

What Difference Does a Robot Make? The Material Enactment of Distributed Coordination

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What difference does robotic telepresence make to the coordination of complex, dynamic, and distributed knowledge work? We explored this question in a post-surgical intensive care unit where medical workers struggled to coordinate their work in the face of different assessments of their extremely sick patients. Our in-depth field study examined night rounds, a central routine for coordinating work in this unit that was performed remotely through different technologies. We found that night rounds that are materially enacted through robotic telepresence intensify coordination outcomes both positively and negatively, resulting in contrary implications for subsequent coordination of work. We further found that these differences in intensification depend on whether preparatory work is more or less distanced from the bedside. We develop a theoretical account of these findings by explaining how the coordination of complex, dynamic, and distributed work is crucially related to how that work is materially enacted over time.

Keywords: material enactment; robotic telepresence; coordination; practice lens; temporality; provisional settlements

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Introduction

Coordinating complex and dynamic knowledge work is hard. Multiple workers engage with changing realities across different times (Mol 2002), spaces (de Vaujany and Vaast 2013), activities (Bechky 2003), technologies (Berg 1997), and purposes (Kellogg et al. 2006). This work often includes specialists, whose interests (Carlile 2004, Kaplan 2008), experience (Orr 1996), and expertise (Bailey and Barley 2011) differ, producing conflicting understandings that can threaten the performance of interdependent work (Cramton 2001, Faraj and Xiao 2006, Okhuysen and Bechky 2009). Coordination difficulties increase as knowledge work becomes distributed and mobile (Hinds and Bailey 2003, Hinds and Kiesler 2002, Mazmanian et al. 2013) with workers routinely interacting at a distance and reporting on local conditions and events to others not physically present at the site of the work (Bailey et al. 2012).

Distributed work entails different technologies such as telephone, email, groupware, and telepresence through which distant workers engage with each other and remote environments. Research investigating the coordination of distributed work with these technologies has produced contradictory findings. Some studies find the technologies enabling coordination by supporting a stronger connection among remote workers and their environments (Dourish and Bellotti 1992, Kellogg et al. 2006, Kraut et al. 2002, Malhotra and Majchrzak 2014, Nardi et al. 1995), whereas others find significant coordination difficulties as workers interact through the technologies (Cramton and Webber 2005, Cummings et al. 2009,

Hinds and Mortensen 2005, Mortensen and Neeley 2012, O’Leary and Mortensen 2010).

While their specific findings differ, these studies on coordinating distributed work are alike in treating technology as separable from situated practice. Researchers have long argued that the effects of technologies are less a function of the technologies themselves than of their use (Barley 1986, DeSanctis and Poole 1994, Kling 1991, Orlikowski 1992, Robey and Sahay 1996). The emphasis on use—while offering an important corrective to earlier deterministic accounts of technology—has tended to lose sight of how the specific materiality of different technologies matters in practice (Button 1993, Leonardi and Barley 2008, Orlikowski 2007). Materiality is not an “inherent fixed property of abstract independently existing objects” (Barad 2003, p. 822) that prescribes, mediates or supports some pre-existing work practice. Rather materiality is how that work is instantiated in practice (Orlikowski and Scott 2008). On this view, a practice only exists as it is materialized in specific times, places, texts, artifacts, bodies, infrastructure, and so on (Orlikowski and Scott 2014). What matters then is not the abstract properties of a technology or its affordances or appropriations in use, but how work practices are materially enacted (Introna 2011). As the implications of such enactments for coordinating distributed work have not been well understood in the literature, we focus on them here. Our research question thus aimed to understand the conditions and practices through which specific technologies make a difference in coordinating complex, distributed knowledge work, and with what consequences.

Coordinating Distributed Knowledge Work Through Technology

Coordinating distributed work has long been an aspect of large-scale organizing as evident, for example, in the operations of the Roman empire, the Catholic Church, and multiple colonial administrations and trading companies (O’Leary et al. 2002). These earlier forms of distributed work depended on technologies (e.g., carriages, ships, and rail) just as contemporary distributed work does (e.g., telephone, email, mobile devices, and more recently robotic telepresence). Understanding the implications of these technologies for distributed work is a growing theme in the literature, as contemporary organizations increasingly globalize, move operations offshore, and depend on virtual teams. Empirical research on the coordination of distributed knowledge work has found technology to be both enabling and constraining.

Studies showing that technology can enable coordination often identify new interaction possibilities for distributed workers who would otherwise struggle to share information and work across boundaries (Fussell et al. 2000, Jarzabkowski et al. 2012, Kanawattanachai and Yoo 2007, Nardi et al. 1995, Nicolini 2011). For example, Kellogg et al. (2006) show how distributed knowledge workers in an advertising firm coordinated work across their differing disciplinary orientations by using technologies such as email, calendaring, and networked storage to display, represent, and assemble their work for and with others. In research on distributed teams relying exclusively on collaborative technologies for coordination, Malhotra and Majchrzak (2014) found that the technologies helped team members achieve shared situational awareness without uniformly decreasing coordination performance. More specifically, it was the relative routineness of the work at hand that influenced whether use of the technologies enabled coordination.

Studies showing that technology can constrain coordination often show interpretation difficulties flowing from diverse information (Cramton 2001, Cummings et al. 2009, Dourish and Bellotti 1992, Heath and Luff 1992, Kellogg et al. 2006, Nardi et al. 1995, O’Leary and Mortensen 2010). For example, in a study of automotive engineering, Bailey et al. (2012) show how engineers in India and the United States struggled to coordinate their work as they interacted on simulations of automobiles. Without direct access to cars, parts, or U.S. colleagues, the Indian engineers made incorrect assumptions about vehicles’ components and coded these into their computer models. The U.S.-based engineers—who worked directly with real cars—often had to rework these models. Despite such difficulties, management persistently distributed engineering work on the assumption that working remotely on a simulation was equivalent to working with the real thing. In a study of distributed software development teams, Espinosa et al. (2007)

show how team knowledge, role, and geographic dispersion influence coordination. They find that the work of distributed team members varied by role (e.g., managers coordinated temporal and process aspects of the work, while technical employees coordinated the technical issues). The teams’ regular use of technologies (e.g., instant messaging, email, and the telephone) to deal with their geographic dispersion generally decreased coordination effectiveness, particularly when team members had differing understandings of the work and their coworkers’ participations.

Whether focused on new interaction possibilities or interpretation difficulties generated by using technologies, this literature has tended to posit technology as a separate resource that people use to coordinate their work. Treating technologies as distinct tools or mediators of distributed work that afford/restrict certain activities is valuable, but we believe that additional insights can be generated by treating technology as constitutive of the work (Orlikowski and Scott 2008, Schatzki 2010). In particular, notions of mediation or affordance tend to emphasize distinct properties of technologies and examine how these influence some separate work activity. A constitutive view, in contrast, emphasizes practices, recognizing that work is an ongoing accomplishment that will be performed differently depending on its material enactment through different technologies. From this perspective it is not the case that a (self-standing) technology such as email or the telephone affords or mediates (pre-existing) work processes, but rather that the work and the technology configure each other in practice. On this view, differences in how the work is materialized in practice are deeply consequential.

Viewing the coordination of distributed work through a lens of material constitution entails a practice perspective (Feldman and Orlikowski 2011; Schatzki 2002, 2010) that focuses attention on the different ways that coordination is accomplished through specific technologies. This both builds on and departs from Faraj and Xiao’s (2006, p. 1157) practice-based definition of coordination as “a temporally unfolding and contextualized process of input regulation and interaction articulation to realize a collective performance.” The critical difference lies in our emphasis on the material enactment (Introna 2011, Orlikowski and Scott 2014) of coordination that entails examining how practices are materialized in specific times, places, texts, artifacts, bodies, infrastructure, etc., and with what implications for the work.

Research Setting

Our research involved a 14-month comparative field study of night rounds conducted by distributed medical workers in a post-surgical intensive care unit (SICU) at Hopeland,¹ a mid-sized, nonprofit teaching hospital. Hopeland included 387 patient beds, nearly 450 physicians, and more than 4,000 nurses, therapists, and other

support staff. Within Hopeland's SICU, change was an ever-present threat to the complex, highly interdependent, and life-saving work being performed. Patients only entered the SICU to recover from intensive surgery. They were all, in the local lingo, "very sick"—often unconscious, ventilated, and on a range of life-sustaining machines and drugs. As patients' conditions were multiple and highly unstable, their treatments required frequent and careful adjustment by a variety of professionals at varying times. Without regular attention to different assessments of patients' status, symptoms would be missed or dismissed, coordinated work would be impaired, and patients could deteriorate and die. The purpose of the SICU was to stabilize patients so that they could begin the long road to recovery.

Each SICU patient received a separate sealable room with a dedicated nurse. Hopeland's SICU had 24 patient rooms, with a nursing station in the middle. Rooms 1 to 18 were included in our study. Each patient room had a standing desk next to its glass door, with a networked PC, medical monitors that displayed real-time data on vital signs, and two separate paper-based patient records. Both these patient records—the flowsheet and Kardex—were organized in a matrix, with rows recording quantitative indicators of a specific kind (e.g., fluid balance) and columns recording those data at specific times and dates. Patient care in the SICU was handled by members of three occupational groups: nurses, residents, and attending physicians. These groups drew upon the same system of professional knowledge (the medical canon) and had interdependent but distinct forms of expertise and experiences.

Nurses in Hopeland's SICU were highly trained in intensive care; almost half of the 71 nurses had worked there for more than 15 years. Nurses worked in two basic shifts, from 7 A.M. to 7 P.M., and from 7 P.M. to 7 A.M., with no more than 12 nurses working per shift. Our study involved the participation of 27 nurses overall. *Residents* had recently received their medical degrees and were now receiving specialized training. They engaged in two-to-three-month rotations within different departments of the hospital. At any given time, four or five residents rotated through the SICU, and 14 did so during our study. *Attending physicians (AP)* were senior intensive care specialists with an average of 20 years of ICU experience. Five APs worked at Hopeland's SICU, and all five participated in our study. One AP managed the SICU each week, bearing ultimate responsibility for all the care delivered in the unit during that time.

Night Rounds in the SICU

Our study focused on the performance of night rounds, a central routine in the unit, intended to identify and address complications or ambiguities that had arisen with patients in the afternoon. At 5 P.M. each day, the

AP and four residents left, leaving a resident "on call" (responsible for the SICU overnight). From 7 P.M. to 9 P.M., the on-call resident was expected to prepare for night rounds by gathering patient information. At 9 P.M., the AP contacted the resident to do night rounds. Traditionally, night rounds were performed through telephone interactions with the APs at home, or occasionally elsewhere (e.g., walking the dog, driving). The SICU administrator typically answered the call, put the AP on hold, then notified the resident who would take the call while seated in the nursing station adjacent to a networked PC.

The hard-wired telephone meant that the residents could only move a foot or two away from their position at a desk behind a partition, and could only access their notes and a networked PC during the conversation. Nurses occasionally stood or sat at a distance from the resident, but did not speak during the call. The AP only interacted with the resident and, rarely and with considerable effort, accessed online medical records. **The resident and AP discussed each patient in ascending order by bed number, and the performance of night rounds concluded after the last patient had been discussed.**

In 2008, Hopeland leased six telepresence robots (model RP-7 from InTouch Health)² to assist in the performance of hospital work. This technology offers mobile videoconferencing controlled at a distance, allowing individuals to navigate distant locations while interacting with remote workers or problems via two-way video and audio (Lee and Takayama 2011). Performing night rounds with the robot involved the AP connecting remotely to the RP-7 through proprietary software and hardware. A webcam captured video of the AP and displayed it on the robot's screen. Forward-facing cameras on top of the RP-7 captured a 178-degree view of the SICU, visible on the AP's laptop. Using a joystick, the AP could move the RP-7 in all directions, and tilt and rotate its "head" (screen and cameras) nearly 360 degrees. With these controls, APs could navigate the RP-7 around the SICU, initiate conversations with others, and direct their attention in the SICU environment.

Performing night rounds through the RP-7 involved the AP initiating a remote session at 9 P.M. The resident on call approached the RP-7 (parked behind the nursing station) and began interacting with the AP. The AP navigated the robot to each patient's room and conducted night rounds with the resident as well each patient's nurse. As in night rounds enacted through the telephone, the resident and AP began with the lowest-numbered room and proceeded in numerical order. At the end of this sequence, the AP piloted the RP-7 to its charging station where the resident would plug it in for the night.

Research Methods

Data Collection

The first author conducted a field study of night rounds conducted by distributed medical workers at Hopeland's

SICU for over 14 months. During this period, and as part of a larger assessment being conducted by the hospital, RP-7 use was randomized for night rounds. Participating APs were given an envelope each day indicating the robot/telephone assignment for that night's rounding.³ During the study, the researcher observed SICU work activities and interviewed SICU staff. Formal interviews were conducted in private offices, typically lasted an hour, and were recorded and transcribed. Participants were asked about the SICU, their work with other staff and the RP-7 robot, and their role in night rounds.

The researcher visited Hopeland's SICU 62 times and collected detailed observational data on 34 sets of night rounds (17 robotic and 17 telephone) covering 424 patients (208 robotic and 216 telephone). These observations covered the work of 5 APs, 14 residents, and 27 nurses, with the residents and APs participating in all 424 patient interactions, and nurses only in the 208 interactions involving robotic telepresence. The researcher engaged in considerable informal interviewing with the 46 participants while on site, and also conducted 34 formal interviews with them. In particular, he conducted 8 AP interviews (with 5 APs; 3 of them twice), 8 resident interviews (with 5 residents; 3 of them twice), and 18 nurse interviews (with 14 nurses; 4 of them twice). Relatively fewer residents were formally interviewed as they were preoccupied with training and were less available. Field notes were taken during each visit, documenting notable events, informal interviews, and basic workflow information.

After four months in the field, the focus shifted to night rounds. During this time, the researcher arrived at the SICU at 7:30 P.M. and stayed until 10:00 P.M., observing work before, during, and after night rounds, and engaging in informal interviews. Near-verbatim records of round-related conversations, technology use (e.g., PC's, medical monitors, telephone, RP-7), and other aspects of the work (e.g., spatial orientation, gaze direction, gestures) were entered into a spreadsheet on a laptop. These data were time-stamped at the start/end of night rounds and the start/end of discussion about each patient. After five months of night rounds observation, a number of participants were interviewed again. In addition, feedback on preliminary findings was solicited from a subsample of APs, residents, and nurses. A final round of interviews with nurses and APs was conducted 12 months after the study had begun.

Data Analysis

Analysis of our data was inductive and iterative (Strauss and Corbin 1997), motivated by an interest in how the coordination of distributed knowledge work was materially enacted through different technologies. Our focus on the moment-by-moment performance of intensive care work in the SICU was informed by a practice lens (Feldman and Orlikowski 2011, Schatzki 2010). Diverging

assessments of patients' conditions were a central and ongoing threat to coordination in the SICU, and our initial analysis suggested that managing these assessments was particularly salient during the performance of night rounds when distributed actors interacted through technologies to stabilize patients for the night. Beyond their importance for subsequent coordinated work, enactments of night rounds themselves were clearly a coordinated affair. We therefore selected night rounds as the unit of observation in our study.

We proceeded with multiple readings of our field notes, exploratory writing, discussions with colleagues, and consideration of a variety of literatures (Eisenhardt 1989), paying particular attention to surprises and puzzles (Abbott 2004). During this process, we solicited reactions to interim findings from the participants. Our first round of analysis produced a number of initial themes related to work in Hopeland's SICU and night rounds in particular. These included basic activities (e.g., interactions among participants, viewing medical monitors), emic categories (e.g., the importance of patient stability), and common orientations (e.g., the purpose of night rounds). We supplemented these as new salient categories emerged. This, in conjunction with the time-stamped data referenced above, allowed for a variety of descriptive statistics for the key activities performed by the participants (by AP, residents and nurses during night rounds, see Table 1). These allowed for additional insights through iterative comparisons with narrative-style interviews and field notes.

In the second round of analysis, we considered how workers interpreted patients' conditions and arrived at temporary assessments about patients' stability through their night round activities. This led us to draw on provisional settlements (Kaplan and Orlikowski 2013) as the unit of analysis for investigating how night rounds addressed diverging assessments to facilitate coordination. Provisional settlements are temporary suspensions of disagreement that allow work to proceed. Such settlements are particularly valuable in complex, dynamic work where time pressures require action despite high uncertainty and dissent (Girard and Stark 2002, Kaplan and Orlikowski 2013, Kellogg et al. 2006, Neff and Stark 2003).

Provisional settlements helped us see night rounds as achieving temporary assessments of patients as either stable or on the way to stability. This allowed us to analyze the performance of night rounds as a particular sequence of activities, beginning with the resident reporting on and substantiating his/her descriptions of patient conditions and the AP either accepting these claims or probing on and revising them. This continued with one or both of them suggesting adjustments to treatment plans, and the AP assenting (often via silence) to the revised assessments of patient conditions and

Table 1 Activities Observed in Night Rounds

Conducting night rounds	Performed via telephone	Performed via robot
Number of rounds	17	17
Total patients covered	216	208
Average time/Night round	15.47 minutes	33.71 minutes
	% (freq.)	% (freq.)
Actions (across all patients)^a		
Talking about patients (AP and resident only)	100% (216)	0%
Talking about patients (AP, resident, and nurse)	0%	100% (208)
Reaching for and looking at flowsheets, Kardex, PC's and medical monitors (all participants)	4% (8)	47% (98)
Gesturing (e.g., pointing, nodding, directing gaze) (all participants)	0%	98% (204)
Looking at and touching patients (all participants)	0%	26% (55)
Interactions (across all patients)^b		
Claiming stability (substantiated) (by resident)	46% (99)	35% (73)
Accepted by AP	20% (44)	37% (27)
Claiming stability (unsubstantiated) (by resident)	15% (33)	5% (10)
Accepted by AP	85% (28)	80% (8)
Declaring puzzles (by all participants)	25% (54)	24% (50)
Declared by resident	81% (44)	68% (34)
Revising (by AP and nurse)	72% (155)	224% (465)
Didactic questioning (by AP)	25% (55)	49% (102)
Teaching (by AP)	43% (93)	42% (87)
Interjecting (by nurse)	3% (7)	133% (276)
Adjusting (by AP and resident)	46% (99)	98% (203)
Asserting (by AP)	19% (40)	52% (108)
Asserting (by resident)	6% (12)	6% (12)
Suggesting (by AP)	22% (47)	40% (83)

^aInstances were included only when relevant to the patient discussion at hand.

^bFigures for "revising" and "adjusting" are aggregates of the actions that comprise them.

overnight care plans, thus provisionally settling the matter. Though performed differently, all night rounds were conducted in this sequence and all produced provisional settlements, one per patient.

Despite similarities in the sequence of activities constituting night rounds, we found wide variation in how these activities managed differing assessments of patients' conditions and facilitated coordination. These variations were critically related to how night rounds were enacted through robotic telepresence as compared to the telephone. These different material enactments strongly influenced how work was coordinated

overnight. Further differences were also evident in the performance of night rounds and we explored these in a third round of analysis that found these were strongly related to work done before and after night rounds. In particular, differences in preparation work had important implications for provisional settlements reached in night rounds, and for subsequent coordination of care.

Our analysis allowed us to develop a grounded understanding of how night rounds managed differing assessments of patient conditions and the implications for overnight care. We draw on this analysis to argue that coordinating distributed knowledge work is crucially related to how it is materially enacted over time.

Coordinating Distributed Knowledge Work in Night Rounds

Given the purpose of Hopeland's SICU—the post-surgical care of critically ill patients—it is no surprise that diverging assessments of patient conditions were a serious challenge. While the reasons for admissions into the unit were well documented, patients' conditions and knowledge of these conditions changed from the moment they arrived. Their temperature, heart rate, and other vitals shifted constantly, they might spontaneously "crash" (enter cardiac arrest), gain or lose consciousness, excrete too much (or too little) fluid, struggle against their ventilator, and so on. Also, nurses, residents, and APs attended to different phenomena at different times, drew on different expertise and experience, sought different data from various devices, and interacted with different people, including patients' families. Assessments of patients' conditions, their status, and treatment thus shifted, multiplied and diverged.

There never is [a black and white answer] with medicine and health. You know what I mean, like, there's always all kind of variables, and it's always through people's perspectives. That's a common thread through any, you know, collaboration—just trying to achieve the best at the time, or whatever is most appropriate at the time. But everybody has different ideas as to what the situation is.

—SICU Nurse

Differences in how nurses, residents and APs understood patients' conditions directly threatened patient care. In order to treat their patients, nurses, residents, and APs performed varying yet interdependent tasks, while relying on ongoing interaction with each other and medical devices to coordinate their work. For example, nurses required physician approval for key adjustments to bedside treatment, while physicians could not start critical procedures without nurse input on changing patient conditions. The moment-by-moment coordination of care required to sustain life could be jeopardized as these dispersed actors developed multiple, conflicting assessments of patient realities. Bluntly, without some mutual

assessment of how to keep patients stable, patients could destabilize and die:

I'm always thinking in the back of my mind, they're in the ICU for a reason, they could potentially get sick[er]. ... These people, when they're unstable they tend to be pretty unstable, and then when it gets worse it gets a lot worse. These are the sickest patients in the hospital, so ... I always want my patients to be "stable." I don't know why, it's a good question. It's kind of hard to [explain]. It's just kind of given that that's the goal, and that is your plan in the back of your mind. —SICU Nurse

The most welcomed refrain about patients in the unit was that they were "stable." Stable patients had been assessed appropriately and dealt with competently (Faraj and Xiao 2006); their conditions were more predictable, at least "for now." **At the same time, nurses and doctors recognized that achieving complete agreement was neither possible nor desirable.** This would have taken too much time, attention, and resources, and other patients would have suffered. All understood that differing views would soon arise as patients' conditions changed, as treatment plans were implemented by distributed workers, and as new complications or symptoms set in. Ensuring that patients were stable enough for now was a critical enabler and consequence of successful coordination in this SICU. **While much of the work in the unit was focused on this result, it was the primary concern of night rounds—a well-established routine that produced the provisional settlements workers relied upon to coordinate their subsequent work.**

The production of provisional settlements within night rounds began with residents engaging in preparation work between 7 P.M. and 9 P.M. This involved gathering data on (and sometimes adjusting care for) patients to produce an assessment of their conditions that would inform discussions during night rounds. Concretely, residents prepared for night rounds through such activities as visiting the bedside; touching, listening to, and smelling patients; speaking with nurses, specialists, and patients' families; and examining charts, monitors, and electronic medical records.

Once night rounds were initiated at 9 P.M., workers drew on a repertoire of activities to reach provisional settlements about each patient's stability. As in prior work (Kaplan and Orlikowski 2013), these settlements had to be plausible (i.e., reflect participants' shared experiences), coherent (i.e., meet participants' criteria for logical integrity), and acceptable (i.e., address key participants' interests). In Hopeland's SICU, proposed settlements were *plausible* when they were based on direct experience of the patient at the bedside and over time (e.g., knowing that the patient's heart rate was fluctuating because they were struggling against a breathing tube). Plausible settlements included information that was relevant to the patient's condition (e.g., blood pressure might be ignored if the patient was agitated), and

that clarified salient issues (e.g., X-rays of a knee injury might not be taken if a patient's brain was swelling).

[A plausible account] definitely gives you a better clinical picture as to what's going on with the patient. Again, they [nurses] are going to share the subtleties that [residents] don't hear, either hard data or subtleties that the resident isn't portraying. Or they put it into perspective, so "The patient is obtunded [depressed]," "Yes, they've been that way for eight hours now, or six hours, or they were that way last night and now they're a little better." You know again, they know the whole course of living with that person. The perspective is key. —SICU AP

In the context of intensive care, *coherence* required information about the patients' conditions to be framed theoretically and contextually. As Abbott (1988) notes, such framing entails use of rich and domain-specific descriptions drawn from the knowledge system in use. In night rounds, this required participants to interpret their observations and experiences of patients in terms of the formal medical schemas, classifications, and logic that they shared. Finally, proposed settlements became *acceptable* in night rounds when the AP endorsed them, and they remained acceptable after night rounds if the patient's nurse supported them. The AP was ultimately responsible for the unit and its patients, and had the greatest combination of clinical experience and expertise in the medical knowledge system within the SICU. This combination of final responsibility and professional legitimacy meant that AP endorsement was required for settlements to be deemed acceptable during night rounds. However, such settlements only stayed acceptable if the nurses subsequently upheld them in their overnight patient care. When patient conditions changed overnight, some of the settlements reached in night rounds became implausible and would then be resisted or reworked by the nurses in practice.

APs and nurses put a premium on plausible settlements, and as a result placed great store in bedside interactions. Everyone recognized that residents were still learning, and would regularly miss important phenomena, collect inappropriate data, and draw underdeveloped conclusions. To the extent that residents gathered at least some data at the bedside, the belief was that they would notice important subtleties (often with nurses' help) and be able to offer accounts of patients' conditions in night rounds that would enable plausible provisional settlements. An AP noted the value of direct observation when talking about nurses who gained considerable knowledge of patients through being at the bedside:

They know what to do. They know how to take care of these patients. They may not know *why* but they know. They have good judgment. They know when patients are sick and when they're not sick, and that's the important thing that I need to know because in the middle of the night, I don't need to know specifics, I need to know

when somebody is getting better or they're getting worse.
 If they're getting worse then I have to come in.

—SICU AP

Once provisional settlements were reached during night rounds, they informed the coordination of overnight care subsequently delivered by the resident and nurses.

Our research examined night rounds performed through the telephone and robotic telepresence, and investigated the conditions, practices, and consequences of these different material enactments for the coordination of the work.

Performing Night Rounds Through the Telephone

Night rounds at Hopeland's SICU had been performed through the telephone for over 20 years, and involved the on-call resident talking to the AP at 9 P.M. The resident would take the AP's call on the hard-wired telephone located at the nursing station, and the two of them engaged in a discussion about each patient in the unit. During this conversation, the resident drew on his/her prerounding preparation work to offer status updates and respond to the AP's queries. These discussions resulted in provisional settlements on all patients. Such settlements then informed the subsequent coordination of work as the resident and nurses worked together

to provide overnight patient care. As detailed below and outlined in Table 2, we identified two pairs of practices that first prepared for and then performed night rounds through the telephone—regulating/calibrating and skimming/guiding.

Regulating/Calibrating. In preparing for telephone night rounds at 9 P.M., residents typically spent the preceding hour or two moving from patient room to room gathering extensive data and making small adjustments to patients' care. On these nights, residents typically asked each nurse how their patients were doing, inspected medical monitors and flowsheets, examined patients visually and physically, conversed with them (and/or their families) if possible, ordered additional tests, adjusted treatment incrementally (e.g., changing sedation or ventilator settings), and recorded brief handwritten notes. The process generally took between five and ten minutes per patient, but could take much longer if a patient was new or in a particularly acute condition. When residents prepared in this way, they were in near constant motion and conversation between 7 P.M. and the AP call at 9 P.M., visible to many within the unit.

Table 2 Activities Observed During Preparation and Night Rounds

	Regulating/ Calibrating	Skimming/ Guiding	Regulating/ Exploring	Skimming/ Bypassing
Preparing/Conducting night rounds				
Number of Rounds	14	3	9	8
Phone/Robot	Telephone	Telephone	Robot	Robot
Total patients covered	183	33	109	99
Average time/Night round	13.8 minutes	23.4 minutes	33.6 minutes	33.8 minutes
	% (freq.)	% (freq.)	% (freq.)	% (freq.)
<u>Actions (across all patients)</u>				
Talking (AP and resident only)	100% (183)	100% (33)	0%	0%
Talking (AP, resident, and nurse)	0%	0%	100% (109)	100% (99)
Reaching for and looking at flowsheets, Kardex, PC's, medical monitors (all participants)	4% (7)	3% (1)	51% (56)	42% (42)
Gesturing (e.g., pointing, nodding, directing gaze) (all participants)	0%	0%	23% (102)	31% (102)
Looking at and touching patients (all participants)	0%	0%	20% (22)	33% (33)
<u>Interactions (across all patients)</u>				
Claiming stability (substantiated) (by resident)	47% (86)	39% (13)	32% (35)	38% (38)
Accepted by AP	44% (38)	46% (6)	29% (10)	45% (17)
Claiming stability (unsubstantiated) (by resident)	18% (33)	0% (0)	8% (9)	1% (1)
Accepted by AP	85% (28)	n/a	78% (7)	100% (1)
Declaring puzzles (by all participants)	21% (39)	45% (15)	39% (42)	8% (8)
Declared by resident	79% (31)	87% (13)	74% (31)	38% (3)
Revising (by AP and nurse)	61% (112)	130% (43)	174% (190)	278% (275)
Didactic questioning (by AP)	21% (39)	48% (16)	24% (26)	77% (76)
Teaching (by AP)	37% (67)	79% (26)	41% (45)	42% (42)
Interjecting (by nurse)	3% (6)	3% (1)	109% (119)	159% (157)
Adjusting (by AP and resident)	38% (69)	91% (30)	109% (119)	85% (84)
Asserting (by AP)	16% (29)	33% (11)	58% (63)	45% (45)
Asserting (by resident)	5% (10)	6% (2)	9% (10)	2% (2)
Suggesting (by AP)	16% (30)	52% (17)	42% (46)	37% (37)

As the resident discussed and examined each patient with the patient's nurse and consulted lab results and monitors, patient conditions were collaboratively identified. This shared, copresent work at the bedside aligned the resident's and nurse's assessments of that patient's status and treatment. In addition, the resident and nurse generally agreed upon incremental adjustments to the patient's care. Such changes served to stabilize patients while eliciting diagnostically meaningful information (e.g., blood pressure improvements in response to fluid administration). This preparatory practice prior to night rounds—which we label *regulating*—allowed residents to offer substantiated claims of stability for roughly half (47%) of the patients in the SICU during the subsequent telephone interactions with the AP. **Credible, substantiated classification of patients as stable and requiring no action was evidence that a resident had attended to their patients competently.** However, as well-documented in the literature (Bosk 2003, Conrad 1988, Kellogg 2010, Zussman 1994), the ideal among residents was to make claims about patient stability without needing to offer *any* substantiation (e.g., by simply asserting “Bed 3's fine”) and for this to go unchallenged by the AP, thus signaling that the AP trusted the residents' accounts. This ideal was often difficult to achieve given patients' multiple conditions and complications and residents' relative lack of experience. Despite this, we found that during the subsequent telephone interaction with the AP, residents offered unsubstantiated accounts of stability for 18% of the patients in the SICU.

The material enactment of telephone night rounds allowed the AP and resident to hear each other's voices, while excluding the nurse and precluding any interactions with patients or monitors at the bedside. Night rounds interactions were constituted by these inclusions and exclusions, generating specific consequences (Table 3 details these for all four practice pairs in our study). Once night rounds began, the AP and resident proceeded quickly, taking an average of 13.8 minutes to reach settlements on all patients. They focused their discussion on the few patients whose conditions had not yet allowed them to be declared stable. In these cases, the AP and resident briefly spoke about the patient's symptoms and discussed any available data, but primarily discussed puzzles, raising multiple potential interpretations of complex patient cases, as in the case below where the resident refers to a nurse's question.

Resident: He did get the unit of platelets; he still has some blood, the nurse brought up a good question, given that he really doesn't need to be intubated, and the fact that he's now got blood, what's the threshold for keeping...

AP (interrupting): He's encephalopathic [has global brain dysfunction], we have to protect his...

Resident (interrupting): airway yeah...

[Field Notes, December 26, 2011]

These conversations that described and inquired into competing potential explanations for patient symptoms had the distinct flavor of a dialogue—the resident or AP would offer an explanation and they would then jointly discuss whether and how the available information supported this explanation:

If [it] requires a more subjective interpretation, [which] I guess could be the patient looks uncomfortable on these ventilator settings even though I know what the settings are. And I may ask [the resident], “Is he uncomfortable because his respiratory rate is high or is it because he's working with each breath, his respiratory rate is fine and he's coughing on the tube or whatever it is?” It could be a number of different things. —SICU AP

Such dialogue—which excluded direct sensory experience of the empirical realities to which it referred—highlighted differences in assessment that arose when multiple actors attended to similar patient realities, but produced different, often conflicting interpretations of those realities. APs particularly valued these focused discussions:

With... residents who are really on top of things, they go to the problem. They will say: Okay, the CT scan was done, and there was no collection, there is no need to do anything.” And we move on, okay? But maybe the other residents will say the stats slowly, and they'll do this with somebody [a patient] that I know by heart! —SICU AP

Furthermore, **APs generally accepted status assessments from residents who had regulated their patients.** When these residents offered completely unsubstantiated accounts of stability (as noted, on 18% of patients), APs very frequently (85% of the time) responded with silence or minimal affirmation, thus collectively producing a provisional settlement for that patient. In this practice—which we label *calibrating*—APs generally suggested few adjustments for contingencies that might arise (16% of the time). This low number reflects APs' understanding that residents would continue to spend considerable effort working with nurses at the bedside and adjusting care as needed, and they put significant stock in these residents' ability to competently and consistently resolve ongoing and emerging problems.

Enacting the regulating-calibrating pair of practices effectively settled different assessments in the short run and eased coordination difficulties overnight. **A regulating approach to preparation work ensured that the provisional settlements produced during night rounds were more likely to reflect patient realities, as well as address the issues that residents and nurses had jointly identified as most pressing.** This meant nurses generally accepted the provisional settlements that had been reached during night rounds. Furthermore, the nurses and residents who prepared through regulating maintained regular contact with each other at the bedside overnight, conferring frequently, and continuing to make ongoing adjustments to

Table 3 Practices That Performed Preparation and Night Rounds

Practices	Material enactment	Inclusions/Exclusions (for coordination)	Consequences (for coordination)
Regulating	Through copresent bedside interaction	<i>Inclusions:</i> <ul style="list-style-type: none"> Nurses, patients Bedside information as well as medical devices and records <i>Exclusions:</i> <ul style="list-style-type: none"> Resident-only access to networked PC 	<ul style="list-style-type: none"> Resident spends intensive time in the SICU Joint resident/Nurse assessment of patients Joint resident/Nurse adjustments to care
Skimming	Through medical records accessed at a distance	<i>Inclusions:</i> <ul style="list-style-type: none"> Resident-only access to networked PC <i>Exclusions:</i> <ul style="list-style-type: none"> Nurses, patients Bedside information as well as medical devices and records 	<ul style="list-style-type: none"> Resident works or rests away from the SICU Largely independent resident/Nurse assessment of patients Limited, ongoing unilateral adjustments to care by nurse
Calibrating Guiding	Through the telephone	<i>Inclusions:</i> <ul style="list-style-type: none"> Directed AP-resident discussion (audio only) Resident-only access to networked PC <i>Exclusions:</i> <ul style="list-style-type: none"> Visual cues during conversation (e.g., AP and resident body language) Nurses, patients Bedside information as well as medical devices and records Sights and sounds of the SICU 	<ul style="list-style-type: none"> Relative privacy for AP and resident Nurses do not participate or contribute Slow, difficult, resident-only access to abstract, out-of-date patient information AP relies on residents' empirical claims for diagnosis and treatment decisions AP can teach methodically and extensively Residents can ramble and ask relatively "dumb" questions Residents and AP can skip stable patients, conversations can be focused and brief AP can multitask (e.g., walk the dog)
Exploring Bypassing	Through robotic telepresence	<i>Inclusions:</i> <ul style="list-style-type: none"> AP and resident movement around the SICU to each patient room Nurses, patients Verbal and visual information from people, spaces, technologies in SICU Bedside information as well as medical devices and records <i>Exclusions:</i> <ul style="list-style-type: none"> Directed AP-resident discussions Resident-only access to networked PC 	<ul style="list-style-type: none"> Very little privacy for AP and resident Nurses participate and contribute Rapid, easy, multiparty access to diverse sources of up-to-date patient information All parties can corroborate empirical claims to diagnose puzzling/emergent symptoms Residents almost never ramble or ask "dumb" questions Resident and AP do not skip stable patients, extensive discussions take much time AP can teach publicly albeit briefly AP cannot multitask

patient care. Nurses saw such residents as both helpful and flexible as a result:

If I'm stuck in my [patient] room, I don't have time to come up and tell you what's going on with my patient. A good resident will always come back and follow up and figure out, "did this work, if not let's do something else." They're there. . . . They're working on that patient to figure out what medicine, or what algorithm will work for this particular patient. —SICU Nurse

Additionally, the provisional settlements produced during the calibrating practice were less complex and better understood, allowing the residents to treat them as genuinely provisional when they returned to work. Such an approach better matched nurses' orientations to care, thus enabling their coordinated work overnight:

The patient is changing quite frequently . . . at night, part of their whole circadian rhythm and everything. Fevers

happen at night, people deoxygenate at night, people sun-down [become confused, agitated] at night. There's a lot of things that happen to the body specific to the night shift that kind of like, you know, peak during the night.

—SICU Nurse

Residents involved in enactments of the regulating practice proactively addressed issues collaboratively with nurses as they arose overnight. Nurses put a premium on these frequent adjustments:

We can be [working] for 24 hours, basic stuff moving people forward, and I find that at night, some of these grind to a halt and that depends on the resident. There are residents who are very proactive and they're making vent changes and weaning people and there are others that just let people coast for 12 hours. That doesn't help the patient.

—SICU Nurse

The material enactment of residents' and nurses' joint overnight work facilitated coordination similarly to the

regulating activities they had performed before night rounds: making adjustments collaboratively at the bedside aligned their assessments of patients' conditions. This significantly eased coordination efforts in their overnight work at the bedside, with important implications for patient care.

Skimming/Guiding. For some night rounds performed through the telephone, residents engaged in little preparation. In these cases, residents were rarely present in the unit before and after night rounds. On these nights, the most common response by nurses to "Where's the resident?" was a shrug. To prepare for night rounds, these residents gathered information on patients by consulting the electronic medical records via a PC in the break room and referring to experiences they had had earlier in the day. As they did so, they made handwritten notes on a small piece of paper, which typically followed the layout of the Kardex and flowsheet. **The material enactment of this preparation practice—which we label *skimming*—omitted the bedside observations and patient adjustments performed during regulating.** Such exclusions strongly influenced the subsequent performance of telephone night rounds.

During the telephone night rounds that followed the skimming practice, residents tended to offer accounts that rigidly adhered to a Kardex-style protocol, overreporting irrelevant detail, and underreporting important distinctions. These conversations focused on puzzles with some frequency (for 45% of patients) but unlike those in calibrating, these tended to be more urgent or ambiguous problems that residents needed help with. Notably, residents never offered unsubstantiated accounts of patient stability during their telephone discussions. The performance of night rounds through the hard-wired telephone on the desk made it possible for these residents to speak one-on-one with the AP, while limiting their ability to move around the unit and observe at the patient bedside. Given that these night rounds followed and relied upon the distanced and somewhat disengaged skimming practice, residents' accounts of patients' conditions were often neither plausible nor particularly coherent, and thus unacceptable to the AP. As the telephone interactions also excluded the AP's access to patients or medical records, the AP had to verbally prompt these residents to generate accounts that might produce provisional settlements:

AP: Yeah, [night rounds are] routine, unless—unless you get the sense that the resident is missing something.

Interviewer: Okay, and how [do you sense this?]

AP: Well, you can—you can sense that simply from what they tell you: "Well, Mrs. Jones is now on, she is on 5 of Neo [-Synephrine, blood pressure boosting drug]" and I said, "Now wait a second, she was only on one of Neo when I left at 6 o'clock, why she is on 5 of Neo?" "Well I don't know." "Did you check on the hematocrit [red blood cell count]?" "Well, yeah, the hematocrit is

down 5 points." I said, "Well it sounds like maybe they need blood rather than more Neo." So there's, it obviously takes a bit of experience to be able to tease out when somebody doesn't realize that they're in the weeds.

—SICU AP

In this response, the AP modeled the form of didactic questioning used to elicit additional patient information, compare it to prior conditions, and generate a more coherent account through the exercise of guided logic. As part of revising these residents' accounts, APs also engaged in teaching, which added explanatory power to the emerging assessment by reducing conceptual complexity:

AP: I would probably not chase him [on fluid balance], he's supposedly diabetic. I would try to give him a small bolus [injection]. I would give him diuretics, [but] especially with diabetic patients there is increasing evidence that they don't do well on [inaudible drug].

Resident: So if he needs fluids, should we do Albumin [protein solution]?

AP: No, if he needs something, give him crystalloid [saline], but I would not chase it, and he probably won't improve. Overall they have worse outcomes.

[Field Notes, March 10, 2011]

In contrast to the calibrating practice, this practice—which we label *guiding*—highlighted differences in assessment that arose when different actors had attended to different aspects of patients' realities yet could not immediately corroborate their views empirically. Unsurprisingly, the material enactment of the skimming practice which excluded bedside observations led residents and APs to focus on different facts on the ground during night rounds. In order to offer a sound baseline for guidance without access to the SICU or medical records, the APs thus devoted much energy in these night rounds to verbally eliciting and assembling a necessarily abstract but acceptable picture of patients' conditions.

Finally, as part of the guiding practice, the AP generally outlined potential clinical contingencies and described possible responses to these contingencies (as in the AP's suggestion above to give the patient crystalloid). Such recommending of possible clinical adjustments further helped to manage differences in assessments. The probing nature of the guiding practice is more evident when contrasted with the calibrating practice. During guiding, APs revised residents' accounts through the telephone more than twice as often as they did in calibrating (1.3 times/patient versus 0.61 times/patient), engaged in teaching more than twice as often (0.79 versus 0.37 times/patient), and they proposed contingent adjustments to treatment plans more than three times as often (0.52 versus 0.16 times/patient). As a result, night rounds that entailed guiding took nearly twice as long on average than calibrating (23.4 minutes versus 13.8).

The material enactment of the guiding practice substantially limited empirical corroboration and thus occasionally produced provisional settlements that misrepresented the situation on the ground:

It depends on how they [the resident] understand what is happening to the patient. They may not understand the underlying physiology and they may not report what is happening because they don't consider it significant. If I don't have [the] information, I can't interfere. So it depends how they view the patient, how they analyze the situation and then how they present the situation. So, unless I ask in detail about all [bodily] systems, I wouldn't figure [it] out and I would maybe miss [something].
—SICU AP

This AP highlights how less coherent assessments can contribute to incomplete views of patient realities, which may produce misinformed provisional settlements. This can easily arise during the guiding practice given that its material enactment excludes direct access to patients by the resident and AP. This happened, for example, when a resident did not detect a patient problem during skimming; this was not uncovered through the AP's questioning during night rounds, and the AP participated in erroneously settling on the patient as stable when this was not consistent with the patient's condition.

While the guiding practice produced acceptable settlements that allowed for coordinated action, these were often less plausible and less coherent than they should have been, leaving potentially relevant patient realities unaddressed. The residents' remote skimming activity greatly limited their access to—and influence on—patients' changing conditions (e.g., responses to medication), and did little to address differences between their and nurses' interpretations of patient status. As a result, the provisional settlements reached during the guiding practice generally managed to tackle only gross assessment differences regarding empirical realities, and risked overlooking issues during night rounds that had been missed or omitted by the residents during their preparation.

Even as the material enactment of skimming and guiding practices served to settle differences in assessment during night rounds, they often contributed—paradoxically—to assessment differences with nurses as the residents returned to performing overnight care. Given the residents' skimming preparation work, the clinical adjustments made during night rounds often did not reflect nurses' assessments of patients. When nurses found the provisional settlements reached during the guiding practice to be incoherent or implausible, they resisted or modified them in their overnight work in the SICU:

[Resident says the plan is to stop a given drug]

Nurse: So you want to dc [discontinue] it?

Resident: Yeah.

Nurse: Yeah, so we're going to have to wean it, because that drug you can't just drop it down, (pause) you can't just drop it (pause). We just don't titrate [quickly drop] that drug.

Resident: All right.

[Field Notes, December 15, 2011]

On nights when they had prepared through a skimming practice, residents' overnight activity was very similar to their preparation work. They spent minimal time at the bedside, gathering relatively little information that might lead them to reinterpret their patients' dynamic situations, thus limiting the plausibility and coherence of their assessments as the night progressed. This material enactment of overnight work also restricted their ability to make adjustments in care that would stabilize patients:

You have people [residents] who are knowledgeable and proactive, you have people who are frightened and can't do anything in a crisis. You have people who push off every single decision, no matter how trivial or big to the morning. It's very frustrating. You're in a very dangerous spot. You want a high quality resident who's decisive and knowledgeable, and doesn't wander off, and doesn't fall asleep for 6 hours.
—SICU Nurse

Working at the bedside on these nights led the nurses to compensate for these residents' relative lack of effective overnight action by making clinical adjustments on their own:

I will—I probably shouldn't even say this out loud—implement an order, then call them [the resident] later: "Listen, this is what we've done, this is what we had to do." You know, because, you know, this is what we had to do to keep this patient [alive].
—SICU Nurse

The material enactment of bedside work—touching, smelling, and looking at patients, changing dressings, checking monitors, administering medication, and capturing vitals—meant that nurses continued to gather information and adjust treatment to stabilize their patients in the face of complex and dynamic situations. These ongoing adjustments amplified assessment differences between nurses and the largely-absent residents even more, further hampering their coordination of overnight patient care.

Performing Night Rounds Through Robotic Telepresence

The performance of night rounds through robotic telepresence began at Hopeland's SICU in 2008 with the leasing of the RP-7 robotic system. To initiate robotic night rounds, the AP connected remotely to the RP-7 at 9 P.M., and the on-call resident moved to stand in front of it. The AP then navigated the RP-7 to each patient room in turn, discussing each patient with the resident and the patient's nurse. The resident, AP, and nurse drew on immediate bedside observation and any

prerounding preparation to offer updates and respond to each other's queries, resulting in provisional settlements for each patient. These settlements then informed subsequent coordination as the resident and nurse worked together to provide overnight care to the patients. As we discuss below (and as indicated in Table 2), we found that two pairs of practices prepared for and then performed night rounds through robotic telepresence—regulating/exploring and skimming/bypassing.

Regulating/Exploring. As evident before the performance of night rounds through the telephone, residents sometimes prepared assiduously in the hours before their 9 P.M. robotic night rounds. They moved visibly around the unit, stopping at each patient's bedside, and working with nurses to collaboratively make adjustments related to their copresent experience of patient phenomena such as temperature spikes, skin pallor, blood gas levels, and mood. During these stabilizing interactions, these residents made short, handwritten notes on each patient. As before, the material enactment of this preparatory practice of *regulating* reduced differences in assessment about what aspects of patients' dynamic situations were relevant, while also producing multiple competing explanations for their conditions (e.g., a fever could be due to sepsis or another serious but quite different infection).

In the subsequent performance of robotic night rounds, the resident and the AP (piloting the RP-7) moved to each patient's room. They engaged in extensive interactions with the nurse, the patient, the medical monitors, and other aspects of bedside reality, taking an average of 33.6 minutes to reach settlements on all patients. In this practice, the AP, nurses, and resident all had real-time access to each other, the patients and the SICU. Beyond allowing them to converse publicly, the material enactment of this practice allowed for a range of actions and interactions (Table 4 offers some specific examples).

During night rounds, the resident, AP, and nurse periodically focused on puzzling clinical patterns (for 39% of patients), as in the following instance:

AP (moves RP-7 into patient room): Where is his monitor? If you can step back.
Resident: Definitely no quas (pointing to monitor).
AP: Okay if you can step to side, I will look at the monitor (turns RP-7 head toward screen) (resident had already turned the screen toward the RP-7). You know, it looks irregular, and...
Resident (interrupting): exactly
AP: ...and you have sinus or afib [irregular heart beat]?
R: So you think chelate?
AP (still looking at screen): This is definitely sinus. I would try to give him low pressor [blood pressure boosting drug], okay?
R: I see p waves there (pointing to screen).
[Field Notes, March 27, 2012]

Table 4 Performing Night Rounds Through Robotic Telepresence

Example	Details from field notes
Directing vision in the space	AP: Do you have it [heart catheter]? R: It's in her room, I think (<i>goes and gets it</i>). R: Yeah, so I don't know if you can see it (<i>shows</i>), at the end there was this yellow piece...
Uncoupling work activities	N (responding to resident's question): Yes, since this morning. R: Yes, let's give her 10mg. (<i>AP moves RP-7 to next room, resident stays behind to confer with nurse about order</i>)
Communicating by gesture	AP: No, don't give him a bolus (<i>nurse hand signaling to other nurse</i>) N: [The other nurse] was asking whether to mix fluids. (<i>AP drives RP-7 to next patient room</i>)
Noting and resolving an emergent issue	AP (to nurse): How are you doing? N: Good to see you. AP: Good to see you too. (<i>AP turns the RP-7 to view the patient</i>) AP (under breath): Oh my god. AP: <i>She's going to fall, guys—from the bed!</i> R: Okay. AP: <i>She's trying to get out of bed, this woman.</i> R (to patient): Stay in bed, we're going to try to help you. (<i>AP drives RP-7 forward to look at patient. Then turns RP-7 to view vitals on the medical monitor</i>)
Checking adjustments to care	N: He's been breathing over the vent settings. AP: I can check all the [air] volumes now, guys (<i>nurse laughs nervously</i>).
Shifting to caregiving and supervision	R: So room 8 is becoming more agonal in her breathing pattern, and I'm going to intubate her. AP: Do you need to take care of that right now and deal with this later? (<i>Resident goes to room 8 to check, then calls neurosurgery. AP drives the RP-7 to room 8 to observe the patient, and then watches the resident intubate the patient with the help of three nurses</i>)

APs, nurses, and residents engaged with such puzzles by sharing their views about the patient's conditions, asking each other questions, looking and gesturing at the patient, and glancing at the flowsheet, electronic medical records (on a PC), and medical monitors. They took rapid and frequent turns in conversation, offering multiple, alternative perspectives on the patient's situation (e.g., all agree that a patient is disoriented, and discuss possible explanations such as dementia, blood sugar levels, and swelling in the brain, pointing at various monitors in the process). While engaging in this collective interaction—a practice we label *exploring*—the AP, nurses, and the resident frequently discussed potential contingencies and made short- and longer-term adjustments:

If I gave a piece of information [during robotic night rounds], it's something that both of them [resident and

AP] can chew on and then say, “Yeah, let’s give that a try tonight” or “No, put that off until tomorrow.” Incremental changes that might help, not big stuff. Sometimes we lose a lot of ground overnight. There are things that we could be doing to move the patients along incrementally overnight that shouldn’t wait 12 or 14 hours. If you’ve got them both right there, it’s a real quick question; if you’ve got a tube feed or a vent change, or getting certain treatment started, a bowel regimen, you might get what you need right away.
—SICU Nurse

The AP and resident made more adjustments to plans of care (1.09 times per patient) during exploring than in any of the other practices that performed night rounds. As the exploring practice engaged the participants in bedside interactions, it was far more difficult for residents to appear competent via unsubstantiated accounts of stability. The nurse and AP each had an order of magnitude more clinical experience than the resident, and the material enactment of night rounds through the robot allowed everyone real-time visual and auditory access to each other and the patients’ environment. Subtleties were detected, questions were raised, and accounts of patients’ stability were routinely and collaboratively revised in free flowing, rapid dialogue involving gestures and visual consultation (1.74 times per patient).

Not surprisingly then, residents offered fewer substantiated (for 32% of patients) and unsubstantiated (for 8% of patients) accounts of stability during exploring (through robotic telepresence) as were offered during calibrating (through the telephone). Indeed, the AP accepted claims of stability only 29% of the time in this exploring practice (in contrast with 44% of the time during calibrating). Instead of offering accounts of stability, residents proactively facilitated the exploration of puzzles:

I think that generally I found that when the robot was used, I had more opportunity, or the nurses had more opportunity to kind of give some feedback as to what they thought what was going on with the patient, whereas when the robot wasn’t in use, that wasn’t really an option for them.
—Resident

[These residents] are bringing up possibilities [on the robot], where[as] on the phone they’re being asked less because they have given them [the AP] all the information they need. They’re prepared [on the telephone], whereas there’s a dialogue going on with the robot, things might be coming at them, they say “Well what happens if we go down this route, like what to do?”

—SICU Nurse

Given the premium that APs (and nurses) placed on direct bedside observation and interaction with patients’ empirical realities, they readily engaged in dialogue and empirical investigation that provided an opportunity to account more extensively for patient realities and possibilities. In the midst of producing provisional settlements, however, exploring puzzles temporarily increased

assessment differences. As a result, the plausibility and coherence of a proposed settlement were repeatedly challenged (by all parties) as new interpretations were sought:

Resident: Essentially his liver enzymes are high, and have fallen to 26 in 2.5 hours.

AP (zooms in on chart): and platelet count is 65 and half?

Resident: Yes, is he on heparin (turns head to nurse)?

Nurse: Yes, he is.

AP: I would stop that, guys.

Resident: Stop that?

AP: It’s probably consumption, what about platelet consumption, and Nancy [nurse], how are we with [inaudible]?

Nurse: It’s 22.

AP: What about fluid balance for him?

Nurse: 7 liters.

AP: So it’s probably dilution.

[Field Notes, March 27, 2012]

Exchanges such as this one revised residents’ accounts by making them more plausible (e.g., “is he on heparin?”) and coherent (e.g., “it’s probably dilution”). In order to explore puzzles, the resident, nurse, and AP interacted rapidly with each other, taking regular turns in conversation through frequent reference to their shared physical environment. Nurses interjected (1.09 times per patient), and these interjections generally supplemented residents’ accounts. This focus on joint exploration led to the highest frequency of direct assertions regarding clinical care (“I would stop that, guys”) in any of the practices performing night rounds (for 67% of patients), and residents made more of these (for 9% of patients) than in the calibrating practice (for 5% of patients). The increase in adjustments was facilitated by the presence at the bedside of all the participants (residents, nurses, and APs), which allowed any of them to easily challenge the coherence and especially plausibility of a given clinical adjustment:

Had a patient last night on the phone, and the data was “Pulmonary came by, and wants to intubate the patient.” so my question was “who is making this recommendation?” So I went back and forth with the resident and I said “Does he look clinically different than he did with us?” “No.” And the final thing I said to him was “You’re going to decide, because you’re there looking at him.” If I had the robot, I would be looking at [the patient] and might not let the resident [decide]. I might just say “he’s the same, leave him alone.” Whereas I’ve got to put more trust in the residents’ decision on the phone.

—SICU AP

The material enactment of regulating and exploring practices produced provisional settlements that provided plausible and coherent directions to residents and nurses in their coordination of care overnight. These directions gave a common reference point that was well understood by both residents and nurses. Not surprisingly,

nurses typically accepted settlements reached in exploring. These settlements also addressed many potential clinical contingencies, and such anticipatory directions eased coordination overnight in much the same way as with the calibrating practice. However, given that robotic interactions in the exploring practice allowed all participants simultaneous and direct access to each other and bedside realities, provisional settlements facilitated coordination even more than in the calibrating practice:

I think [robotic night rounds] provided the opportunity to ask more directed questions, and I found it saved on pages [calls requested by nurses] later on in the evening. If there was a question that they [nurses] weren't really satisfied with the answer that I gave them [during night rounds], I could at least throw it back to the AP with the robot and let the AP kind of give their feedback, and that would be kind of an end-game and they wouldn't keep asking the same question. —Resident

After enacting the exploring practice, residents and nurses managed differences in assessment together overnight, making reference to the provisional settlements produced with the AP at the patient bedside. Given the extensive adjusting during exploring, overnight assessment differences were both preemptively reduced and accounted for by the provisional settlements reached during night rounds.

[Night rounds performed through exploring] are more collaborative... You'll get kind of like your evening and nighttime overnight plan at that point. —SICU Nurse

The provisional settlements reached during the exploring practice meant that residents and nurses could be even more attentive and responsive to fewer patient changes overnight as they drew upon and revised the provisional settlements that informed their coordinated efforts to deliver patient care.

Skimming/Bypassing. As with night rounds performed through the telephone, we found that residents sometimes engaged in little preparation for robotic night rounds. On these nights, residents did not visit the bedside between 7 P.M. and 9 P.M. Instead, they consulted patients' electronic records via a remote PC and referenced experiences they had had earlier in the day, noting these items on a single sheet of paper. As before, this distanced and disengaged preparatory practice of *skimming* meant residents struggled to select and interpret information in ways that were consistent with the medical canon. They therefore offered fewer accounts that the AP and nurse deemed plausible and coherent in the subsequent robotic night rounds conducted at the bedside.

In performing night rounds, the resident and AP (piloting the RP-7) moved to each patient's room, interacted with the patient's nurse as they examined the patient and glanced at medical devices, records, and monitors. During these discussions, nurses interjected their views, responded to direct questions, and answered questions

that the AP had intended for the resident—pointing and looking at the patient, medical records, and medical monitors in the process. As this occurred, the AP and nurse increasingly conversed only with each other, directly interacting with the patient and bedside realities. We label this practice *bypassing*, to indicate how peripheral the residents became in these bedside interactions.

Presenting their assessments of multiple patients was challenging enough for these residents. Doing so in front of practitioners with considerable experience (one of whom happened to be their manager) and in the presence of the living, breathing phenomenon on which they were reporting, was overwhelming:

It sounds initially like it [the RP-7] should be a good thing, but there's good and bad with that. We sort of have a plan, we basically need to brush up on the few things that have to change, small updates, if there's anything that's really especially important to hone in on that, and kind of keep the conversation directed. It's a lot harder to do that when the robot is sort of inviting the contributions of other people. —Resident

Paradoxically, residents offered substantiated accounts of patient stability with similar frequency (for 38% of patients) in bypassing than they did on the telephone in the guiding practice (for 39% of patients). Telephone interactions with the AP materially enacted a degree of privacy that allowed residents to ask “dumb” questions, seek help, and offer more lengthy and tentative accounts. Interactions via the RP-7, by contrast, enacted a more public exposition where the resident was required to offer accounts in front of nurses and patients, as well as the AP. Despite the risk of public correction, residents who had prepared through skimming presented their cases more firmly during robotic night rounds than they had during telephone night rounds. Their accounts stuck even more rigidly to a Kardex-style protocol, reporting excessive detail, underreporting important distinctions and raising less than half as many puzzles (38% of all puzzles) as in guiding (87% of all puzzles). This “keep calm and carry on” approach in bypassing was quite visible as residents' default gaze was at their handwritten notes about their patients. An AP noted the following:

Some residents...they round and they have a list and they read it to me. “The blood pressure is stable, the heart...” I presume it is stable, you know? I don't need to have it repeated to me. I like to be informed about the changes, and they feel that they are obliged to tell me, “We are still on full support, blood pressure is stable, it's ranging 130/60...” If you say they're hemodynamically stable, it's enough, move on. But they will read me the numbers, you know. And only on the robot.

—SICU AP

Synchronous, shared interactions at the bedside allowed nurses and APs to work around residents' minimal preparation to provisionally settle on patients as

stable. Given that residents' accounts often lacked plausibility, the nurse and AP devoted extra effort and time to make these more plausible. Nurses frequently added new or contradictory information, and APs and nurses exchanged and sought information directly (e.g., looking at the patient and/or medical monitors) on complex patient conditions. Through this process, they actively and repeatedly revised residents' accounts (2.78 times per patient):

Resident: Mr. X, he hasn't gotten two units of blood, vaso is 0.04, 12 and three or five...he hasn't gotten [a] unit of blood...

Nurse (interjecting): Yes, he's gotten all [the] blood.

AP (turning RP-7 head toward nurse): Doug, is he still peeing so much?

Nurse: No, it's definitely tapering down. Chi [specialist] came by: in the last hour he [the patient] almost got more CBI [bladder irrigation] than urine.

AP: And did he [the specialist] contact urology?

Nurse: He said no CT [scan], he may embolize (resident moves closer to RP-7).

AP: So this is very suspicious, why is he...?

Nurse: Yeah.

AP: You don't need 10-12 units of blood.

Nurse: Right.

AP: Do you think we can wean him off dopamine?

Nurse: I did, I did what Mario [specialist] did.

AP: It should be more vasodilating.

Nurse: He [the specialist] likes the blood and whites [immune blood cell count] is important.

Resident: Yeah [inaudible].

[Field Notes, March 8, 2012]

As the residents had prepared remotely, they struggled to make reports more plausible or coherent in these discussions, and made very few assertions (for 2% of patients). Residents thus became somewhat irrelevant to the production of provisional settlements in the bypassing practice. **While reducing assessment differences between the nurse and AP, the material enactment of this practice increased assessment differences between the resident and the AP/nurse.** As the nurse and AP's interactive and iterative revising of accounts made settlements more plausible and coherent, the AP asserted frequent changes (for 45% of patients) to patients' care. Thus for different reasons, enactments of bypassing took approximately the same time as enactments of exploring (33.8 versus 33.6 minutes).

When residents and nurses returned to work after the performance of night rounds, they had a shared list of clinical adjustments to make overnight, but the residents often had limited understanding of what these adjustments would do and why they might work. Even though the AP's, residents, and nurses had simultaneous visual and auditory access to each other and patients through robotic telepresence, the material enactment of the bypassing practice largely excluded the resident from

producing provisional settlements. In contrast, the guiding practice performed through the telephone gave residents more opportunity to participate in producing provisional settlements through the probing and teaching activities of the AP:

I definitely felt... less comfortable with everything after using the robot then after using the phone. There's just too much going on. The conversations were... less effective; they got to key issues less frequently than the phone conversations did.
—Resident

Given their lack of understanding of the provisional settlements produced during bypassing, residents clung rigidly to them in their subsequent overnight work:

A lot of times if you make a plan or give a theory to a resident, they will accept that as dictum: "This is the way we do it, this is what we're going to do, we're sticking to this plan." Whereas the nurses, it's like "it usually works this way, but if anything changes, you have to shift gears." So if [nurses were] listening to the conversation, they'd have a much better perspective as to what the plan is and how important it truly is if things change. In medicine in general, that's a huge thing, when you tell them what you're thinking as far as doing and you tell them why, it makes a huge difference in the care or in their buy in, versus "I'm not doing that" or worse, you get compliance without understanding.
—SICU AP

As nurses had participated directly in producing and adjusting the provisional settlements reached on patients during bypassing, they accepted them more readily. This served to reduce differences in assessments to a degree, but residents' general lack of bedside presence overnight served to exacerbate these differences as did nurses' resistance to and deviation from residents' directives when these failed to account for changing patient conditions. And because provisional settlements had been reached via the more public robotic telepresence discussions, nurses were able to compel residents to adhere to them:

They can't have this lackadaisical demeanor about them where, "All right, everything seems okay, I'm going to go either grab a bite to eat or I'm going to maybe try to catch a few winks of sleep," where [on the robot] it's like: "No. You have a very... important and even very powerful role right now and we're going to hold you to it."
—SICU Nurse

Enacting the skimming/bypassing practice pair thus created unique coordination challenges related to assessment differences overnight. Residents' minimal and distanced preparation in the skimming practice severely limited access to and influence on patients' conditions, and did very little to address differences between their and nurses' interpretations of these conditions. The bypassing practice of performing night rounds resolved more of these differences than had been achieved through the telephone. However, this was accomplished

at the expense of residents' understanding of the provisional settlements reached, thus exacerbating differences in interpretations among residents and nurses, and increasing coordination challenges overnight as residents exhibited "settlement rigidity" as the night progressed.

Discussion

Our research question focused on how distributed knowledge work is coordinated through specific technologies, and with what consequences. Our findings show that coordination effectiveness in such work is critically related to how interconnected practices are materially enacted over time. In particular, we find that performing night rounds through robotic telepresence intensifies coordination outcomes both positively and negatively, resulting in contrary implications for coordinating future work. We further find that intensification differences depend on whether preparatory work is done at or away from the bedside. To explain our findings, we developed a grounded, temporal understanding of the conditions and practices through which different technologies make a difference in coordinating distributed knowledge work.

We drew on a practice lens to study the materialization of night rounds through two technologies. We identified four practice pairs that performed night rounds through the telephone and robotic telepresence. Analyzing differences in the material enactment of these interconnected practices, we observed that they included/excluded different information, individuals, and interactions in achieving provisional settlements, making a substantial difference to subsequent coordination effectiveness (see Figure 1). Our study offers a number of insights and contributions to the literature on coordinating distributed work through technology.

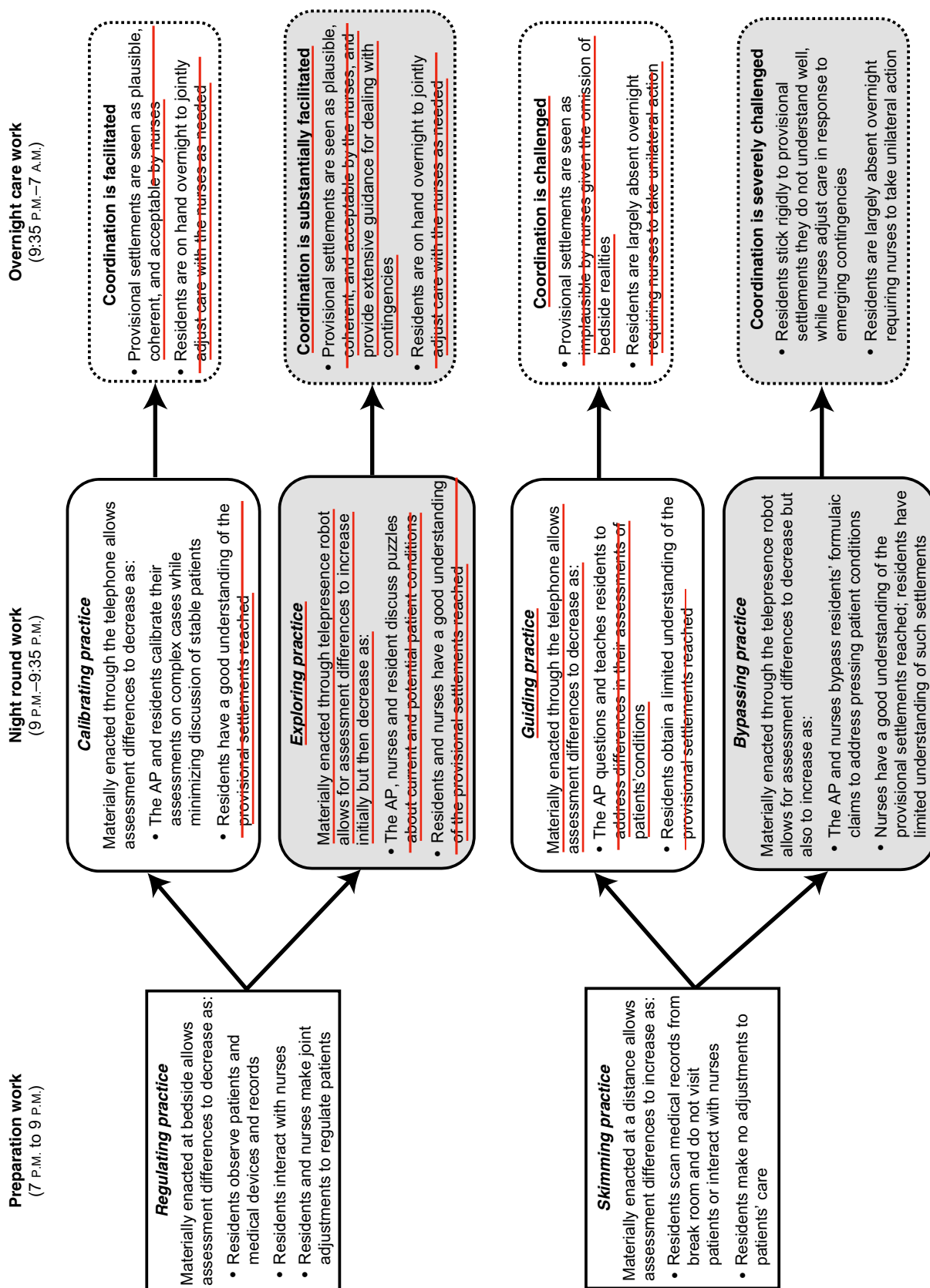
We found that conceptualizing coordination as materially enacted in practice is a particularly useful lens for understanding how distributed work is coordinated. This perspective contrasts with the existing literature that has emphasized distinct properties of technologies and examined how these influence coordination in different contexts and uses. Such studies have focused attention on either technological properties or patterns of use, and found coordination to be either enabled or constrained. We argue that viewing technologies (e.g., email, telephone, telepresence robot) as separate from and affording or mediating work overlooks how these are performed together. We thus examine the different ways that coordination is materialized through specific technologies. And as we saw in our study, the different ways in which the night rounds practice was materially enacted through different technologies made a significant difference to coordination. Focusing on material enactments drew our attention to specific inclusions and exclusions, and their constitutive consequences in practice.

Conducting night rounds through a hard-wired, centrally located telephone meant that only the AP and resident participated in key interactions, with the nurses, medical devices, medical records, and patients being essentially excluded. Two different pairs of consecutive, interconnected practices performed night rounds through the telephone. The regulating-calibrating practice pair allowed for focused verbal troubleshooting on a few patients while accepting most claims of stability. This facilitated coordination as it produced settlements that residents understood and nurses accepted, and that both relied on as they worked at the bedside overnight. The skimming-guiding practice pair involved more discussion of more patients and required APs to teach extensively. The incompleteness of these discussions challenged later coordination as residents did not well understand the settlements reached, the settlements typically did not reflect patient realities or nurse assessments, and settlements were often resisted by nurses who had limited opportunity to interact with the largely absent residents overnight.

Performing night rounds through robotic telepresence included a range of different phenomena—interactions among the AP, resident, and nurses; movement in the SICU; scrutiny of medical monitors, devices, and records; and observations of patients and other bedside realities—while excluding directed discussions between the AP and resident. As with the telephone, these inclusions/exclusions mattered for coordinating overnight care. Two pairs of consecutive practices performed night rounds through robotic telepresence. The regulating-exploring practice pair initially increased but then markedly decreased differences in assessments of patients' conditions. This facilitated overnight coordination substantially as it produced settlements that addressed current and possible patient conditions, and residents and nurses understood, accepted, and held these lightly as they worked together at the bedside overnight. In the skimming-bypassing practice pair, differences in assessments of patients' conditions decreased as the AP and nurse interacted but increased as the resident was left out of these discussions. Overnight coordination was severely challenged as residents did not well understand the provisional settlements reached, held to them rigidly, and engaged little with nurses at the bedside.

We further found that performing night rounds through robotic telepresence intensifies coordination, both positively and negatively. After a preparatory practice of regulating, night rounds enacted through the telephone facilitated overnight coordination, whereas those enacted through robotic telepresence did so to a far greater degree. In turn, after a preparatory practice of skimming, night rounds enacted through the telephone challenged overnight coordination, whereas those enacted through

Figure 1 Coordinating Night Rounds Through Interconnected Practices Over Time



Note. Shadowed boxes show enactments through robotic telepresence.

robotic telepresence severely challenged such coordination. Explaining this intensification in outcomes requires understanding the material enactment of night rounds. In robotic night rounds, the inclusion of bedside information, physical artifacts, nurses and patients served to reconfigure the kinds of actions and interactions that were possible. More specifically, these inclusions revealed how preparation for night rounds had been materially enacted. When preparation included direct engagement at the bedside including discussion with nurses and regulation of patients, robotic night rounds entailed an informed exploration of puzzles by all participants. When preparation was performed at a distance by skimming records and not examining patients or consulting nurses, robotic night rounds entailed bypassing residents' formulaic reports. The collective exploring of puzzles or bypassing of residents was not possible when night rounds were performed through the telephone as the AP could only talk to the resident and had no direct access to nurses or bedside realities.

Our study highlights how significantly preparatory practices shape subsequent coordination. We found that different material enactments of preparatory work contributed crucially to the performance of night rounds and the effectiveness of overnight coordination. Previous research on coordinating distributed knowledge work has not emphasized the salience of preparation, yet collaborative work relies on prior activities. We found that preparation in the form of careful, collaborative, and co-present engagement at the site of work was a key practice for addressing divergent assessments and preemptively intervening in the phenomenon at hand. As we saw in the calibrating and exploring practices, the performance of the prior regulating preparatory practice—materially enacted at the bedside with nurses, patients, medical devices, and involving adjustments to patient care—made residents' subsequent accounts more plausible and coherent. These helped to produce provisional settlements that were more acceptable to the nurses, thus facilitating coordination overnight. In contrast, as we found in the guiding and bypassing practices, performance of the prior skimming preparatory practice—materially enacted away from the site of work and excluding nurses, patients, medical devices, and adjustments to patient care—limited the plausibility and coherence of residents' subsequent accounts. These produced provisional settlements that impeded subsequent coordination as nurses felt compelled to make overnight interventions unilaterally to stabilize their patients' dynamic and complex conditions.

Our research suggests that provisional settlements can be an important mechanism in facilitating coordination. The literature has not much focused on this role for provisional settlements. One exception is the Kellogg et al. (2006) study of advertising work that showed how disagreements were periodically and temporarily suspended

in favor of provisional agreements that allowed coordinated action to keep time-critical projects on track. We similarly find that producing provisional settlements served as a valuable mechanism for participants to temporarily settle on patients' conditions and treatments so as to ease the coordination of overnight care. However, the Kellogg et al. (2006) study as well as others examining provisional settlements were situated in contexts where authority and accountability are uncertain, jurisdictional boundaries are contested, and actors are embedded in multiple occupations that do not share a common knowledge system. In contrast, our study of medical workers found provisional settlements to be particularly valuable even in conditions of low uncertainty about decision-making authority and accountability and a shared knowledge system (Abbott 1988, Freedson 1988). Furthermore, although prior literature has found provisional settlements to be infrequent and hard-won, we found such settlements to be frequent and routine. Indeed, the ongoing production of provisional settlements to coordinate work was crucial given that post-surgical patient care was a moment-to-moment, complex, and dynamic process. It thus required multiple, recurrent provisional settlements to achieve and maintain patient stability, while moving coordinated care forward.

We also found that provisional settlements are not equally provisional for everyone. On nights when residents prepared through the skimming practice, they held more tightly to the provisional settlements reached during night rounds than on nights when they prepared through the regulating practice. Skimming greatly limited residents' capacity to notice and understand subtle changes in patients' multiple, dynamic conditions, whereas regulating extended the capacity to notice and understand these changes with reference to the knowledge system in use. Also, residents who prepared through regulating spent discretionary time working with nurses at the bedside on problems and puzzles, while making proactive adjustments to care. Such activities improved and updated their assessments of patient conditions. These differences in preparation help to explain the varying settlement rigidity we found in our study. Settlement rigidity is problematic as it contributes to misunderstandings that can hamper the coordination of collective work. Thus paradoxically, even as reaching provisional settlements decreased differences in assessments, it increased them as workers who had enacted a skimming practice clung rigidly to those settlements in later activities, with problematic consequences for overnight coordination.

Implications

Our research offers a number of important implications for further study. First, rather than treating different technologies (such as the telephone or robotic

telepresence) as separate tools for or mediating influences on the coordination of distributed knowledge work, we articulate the value of seeing coordination as materially enacted in practice. In our study, the enactment of the practice pairs—regulating-calibrating, skimming-guiding, regulating-exploring, and skimming-bypassing—was materialized through the multiple participants, objects, devices, monitors, spaces, documents, and bodies that accomplished the work of intensive care in the SICU. Studying the coordination of distributed knowledge work without examining ongoing material practice excludes critical constitutive aspects of how that work is done. As we have shown, performing distributed knowledge work through the telephone or robotic telepresence makes a consequential difference to coordination. This highlights how existing research, by overlooking the materialization of practices, limits its capacity to understand effective coordination. Furthermore, to the extent that technologies are becoming increasingly central to the performance of distributed knowledge work, such an oversight limits the explanatory power of future studies.

Second, by emphasizing the constitutive role of materiality in the performance of practices, our research raises important questions about the effectiveness of coordination and collective work in an age of data analytics. To the extent that trends toward collecting and mining large-scale data continue, decision makers will increasingly be working with data that is abstracted and distanced from the site of work. As we saw in both the skimming and guiding practices, the more information, individuals, and interactions that were excluded from the material enactment of a practice, the more significant were the challenges to effective comprehension and coordination. How this plays out in other contexts with different material practices is a critical and open area for future research.

Third, our study emphasizes the importance of attending to temporality in coordinating. The dynamics and implications of the night round practices of calibrating and exploring, for example, would be difficult to explain without referring to the regulating preparatory practice that had been materially enacted just before. Previous studies make considerable reference to situated practices that make coordination possible (Bechky 2006, Faraj and Xiao 2006, Gittell 2002, Kellogg et al. 2006), but do not explore the temporal interdependence of such practices with prior or subsequent work, nor whether and how this makes a difference to coordination. Our findings suggest that considering the interconnectedness of practices performed before, during, and after the focal coordinating practice may shed important light on the multiple ways in which temporality makes a difference to how work is coordinated in practice.

Fourth, the coordination literature indicates that shared understanding of the work at hand is a crucial

coordinating mechanism (Okhuysen and Bechky 2009). This literature holds that workers go to great lengths to produce shared understanding (Bechky 2003, Carlile 2004), and that this allows them to structure their activities so they mesh well with others. We found that remote, interdependent workers regularly reached and relied upon provisional settlements for similar reasons, suggesting that shared understanding may not always be required for effective coordination. Rather, producing provisional settlements through temporary suspension of disagreement may be sufficient to effectively coordinate work. Close scrutiny of other complex, dynamic, and distributed coordinated activity may well reveal frequent (even if minor) provisional settlements that allow workers to take effective interdependent action. Future research can explore the conditions and practices where producing provisional settlements rather than shared understandings can be a practical alternative for effective coordination.

Our study was limited to medical work within a single hospital's SICU and a particular routine, night rounds. We focused on the performance of night rounds through the RP-7 robotic telepresence system, as compared to night rounds performed through a hard-wired telephone over 14 months from 2011–2012. These conditions bound our contributions contextually, materially, and historically. However, we believe that the central finding—that coordinating complex, dynamic, and distributed work depends on specific material enactments of interconnected practices over time—can usefully inform future research. To the extent that knowledge work is becoming more distributed and technologies such as robotic telepresence are increasingly being deployed for that work, our results offer insights into how coordination may be more or less effectively accomplished in contemporary organizations.

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Endnotes

¹To retain confidentiality, the hospital name and additional identifying information have been changed.

²http://usatoday30.usatoday.com/tech/news/robotics/2006-10-19-robot-doctors_x.htm (accessed September 16, 2015).

³By this time, the RP-7 robot had been used intermittently in the SICU for over three years, so APs and nurses were reasonably familiar with it.

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