

Examining the Complexity Behind a Medication Error: Generic Patterns in Communication

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Abstract— Communication was the most frequently cited cause of medication errors reported between 1995 and 2003. More detailed models of how communication breakdowns contribute to adverse events are needed to intervene to improve communication processes. We describe in detail an incident where an oncology fellow physician erroneously substituted the medication navelbine for the intended etoposide during ordering, resulting in a prolonged hospitalization with severe leukopenia for the patient. A team of human factors and medical experts analyzed the case and identified communication patterns described in the human factors literature. We discuss how the findings suggest targeted ideas for improving communication processes, media, and systems that may have higher “traction” for improving patient safety than are possible solely from aggregated analyses of coded descriptions of large sets of cases.

Index Terms—communication, human factors, medical decision making, safety

I. INTRODUCTION

COMMUNICATION is frequently implicated as a contributor to adverse events. Communication was the most frequently cited cause (>60%) of medication errors reported to the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) between 1995 and 2003 [1]. In a retrospective review of 16,000 in-hospital deaths in Australia, communication errors were found to be the leading cause, twice as frequent as errors due to clinical skill [2]. Also in Australia, a study of primary care physicians revealed that approximately 50% of all detected adverse events were

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associated with communication difficulties [3]. In the United States, Dynamics Research Corporation determined from a retrospective review of 4.7 million patient visits to an emergency department that teamwork failures occurred in 43% of the closed claims [4]. The teamwork failure that most frequently contributed to the occurrence of clinical error was “cross-monitor actions of other team members.”

It is unclear what, if any, interventions could reduce the rate of adverse events by improving communication processes. To increase our understanding of how communication breakdowns contribute to adverse events, there is consensus that further research needs to be conducted. [5] One approach is to conduct detailed process tracing analyses of how communication mechanisms and breakdowns contribute to single incidents. Over time, these case-based analyses could build a foundational understanding of the complex, interconnected nature of communication processes and generic patterns of communication in healthcare.

To this end, we describe a complex sequence of events leading to a medication error on an oncology care ward and discuss how these events relate to communication patterns and possible interventions described in the human factors literature. In this case, an oncology fellow erroneously substituted the medication navelbine for the intended etoposide during ordering, resulting in a prolonged hospitalization with severe leukopenia, which is a radical lowering of the white blood cell count that raises the potential for serious infection. The case description synthesizes what was learned during critical decision method interviews [6] conducted individually with the oncology fellow, oncology attending, pharmacist, nurse, and nurse manager directly involved with this incident.

II. CASE DESCRIPTION AND COMMENTARY

A. Initial diagnosis and treatment plan

On Monday, a 70 year-old smoker with a prior medical history of chronic atrial fibrillation and hiatal hernia repair presented with complaints of progressive dyspnea on exertion, loss of 17 pounds over the preceding two weeks, and malaised and fatigued for the last two months. A Computed Tomography (CT) scan was read as impending superior vena cava (SVC) syndrome based on a mass in the right upper lobe (RUL) compressing the SVC with possible lung cancer or post-obstructive pneumonia. The patient had

no insurance coverage at that hospital and so was not admitted. On Tuesday, the patient was admitted as a new patient in the Emergency Room (ER) of a second hospital with leukocytosis (a high white blood cell count) and a right hilar mass.

Commentary: The initial diagnosis and treatment plan in the second hospital's emergency room was based on less reliable information than were available in other locations. No prior history or medical records were available because it was the first time the patient was treated in the hospital. Medical records are preferable to patient self-report in general to reduce reliance on memory for technical information that non-healthcare professionals might not fully understand as well as for dates for surgeries, vaccinations, and other critical events. In this case, the patient was also not feeling well, was fatigued, and was emotionally stressed from hearing the diagnosis of possible cancer of the lung and from the inability to receive treatment at the first hospital due to economic constraints. Finally, the emergency room was not the ideal location to conduct a detailed history elicitation due to the unpredictable nature of the setting and the high probability of interruptions. Note that it is likely that a more thorough history was conducted and/or the records retrieved at a later time.

On Wednesday, a pulmonary consultant decided that a bronchoscopy would be performed the next day with the attending physician.

Commentary: The bronchoscopy was scheduled for Thursday, which was as prompt as possible given that the patient was required to fast overnight for the procedure. In addition, by scheduling the procedure at a time when the pulmonary consultant, the oncology attending physician, and the first oncology fellow were all available, their expertise could be utilized to make decisions real-time during the procedure.

B. Confirmed diagnosis of small cell lung cancer and SVC syndrome

On Thursday, the patient underwent bronchoscopy, which showed an obstructing lesion of the right upper lobe (RUL) and most of the right middle lobe (RML). The patient was diagnosed with postobstructive pneumonia. A trans-bronchial biopsy was performed. On Friday, it was judged that the biopsy definitively showed small cell lung cancer. The patient developed increased swelling of his right upper extremity on Friday night, and was diagnosed with SVC syndrome.

Late on Friday, the oncology fellow consulted a radiation oncologist given the SVC syndrome diagnosis. The treatment plan was determined to be emergent radiotherapy, steroids, and continued antibiotics for pneumonia. Note that the oncology attending later stated that, for this case, he would have initiated chemotherapy without radiotherapy, which was confirmed by the literature to be the recommended treatment plan.

Commentary: Although normally results of a bronchoscopy

are received in 48 hours, in this case the results were received in less time. In the typical situation, the biopsy results would not be available until Saturday, creating a dilemma regarding whether to wait until Monday, per hospital policy, or to initiate chemotherapy immediately, per recommended medical practice for this case. Another alternative, that would likely be impractical due to economic constraints, would be to transfer the patient to a facility with weekend staff with specialized knowledge of how to initiate emergency chemotherapy.

The increased swelling occurred on a Friday night, when the nurse immediately informed the first oncology fellow of the event. The decision by the first oncology fellow and the radiation oncologist to use emergent radiotherapy based on this event was made without the involvement of the oncology attending, who later stated that he would not have used radiotherapy, or the oncology fellow who was responsible for the patient the next day. Although it would have reduced the opportunities for problems with communication, it is likely that involving the oncology attending and the other oncology fellow real-time in the decision making would be difficult and expensive. Note that the biopsy results and increased swelling were potentially predictable, but no plans were made for those contingencies in advance.

C. Patient handoff to second oncology fellow

On Saturday morning, emergent radiotherapy and steroids were initiated based on the orders written on Friday night by a second year oncology fellow. On Saturday at around noon, a different, first year oncology fellow accepted responsibility for the patient for the weekend. He promptly called the oncology attending at his house and left a message on his answering machine in order to discuss the treatment plan. When the attending physician heard the message at 8 pm, he immediately paged the oncology fellow. The fellow immediately responded to the page by calling the attending from his personal cellular phone while he was driving.

Commentary: The decision by the fellow physician to leave a message on the attending physician's home answering machine to contact him was surprising to the attending physician, who wore his hospital pager while attending a conference on Saturday. It is unclear what factors contributed to this decision, or whether the fellow physician was aware that attending physicians at this hospital are "on call" 24 hours a day on the weekend via the pager. Note that messages left on answering machines might be viewed as less intrusive than using a paging system, particularly as neither pagers nor answering machines allow the person initiating the communication to know what activities are being interrupted.

D. Revision of treatment plan

The fellow presented the case to the attending, who said that chemotherapy should be initiated that night or the next morning. The attending asked the fellow what treatment plan he proposed, and the fellow suggested that the same plan could be followed as an outpatient from the previous

week, which was administering navelbine on a weekly basis. The attending dissented because the prior case was a non-small cell as opposed to a small cell lung cancer case. At this time, the fellow and attending agreed that the treatment plan should be VP-16, otherwise known as etoposide, 100 mg/m² on days 1, 2, 3 and Carboplatin 6 AUC on day 1, to be repeated every 3-4 weeks.

Commentary: In the discussion between the attending and fellow, an effective cross-checking strategy was employed and the fellow's proposed treatment plan was substantially revised. During the discussion, the physicians agreed on an appropriate plan, and there was verification that there was no miscommunication. Following the discussion, four factors probably contributed to the subsequent erroneous medication order:

1. It was the first time the oncology fellow had treated this kind of case, which made it more difficult for him to remember the treatment plan because it was unfamiliar.

2. He did not write down the names, doses, or durations of the medications, likely partly because he was driving during the conversation.

3. He ordered the medication the next day, thereby increasing the chances of short-term memory loss.

4. The medication was identified as VP-16 during the conversation, which he had to convert to the name etoposide during the ordering process, making it more difficult to detect the erroneous substitution.

E. Erroneous substitution in medication order by physician

On Sunday morning, the fellow learned that the patient's swelling had continued since the previous day. The fellow called the pharmacist to tell him that he planned to order navelbine [instead of etoposide] at 100 mg/m² and Carboplatin 6 AUC. The pharmacist informed the fellow that the hospital had a policy against initiating new chemotherapy regimens on the weekends. The pharmacist later indicated that he was the only pharmacist staffed that day, that he only worked one day a month at the hospital, and that he had no expertise with chemotherapy agents, but none of this was communicated to or otherwise known by the fellow at this point. The fellow explained that he had discussed the case with his attending and that it was critical to administer the medications as quickly as possible. He decided to order only the first day of the treatment plan. Note that the attending physician later stated that, although the textbooks say that it is critical to treat this kind of case as quickly as possible, it is not clear that it is necessary, which is confirmed by the literature.

Commentary: Although there was a policy against initiating new chemotherapy regimens on the weekends, the fellow did not feel that he had the authority to 1) delay the administration based on this information because it was different than what his attending physician had told him to do, or 2) call the attending physician with this information to ask if the plan should be changed. In addition, the reasons for the policy as

well as the applicability of the concerns motivating the policy in this situation were not communicated or known by the fellow. It is likely a social norm that most fellow physicians would choose to go against a hospital policy after negotiating a plan with their attending physician based on the assumption that the attending would already be aware of hospital policies when trading off the associated risks to the patient.

The pharmacist assented to dispense the medication as long as the physician would handwrite the request on a special order form and hand him the form personally. The fellow wrote the order for one-time NOW doses of Nevelbine [instead of Navelbine] 100 mg/m² and Carboplatin 6 AUC and handed the form to the pharmacist.

Commentary: Although the use of the special order form likely helped to emphasize the hospital policy of not initiating new chemotherapy regimens on the weekend by requiring that the physician perform a non-routine activity to order a chemotherapy medication, an unintended consequence of its use was that electronic detection of particularly high or low doses was not possible. In the case of chemotherapy agents, standard dose ranges were not available in the provider order entry software in any case due to their complexity and how frequently recommendations changed. Although "smart IV pumps" were not used at this hospital at the time of this case, it is likely that the chemotherapy medications would not be included for similar reasons on the dose verifications.

F. Medication verification by pharmacist

The pharmacist called the hospital's pharmacy expert (a PharmD who specialized in chemotherapy medications) at her home. She did not answer the phone, and she was not on-call. He read the package inserts for both medications, which had the Physician's Drug Reference (PDR) reference information. He read that carboplatin was used with navelbine in non-small cell lung cancer cases, which he felt confirmed that the medications were meant to be combined and that the physician meant "Navelbine" even though "Nevelbine" was written. He read that the standard dose was 30 mg/m² for Navelbine and so called the fellow to be sure that 100 mg/m² was not too high.

Commentary: The pharmacist felt that it would be helpful to access specialized pharmacist expertise to verify the chemotherapy order, but was not successful in doing so. Because the hospital had a policy against initiating chemotherapy treatments on the weekend, no provision had been made in terms of assigning on-call responsibility for that expertise. It is possible that a specialized pharmacist would know that navelbine was indicated for non-small cell lung cancer but not small cell lung cancer, but patient diagnoses are not normally included in medication orders.

Although a pharmacist who specialized in chemotherapy might have more easily detected that the ordered dose was higher than would be expected for navelbine, this pharmacist did detect that discrepancy and alerted the fellow physician. Nevertheless, the oncology fellow did not perceive that he had

the authority to change the plan that was negotiated with his superior. In essence, the fellow physician interpreted the “are you sure?” question regarding the high dose to mean “Are you sure that this is what the attending physician wanted to do?”

G. Medication administration by nurse

In preparation for administration of the chemotherapy medication, the patient was transferred from a private room on an acute care ward to an oncology ward where he shared a room with two other patients. The patient was assigned to the only Registered Nurse (RN) on the ward who was authorized to administer chemotherapy agents. The nurse, who worked part-time twice a week, already had a high patient load prior to accepting this patient because another nurse had called in sick. Twelve family members, including the patient's ex-wife with whom relations were strained, accompanied the patient during the transfer. A family member asked if they could open the windows because the room was hot, but the nurse refused the request because the policy was to keep the windows closed to protect patients from pollen.

Commentary: Deviating from typical situations often has unintended consequences that are difficult to predict in advance. In this case, by initiating chemotherapy on the weekend instead of during the week, it was more difficult for:

1. The fellow to access other oncologist physicians, including his supervisor (and so the fellow could not informally ask anyone if he should delay the administration based on the hospital policy or if the dose was the correct amount)

2. The part-time pharmacist to access the pharmacist who specialized in chemotherapy or other pharmacists (and so the pharmacist verified the doses of the medication based on the PDR information)

3. The part-time nurse to access other nurses experienced with administering chemotherapy medications or to recruit additional nursing staff to help with other patients when she received the transfer patient (because the nurse manager was not on duty)

4. The nurse to assess cardiac status and monitor the effects of the medications because the medications were ordered to be administered immediately following the transfer from another ward

5. The family members visiting the patient in the shared room to cope with the stress because the room was shared with other patients and hot.

The patient had significant swelling and a history of cardiac problems and so the nurse was concerned that the administration of fluids would increase the risk of heart failure. Note that because the swelling was likely a result of SVC syndrome, heart failure might not have been an imminent risk despite his prior medical history.

The nurse's concern about the swelling given the patient's prior cardiac history might have been a “red herring” in this

case because the swelling was more likely a result of the SVC syndrome. It is possible that the handoff update prior to transferring the patient did not convey enough information about the swelling and diagnostic history to enable her to rule out cardiac concerns.

The pharmacist appeared on the ward with several vials of navelbine in 10 mg/mL units and the carboplatin. He told the nurse that he had wanted to personally dispense the medications to the ward [rather than having a pharmacy technician or robot deliver it] because he was nervous about initiating chemotherapy on the weekend and the high dose of the navelbine medication. The nurse said that she was not very familiar with the medication, and requested that the pharmacist verify again with the physician if he had concerns. The pharmacist called the fellow from the ward and the fellow again verified that the order was correct. Note that the nurse later stated that under the staffing conditions that day, as well as the typical staffing conditions, that it would have been prohibitively difficult to look up the medication in the reference book on the ward. Multiple family members, who had been told that it was important to administer the chemotherapy quickly, asked when the nurse would administer the medications.

Commentary: The pharmacist delivered the medication to the unit personally. The medication was dispensed in multiple vials because the dose was higher than the standard dose for that medication. This physical evidence that the dose was higher than expected was readily apparent to the pharmacist and the nurse, but not the physician because he did not see the actual medication delivered to the unit. In a sense, there was no new information when the pharmacist called again to verify because the pharmacist had already previously told the physician that the dose was higher than expected.

H. Patient response to medication

The nurse completely administered the navelbine medication by hanging all the IV bags. The patient complained that he felt bad, including that he perhaps thought that he was dying. The patient had become diaphoretic, short of breath, and hypertensive. The nurse called the fellow, who told her to hold the carboplatin, which was primarily used to accelerate the impact of the navelbine. Note that the attending physician later stated that he would not have held the carboplatin for that reason and the nurse also later stated that she was surprised that the fellow made the decision so quickly, but did not question it at the time.

Commentary: Based on the nurse communicating the patient's adverse reaction to the navelbine medication, the physician decided to hold the carboplatin. Although this was a fortuitous decision given that navelbine was not the intended medication, the attending physician and the nurse later questioned the decision based on this new information. It is more common to alter the treatment plan to better manage the side effects of the chemotherapy agents than to halt

administration prior to completion.

I. Detection of erroneous medication substitution

On Monday morning, while reviewing the electronic medical record in preparation for rounds with the attending physician, the original fellow detected the erroneous medication substitution. He immediately informed the attending. The attending talked with the patient and family regarding the mistake and consequences. The attending was less concerned than he would have been had the carboplatin been administered. Recovery measures were taken and the patient's hospitalization was prolonged for six days with severe leukopenia.

III. PATTERNS IN HUMAN FACTORS LITERATURE

As detailed in the case and commentary, there were numerous communication issues in this case. Several of the issues relate to patterns described in the human factors literature:

- Local actors do not tailor their actions to meet the intent of distant supervisors when events occur
- Unwarranted shifts in planning following handoffs
- Confusion about responsibilities for tasks with unclear roles
- Difficult to access specialized expertise
- Failure to break fixations by asking "are you sure?"
- Reluctance to question people with greater authority
- Properties of medium influence communication processes

A. Local actors do not tailor their actions to meet the intent of distant supervisors when events occur

The literature suggests that local actors need to know the intent of distant supervisors in order to respond to new events [7]. In this case, there were several instances where understanding the intent of the fellow physician's medication order would have aided the interdisciplinary team in providing patient care. For example, the physician only ordered the first day of treatment without indicating the full treatment plan, including the intent to repeat the treatment every three to four weeks. The long-held tradition of physicians "writing orders" for pharmacists and nurses separates actions from plans and intent. The physician decided to only order one day of the three-day course of treatment, perhaps to encourage reconsideration of the plan when more specialized expertise was easily accessible. Yet notions such as "tentative plan" are not captured by the order entry system, creating a potential vulnerability. The fellow was only responsible for the patient until Monday, at which time a transfer of responsibility was planned to occur. Without ordering the entire treatment course, the default if no action were taken by the next physician would be for the patient to only receive the first day of treatment. Similarly, the plan to repeat the treatment course in a month was not captured. When the intent and plans

behind orders are not communicated, it is more difficult for other team members to detect erroneous assumptions or actions and to predict future actions.

In addition, when the pharmacist read the drug insert information, he was unaware of the small cell lung cancer diagnosis, for which the medication was not indicated. Therefore, being explicit about the intent behind an order may aid communications. On the other hand, note that suggestions to have physicians add diagnosis information to medication orders have often met with resistance due to the increased time to write each order.

Similarly, the second fellow did not have a sufficient understanding of the attending physician's intent in order to adequately revise the plan when the pharmacist questioned the high dose of navelbine, placing him in an "authority-responsibility doublebind" [8] situation. The second fellow felt that he was responsible for executing the attending physician's plan without having the authority to, from his perspective, override the dosing decision, which he expected that the attending physician had decided for a reason to be higher than the standard dose. In contrast, he modified the plan based on the nurse's report of patient reaction to the medication because he perceived that the new information granted him the authority to modify the plan. As implemented at this hospital following this case, the attending physicians, who are the primary distant supervisors with authority, are now involved in "are you sure?" exchanges when initiating chemotherapy on the weekends.

Finally, the nurse administering the chemotherapy had difficulty in determining how to respond to the increased swelling. Nevertheless, the increased swelling was predictable based on the SVC diagnosis. Knowing that the swelling was explained by the SVC diagnosis would have helped the nurse to better evaluate the risks of giving fluid to a patient with a history of cardiac events. This suggests that advance contingency planning and communication of expectations regarding future events could aid the ability to anticipate and respond to events. [9]

B. Unwarranted shifts in planning following handoffs

Ideally, a handoff transfer of responsibility for a patient occurs without a break in patient care and associated activities. A successful handoff avoids unwarranted shifts in goals, decisions, priorities, or plans, including dropping or reworking activities that others were told would be done by the previous person in the role [10]. In this case, the handoff from the first to the second fellow resulted in changes to the treatment plan that were not based on new patient information. Specifically, the emergent radiotherapy initiated by the first fellow was discontinued by the second fellow and instead chemotherapy alone was initiated. Although this was the preferred plan of the attending physician, ideally the first fellow would have incorporated the preferences of the attending physician in the original plan formation. This observation leads to ideas for reducing unwarranted shifts by conducting interdisciplinary

rounds and supporting ad hoc real-time meetings of key decision makers. Additionally, shared access to medical record documentation by the distributed care providers, ideally across hospitals, would help to identify and reduce unwarranted shifts.

C. Confusion about responsibilities for tasks with unclear roles

“The importance of clear roles and responsibilities is rather obvious: When team members have specific assigned duties, they know exactly what is expected of them and can more easily apply their knowledge and skills” (p. 152) [11]. Similarly, Klein and colleagues state that team members need mutual knowledge about the following to effectively coordinate: roles and functions of each participant, routines that the team is capable of executing, skills and competencies of each participant, and goals of participants, including their commitment to the success of the team activity [12]. In this case, responsibility for patient care was distributed somewhat ambiguously over a number of physicians. The fellow physician who initiated emergent radiotherapy was different than the fellow physician who, following a discussion with the attending, initiated chemotherapy without radiation. The fellow who initiated chemotherapy only ordered one day of the treatment plan, leaving the original fellow to write new orders for the remainder of the treatment. Therefore, it is confusing which of the physicians held the primary responsibility for ensuring that the medications were ordered correctly and that the radiologists were informed that radiotherapy was discontinued.

There is also confusion regarding who was responsible for verifying that the chemotherapy medications and doses were appropriate. At some hospitals, attending physicians are required to co-sign all initiations of chemotherapy as a means to encourage them to review the orders. At this hospital, the senior pharmacist with expertise in chemotherapy reviewed all chemotherapy orders when dispensing them, but she was not working that day. Nurses are usually expected to educate patients about new medications, including possible adverse reactions or side effects, and so there is often an implicit check on the medication at that time.

D. Difficult to access specialized expertise

Research in space shuttle mission control revealed that accessing specialized expertise in non-routine situations, and particularly in escalating situations, is a difficult task. To improve this process, NASA mission controllers are explicitly assigned “on-call” responsibility and are expected to invest in understanding mission status on a daily basis in preparation for being called in quickly and unexpectedly [13]. In this case, there was no easy mechanism for accessing specialized chemotherapy expertise on the weekend, partly because there was a policy against initiating chemotherapy on the weekends. Only one of the two fellow physicians discussed the case with the attending physician on the weekend, and the discussion was delayed because the fellow either did not know that he

was supposed to page the attending or did not feel comfortable doing so. The pharmacist was unable to reach the pharmacist with chemotherapy expertise. Finally, the nurse was the only nurse on the ward authorized to hang chemotherapy medications, even though the ward specialized in oncology patients.

E. Failure to break fixations asking “are you sure?”

The literature suggests that the introduction of a fresh perspective can be effective in detecting erroneous assumptions in ongoing plans, otherwise known as breaking fixations in mindset. In contrast, repeatedly asking “are you sure?” questions by the same agent without new information is not effective [14].

The data from this case (Table 1) are consistent with the literature. The plan was revised in three cases where cross-checking was employed. First, the attending physician detected that the fellow’s original plan of using navelbine to treat this patient was inappropriate and an appropriate plan was formulated. Second, the fellow physician revised the plan based on the nurse’s new information about patient response to the medication. Third, the original fellow detected the erroneous medication substitution when reviewing the case Monday morning in preparation for rounds.

On the other hand, the plan was not revised in three cases. The pharmacist’s request to delay initiating treatment until the next day and the two queries regarding the high dose failed to alert the physician to the erroneous medication substitution.

TABLE I
 CROSS-CHECKING OF TREATMENT PLAN

Plan revised	Plan not revised
<u>Attending checking fellow</u> Use VP-16, not navelbine, for this kind of cancer.	<u>Pharmacist checking fellow</u> You want to initiate chemotherapy on weekend despite hospital policy?
<u>Nurse checking fellow</u> Patient diaphoretic, short of breath, hypertensive. Do you want to hold carboplatin?	<u>Pharmacist checking fellow</u> Standard dose is 30 mg/m ² Are you sure you want 100 mg/m ² ?
<u>Fellow checking fellow</u> This is not the right medication for this diagnosis.	<u>Pharmacist checking fellow</u> Are you sure you want 100 mg/m ² ?

It is interesting to note that, in hindsight, the attending physician questioned two decisions, one made by the first fellow Friday night to use radiotherapy, and one made by the second fellow Sunday afternoon to hold the carboplatin. One could view these as cross-checks that could have occurred had the attending physician been aware of the others’ decisions.

These observations suggest that repeating the same “are you sure?” question from the same source should not be relied upon to detect erroneous assumptions. Instead, fresh

perspectives and new information should be provided during cross-checking to break fixations.

F. Reluctance to question people with greater authority

In aviation, it has been well-documented that there are “authority gradients” in that people lower in a hierarchy question people less frequently who are higher in a hierarchy than vice versa [15]. In this case, the fellow did not question the dose recommended by the attending. The pharmacist questioned the fellow but did not question the attending physician about the dose. The nurse encouraged the pharmacist to call the fellow again but did not directly question the fellow or attending physician. It is possible that providing team members with more information about the rationale behind decisions “from above” might make it easier to judge when it is appropriate to question those with greater authority.

G. Properties of medium influence communication processes

Clark and Brennan [16] identified eight constraints that a medium may impose on communication processes:

1. Copresence: when participants can see and hear what each others are doing and looking at
2. Visibility: when participants can see each other
3. Audibility: when participants can hear each other and take note of timing and intonation
4. Cotemporality: when an utterance is received without delay
5. Simultaneity: where participants can send and receive information at the same time
6. Sequentiality: when turn-taking is not interrupted or out of sequence
7. Reviewability: when utterances last beyond the immediate conversation
8. Revisability: when a participant can revise an utterance privately before sending it

In this case, communications appear to have been influenced by the communication medium in that:

- the first fellow generated a treatment plan with a radiation oncologist which the attending later did not agree with, partly because of the inability to judge the interruptability of the attending physician with a pager,
- the pharmacist refused to accept a verbal order over the phone from the first fellow, instead insisting on a written order on a special paper form. Although the physician spelled navelbine as nevelbine, writing the order might have triggered the physician to look up the medication or otherwise detect the erroneous medication substitution,
- the nurse was surprised (at least in hindsight) at how quickly the fellow decided to hold the carboplatin after the incident, but the physician was unaware of this reaction because he did not have the ability to see her body language,

- the fellow physician did not see the numerous bags required for the higher than standard dose that the pharmacist and nurse saw because the communications were conducted by phone,
- the attending physician was unaware of the message left on his home answering machine until he arrived home following a conference,
- the fellow did not have the ability to review the conversation where he discussed the treatment plan with the attention, such as by being able to replay an audiotape, or document the medication orders, because he was talking on a personal cell phone while driving, and
- the pharmacist with chemotherapy expertise was unaware that the pharmacist had called her at home to ask her a question.

These findings suggest that communication modalities may be designed to increase the observability of how receptive a recipient might be to an interruption. For example, the accessibility of a recipient might be inferred from the location of the person, whether the person is talking with someone else, and whether the person is reviewing a patient’s medical record. In addition, accessing people can be made easier by linking phone and pager numbers to roles rather than individuals. Finally, “playback” capabilities might be incorporated. For example, in this case, the fellow physician might have been able to review the conversation he had with the attending physician while driving when writing the medication orders the next day.

As summarized in Table 2, many of the communication issues identified in this case relate to patterns described in the human factors literature and suggest potential ways to improve communication processes, mediums, and systems.

TABLE 2
 SUMMARY OF COMMUNICATION PATTERNS AND POTENTIAL INTERVENTIONS

Patterns	Potential Interventions
Local actors do not tailor their actions to meet the intent of distant supervisors when events occur	Communicate intent behind orders Advanced contingency planning Train how to make trade-offs in time-critical situations
Unwarranted shifts in planning following handoffs	Conduct interdisciplinary rounds Supporting ad hoc real-time meetings of decision makers
Confusion about responsibilities for tasks with unclear roles	Clarify roles and responsibilities Define “minimum responsibility” and “full-service” roles
Difficult to access specialized expertise	Assign on-call responsibility to specialists
Failure to break fixations by asking “are you sure?”	Incorporate fresh perspectives in cross-checking strategies Avoid identical repetition of “are you sure?” questions
Reluctance to question people	Make the rationale for actions

with greater authority	observable
	Provide remote access to records of activities
Properties of medium influence communication processes:	Communication medium designed to enable judgment of interruptability
<ul style="list-style-type: none"> Poor observability of interruptability hampers communication Easier to know the role to contact than the person Easy to forget details of a conversation 	Use role-based rather than individual-based contact information
	Provide playback capability of communication episodes

IV. CONCLUSION

Communication is frequently implicated as a “root cause” of sentinel events. Although we did not identify any single issue as “the root cause,” this analysis revealed that there were many communication-related issues that contributed to the medication error. In addition, communication proved to be important in the detection and mitigation of consequences from the erroneous medication administration.

We believe that the communication patterns and potential interventions we identified are derived from a deeper understanding of the complex interconnected nature of communication processes than is possible from aggregated analyses that are more “distant” from the stories. Despite the obvious limitations of generalizing from the analysis of individual cases, we believe that the targeted ideas for improving communication processes, media, and systems could have higher “traction” for improving patient safety than would otherwise be possible.

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