conceptualisation of the clinicians showed that the formulating actions of *perceiving, interpreting, and aggregating was about contextualising all possible details from the environment on different levels of coupling*. What we refer to as 'all possible details' refers to the action of getting details that can replace the most significant information loss that was 'wh*at has the patient been treated for currently*?'. This information loss was not recorded anywhere on the artifacts.

The synthesis viewed from the perspective of situated cognition highlighted most importantly that the current information was represented 'without a context' (absence for what the patient is being treated for). This has revealed the limitations of the present work system design – and the complexity of the decision making process involved, because of the nature of patient care management in critical care settings. It has also led us to further question - why was the work system (e.g., paper records and artifacts not recording what the patient has) designed in such a way? The initial study of observing context of error had enabled us to highlight the common patterns in the use of artifacts that had led to errors. The observation can lead to design principles that consider safety elements, for example a principle could be that a decision support system must be able to have an alert mechanism. Thus our future work would be conducting longitude studies to obtain a general finding so that the modeling and representing of context of error can be developed.

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Appendix

Categories of case management coding	Description	Example
Information aggregation	Patient information aggregated by the presenter prior to the its interpretation by the entire team; multiple instances of information aggregation possible depending on the number of ongoing medical issues in the case	"MICU day no.3, she was exubated yesterday. Her problem include mental status, hep C, withdrawal, UTI stage 2 DQ ulcers"
Information interpretation	Patient information interpreted based on the evidence at hand	"Because of her size, I can pretty much guarantee you, what's in there is probably a Bovina"
Information loss	1. Inaccurate recall: Recalled patient information that is inaccurate, where correct information is loss 2. Failure to follow up: Question posed by team member but never addressed in discourse	1. Team member discuss patient having a history of diabetes, when the information available did not show this history 2. Team member asked if patient was passing urine, but this question was never followed up

Categories of error coding	Description
Generated error	1. When the information uttered by a team has something that is incorrect or doubtful 2. Anything that is categorizes as relevant information loss, inaccurate interpretation, of faulty decision making
Corrected error	1. When participants themselves or someone else corrects an error 2. When a mistake is detected and corrective actions are taken 3. When an incorrect interpretation or decision is corrected

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