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ORIGINAL CONTRIBUTION

Making decisions "in the dark": Learning through uncertainty in clinical practice during Covid-19

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Abstract

Purpose: The purpose of this study was to explore how decision making and informal and incidental learning (IIL) emerged in the clinical learning environment (CLE) during the height of the Covid-19 pandemic. The authors' specific interest was to better understand the IIL that took place among frontline physicians who had to navigate a CLE replete with uncertainty and complexity with the future goal of creating experiences for medical students that would simulate IIL and use uncertainty as a catalyst for learning.

Method: Using a modified constructivist, grounded theory approach, we describe physicians' IIL while working during times of heightened uncertainty. Using the critical incident technique, we conducted 45-min virtual interviews with seven emergency department (ED) and five intensive care unit (ICU) physicians, who worked during the height of the pandemic. The authors transcribed and restoried each interview before applying inductive, comparative analysis to identify patterns, assertions, and organizing themes.

Results: Findings showed that the burden of decision making for physicians was influenced by the physical, emotional, relational, and situational context of the CLE. The themes that emerged for decision making and IIL were interdependent. Prominent among the patterns for decision making were ways to simplify the problem by applying prior knowledge, using pattern recognition, and cross-checking with team members. Patterns for IIL emerged through trial and error, which included thoughtful experimentation, consulting alternative sources of information, accumulating knowledge, and "poking at the periphery" of clinical practice.

Conclusions: Complexity and uncertainty are rife in clinical practice and this study made visible decision-making patterns and IIL approaches that can be built into formal curricula. Making implicit uncertainty explicit by recognizing it, naming it, and

practicing navigating it may better prepare learners for the uncertainty posed by the clinical practice environment.

INTRODUCTION

> Medicine is the science of uncertainty and an art of probability.—
>
> Sir William Osler.

The uncertainty and complexity of everyday clinical practice was amplified by the Covid-19 pandemic and illuminated the gap in training learners in the health professions, particularly medical students, receive in formal curriculum to function in uncertain environments. Although a range of educational interventions have been described in the literature that aim to prepare medical students for this uncertainty, these interventions do not build on existing theoretical frameworks nor have they been comprehensively synthesized into formal curriculum.[1] To date, formal training to navigate uncertainty in practice is lacking. Health professions educators must understand the essential skills practitioners rely on when navigating uncertain clinical scenarios with high consequences during rapid turnover of knowledge. The authors aimed to describe the learning that took place in frontline physicians who worked in the clinical learning environment (CLE) amid the uncertainty posed by the height of the pandemic.

The CLE represents a complex system consisting of interacting and interdependent components—personal, social, organizational, physical, and virtual—that magnify uncertainty in everyday clinical practice.[2,3] The pandemic heightened our awareness that the CLE is replete with uncertainty. Therefore, an opportunity exists to provide agents in the clinical workplace with a framework to make sense of and act within complex health systems. This "learning in the moment" is likely to occur informally and haphazardly during complex and uncertain clinical contexts, where novel problem-solving strategies are required.[4] The Marsick and Watkins Model of Informal and Incidental Learning (IIL) in the workplace represents one way to describe this process of meaning making.[4]

IIL in the clinical environment is "implicit, unintended, opportunistic and unstructured" and rarely facilitated by a teacher.[5] Marsick and Watkins characterize IIL as integrated with daily work and routines and triggered by an impetus that is not highly conscious, often haphazard, and influenced by chance and an inductive process of reflection and action.[6] Informal learning can be intentional even though unplanned, but it can also be incidental or a semiconscious byproduct of tasks team members in the CLE undertake. For example, adopting practices of a hidden curriculum that may include specific workflows, procedures, and team roles for a designated clinical context.[7] It often occurs when doing something for which the primary purpose is not learning, such as solving a problem in the CLE.[8] In essence, IIL describes how clinicians learn every day as they face circumstances calling for new ways to problem solve and make decisions.[9–13]

While the study of IIL in the CLE has not been explored in health professions education, other similar theoretical frameworks have been described. For example, adaptive expertise, first coined by Hatano and Inagaki, explores how and why solutions in particular situations can be extracted, distilled, and used in new or unfamiliar future contexts.[14] Adaptive expertise relates to asking individuals to develop their own solutions and strategies, particularly when direct links are made between errors and knowledge to be learned.[14] In the setting of the recent pandemic, Merritt et al.[15] share that Covid-19 highlighted new lessons in adaptive expertise: to develop "the ability to learn new information, make effective use of resources, and invent new procedures to support learning and problem-solving in practice."

Although IIL represents a novel framework applied to medical education, this conceptual framework focuses on the dynamic learning process and how learning took place in the clinical environment incidentally during Covid-19. In contrast to adaptive expertise, IIL captures the incidental component to learning that is not necessarily conscious. The focus for this study was on the process of learning and not its outcomes and how learning often occurs without intention. We presumed expertise of our participants through our sampling strategy. IIL offers the opportunity to describe nuances of how physicians learn and navigate complexity and uncertainty in clinical practice. By better understanding this learning process, practical steps to integrate the findings into formal curricula could better prepare learners to engage in meaningful learning during heightened clinical uncertainty.

MATERIALS AND METHODS

The purpose of this qualitative study was to explore how physicians working in the CLE during the Covid-19 pandemic experienced IIL during times of heightened uncertainty. Specifically, from a modified constructivist grounded theory (CGT) approach, we inductively analyzed our data to describe what IIL looks like for physicians working through the complexity and uncertainty associated with patient care. It is important to note that three study investigators (VJM, KW, HL) have extensive expertise with CGT and all study investigators have significant expertise with qualitative research methods (VJM, KW, HL, DP, UV, GA, DZ). Our research team consisted of three

adult learning researchers (VJM, KW, HL), one critical care physician (UV), one emergency physician (DP), and one senior educational leader (DZ). We deliberately chose this team composition to enable investigator triangulation, leveraging different perspectives to balance subjective views during interpretation of data. The study was approved by the institutional review board of Thomas Jefferson University (#21E.565).

Setting, population, and sampling strategy

Because we sought to understand how the uncertainty associated with the height of the Covid-19 pandemic affected the IIL of physicians working in highly complex clinical environments we intentionally recruited physicians who treated Covid-positive patients in the emergency department (ED) or the intensive care unit (ICU) at an urban, academic, tertiary care hospital in Philadelphia, Pennsylvania. Two authors (DP, UV) are faculty in these respective clinical departments familiar with the practice environment. Physician participants were identified through purposive convenience sampling.[16] Criteria for inclusion were that the individual worked as an attending physician treating patients with Covid-19 in the ED or ICU at our institution during March to June of 2020.

To capture an array of clinical experiences across the physician life cycle, participants were chosen with varied accumulated years working clinically in the ED or ICU. Participants were enrolled through targeted emails describing the study and assurance that participation was voluntary. Participants and their respective narratives were deidentified using an internally developed coding scheme.

Data collection

Our study consisted of a series of critical incident interviews, each 45-min long, with frontline ED and ICU physicians. Each interview was conducted virtually using Zoom software by two members of the research team, which allowed for a clinician (i.e., DP, UV) and an adult learning expert (i.e., VJM, KEW, HL, GA) to be cointerviewers.

Procedure

The critical incident technique (CIT) was chosen as the data collection method since it is an approach that creates vivid depictions of the phenomena of interest as well as a window into the reasoning of the individual about the incident.[17–19] An interview protocol (see supplemental material) was developed by study investigators with significant experience with the CIT (i.e., KEW, VJM, HL). The protocol was piloted with one ED and one ICU physician to optimize interview questions. The interview protocol was modified based on these pilot interviews. Pilot interviews were included in the data set. Physician participants were asked to describe a key incident in their daily clinical work during the Covid-19 pandemic when they were faced with a significant degree of uncertainty. Interviews were transcribed for analysis using Sonix software, which were then reviewed by members of the study team for transcription accuracy.

Data analysis

Analysis began by reducing the data to capture a critical story. Interviewer comments and extraneous narratives were removed after which each incident was restoried, rearranging the incident in chronological order for coherence.[19,20] We then identified a title using the participants' own words that captured the essence of the incident. Employing a modified grounded theory approach, we conducted an inductive data analysis on the restoried incidents.[21,22] Our approach differed from strict coding procedures of the traditional grounded theory approach as concepts were formed straight from interpretations of data on an analysis worksheet (i.e., in the form of assertions).[23,24] Inductively, the study team developed assertions about the meaning of each incident as it related to our research purpose[18,19] after a series of iterative conversations to identify what was learned from the critical incidents and how they tied to the research purpose. Once the analysis was completed, we collectively completed a virtual card-sorting activity on a Google Jamboard of our assertions to identify overarching themes.

RESULTS

We identified and interviewed 12 physician participants, seven ED and five ICU physicians. Participants had a mean of 10 years of clinical experience in their respective field (range 4–19 years). Five were female.

Analysis of the critical incidents with cross-case comparisons revealed themes that were classified into three categories: (1) the influence of context on decision making and learning, (2) decision-making patterns in uncertain environments, and (3) IIL strategies utilized during uncertainty and complexity. Representative quotes are included for each theme.

The influence of context on decision making and learning

The Covid-19 pandemic changed the environment that health care workers were accustomed to working in. Physical spaces were reorganized, new equipment was utilized, evidence-based literature was sparse or nonexistent, and more questions than answers occurred. We describe how changes in the physical, situational, emotional, and relational domains were influential to our participants decision-making and ability to "figure it out on the fly"
(PHY03).

Physical and situational context

Participants described a new order in their workspace. What was familiar became foreign: rooms reorganized, materials relocated to different places, communication garbled while wearing personal protective equipment (PPE), and learning new systems and procedures became the daily norm. An overwhelming array of tasks had to be balanced to keep everyone safe. This impacted decision making by introducing environmental and procedural uncertainty. Importantly, the question of how to assure the safety of oneself, team members, and the physician's family was constantly assessed. Participants described elaborate disinfection rituals before they stepped into their homes and attempts at reducing exposure at home by sleeping in separate rooms. At work they role-modeled safety protocols: always being the first (sometimes the only) physician to enter the patient's room, thus protecting junior members on the team, from excessive exposure. What was usually "utterly reflexive had become conscious" (PHY04).

> The dark was the actual physical dark of working a lot of overnights by yourself. Those first few weeks, we really didn't have clear pathways of what we were doing or clear treatment plans.
>
> (PHY01)

Emotional and relational context

The Covid-19 pandemic forced participants to question their own knowledge of how to treat their patients. The paucity of evidence available led to a lack of confidence in making decisions and an omnipresent fear they might be suggesting the wrong step in patient care. This burden magnified the uncertainty around conversations with patients and families causing provider emotional distress. Additionally, the pressure some participants felt from patients' families advocating for anecdotal treatments made balancing decisions even more contentious and emotionally charged—after all, it was truly a question of life and death. This created a "decision burden" (discussed next) that further complicated the situation.

Interactions between individual members of the health care team seemed to morph as well; there was a greater reliance on reading the room and interpreting body language to help facilitate decision making. The relational capital was palpable—that is, leaning on team members helped provide a safety net for our participants.

> How do I confidently but honestly convey to both the patient and family members what I think my plan for the patient should be without having good data to support that plan? And that feeling lasted for a long time, longer than I would have liked.
>
> (PHY02)

Managing the burden of personal responsibility for patient outcome (decision burden)

Being perceived as the leader of the team and the ultimate arbiter of decision making weighed heavily on participants' shoulders. They frequently sought peer opinions, reaching out across institutions, but more importantly looked for verbal and nonverbal cues of team consensus. Their thinking and decision making was impacted by the constant prognostic uncertainty they faced.

> I was in the ICU in March when the first patient with Covid was confirmed. I just remember being near tears for that one week where there was just so much like push–pull uncertainty and everyone sort of looks to you to know the answer. But I really didn't have the answers.
>
> (PHY08)

Decision-making patterns in uncertain environments

Relying on past experience with similar diseases (pattern recognition)

Participants frequently fell back on their prior experience while dealing with medical conditions that appeared similar to Covid-19. Participants expressed a certain comfort with applying what they thought would work based on pattern recognition, i.e., when symptoms and signs are compared to well-established disease processes and a match is identified.

> So, you take an uncertainty and you kind of try to find patterns that you are familiar with, like sepsis, and try to manage it the same way. That's one way of doing it, where you try to take something that you don't know about and try to find a pattern that makes it similar to what you did in the past.
>
> (PHY03)

Relying on reflexes, intuition, and heuristics (simplifying the problem)

Participants described acting on instinct when faced with new problems that seemed familiar. They concentrated on the issues they could address to focus their thoughts amid the deluge of information. They commented on how they sometimes had to act first and then assess consequences to make sense of the situation.

> I reassured myself that I know how to take care of certain things. I know what tools we have to take care of hypoxia and I know what tools we have to make a

diagnosis. And I know what to do to temporize the discomfort in the moment. I just tried to fall back on what I knew how to do best.

(PHY02)

Relying on colleagues to ratify decision making (cross-checking)

Participants frequently leaned on their colleagues and/or interprofessional team members to gain consensus. Interestingly, this was more often observed in the interviews with ICU physicians, where they actively sought out peer physicians' and their interprofessional teams' opinion. It is likely the nature of the ICU working environment lent itself to this observation. In the ED, physicians frequently work in smaller teams and in more emergent situations, making it difficult to seek advice from multiple team members.

We found that being able to rely on consensus and agreement among peers and other members of the hospital team was invaluable. Decisions reached by the physician were influenced by how the team worked together, and the uncertainty itself fostered a closer team working dynamic.

One of the great things about working in the ICU is that you have this very tight team and I think on 90% of the things, you kind of flatten the hierarchy for everyone … from nursing, from respiratory therapy, from the resident level to the attending. Everyone has an opinion, and it all gets factored in. It's very helpful for decision making for me as an attending to stand back and listen to all of this because it informs it.

(PHY04)

Learning strategies utilized during uncertainty and complexity

IIL was embedded in participants' narratives. While working through uncertainty, physicians relied on prior medical knowledge, trial and error, searching alternative sources, and thinking out of the box (i.e., "poking at the periphery"). Over time, physicians were able to build on their experiences, which enabled them to deal with this new disease more confidently.

Relying on prior medical knowledge and using the "trial and error" approach

Most of our physician participants focused on prior knowledge of viral respiratory diseases and applied those concepts to this new disease. Making a decision, implementing it, rapidly assessing consequences, and then changing course, if needed, was a common theme. Some participants ran small experiments when the patient

and/or their families agreed, ensuring that they did not violate any regulations, especially when the alternative was certain death. One of these approaches entailed delaying intubation for patients in acute respiratory failure to avoid the complications of mechanical ventilation. This was despite initial opinions to the contrary, but ultimately was found to be a successful approach.

New things are just new versions of old things. When new things come up, we don't have to throw out everything we've ever known about everything in the absence of data and certainty and knowledge about a specific disease process. You can just fall back on like good critical care strategies that are proven and known to work. You will not be right all of the time, but you'll be right most of the time.

(PHY07)

Thinking out of the box (poking at the periphery)

Participants expressed a tendency to question the evidence they were presented with and used the team as a sounding board for new ideas. Some participants "thought out loud" or even drew new ideas out on paper. This resulted in a few participants trying a different approach to managing patients with Covid-19–related acute respiratory distress syndrome.

Some participants vacillated between applying established protocols for patients presenting with acute respiratory failure and following new anecdotal evidence given that this was a novel virus with unknown consequences. This set up a mental struggle and amplified the complexity of decision making in the pandemic.

When I'm faced with the thing that I don't know anything about, I'm trying to put things together because this patient has eight things wrong with them. How do they all fit in one process? I will take out a paper. I'll turn over my sign-out [sheet] and I draw on it, and I try to explain. And as I'm trying to explain it to myself, I'm teaching the fellows, but essentially, I'm teaching myself and thinking about the complex problem from various angles, and it becomes a learning and sharing moment.

(PHY09)

Seeking out and applying new knowledge (alternative sources)

With cases of Covid-19 rapidly rising and anecdotal evidence of case reports pouring in from around the world, physician participants reported scouring any source of information they could find to help their patients. Though the quality of evidence was debatable given the lack of clinical trials in that initial phase of the pandemic, all reported data impacted day-to-day decision making.

In terms of figuring out what to do, I feel like it was just hearsay. … we were just relying on people who knew emergency medicine, physicians who were working in the stress areas specifically at the time, like New York. … It was like public electronic shared information that was being called [on] by the masses, but not really fact checked.

(PHY05)

Build on experience with the new disease over time (accumulation of knowledge)

All the above strategies and managing multiple patients with a similar disease process led to a degree of experience that made the participants more comfortable with the disease course, treatment, and prognosis.

You know, we're a year in and have I really learned something? And I think that's just part of being an adult and there are so many things that I lean back into that I feel like I learned right, and I have a command of it. And I don't know that I still have a command of this, but maybe nobody does. Right? Or few of us do. I don't know.

(PHY05)

Summary of findings

An inductive analysis of our physician interviews employing the CIT revealed patterns of decision making and patterns of learning that were observed while physicians were immersed in uncertain and complex scenarios posed by the clinical environment.[2] Patterns for learning and patterns for decision making were interdependent. Prominent among these were ways to simplify a problem by applying prior knowledge, using pattern recognition, and then cross-checking information with team members. Learning emerged through trial and error, intentional and thoughtful experimentation, poking at the periphery of a problem, accessing alternative sources of information, and, ultimately, the accumulation of knowledge.

The interaction of these factors is visually summarized in Figure 1. The figure places our physician participants at the center of this representation as they navigated decision making amid uncertainty that spanned several types of clinical contexts (i.e., physical, emotional, relational, and situational). The burden of their decision-making was influenced by the physical, emotional, relational, and situational uncertainty of their work.

DISCUSSION

We know from prior literature on constructivist and situated learning[25] that learning is social and takes place in groups—we learn from
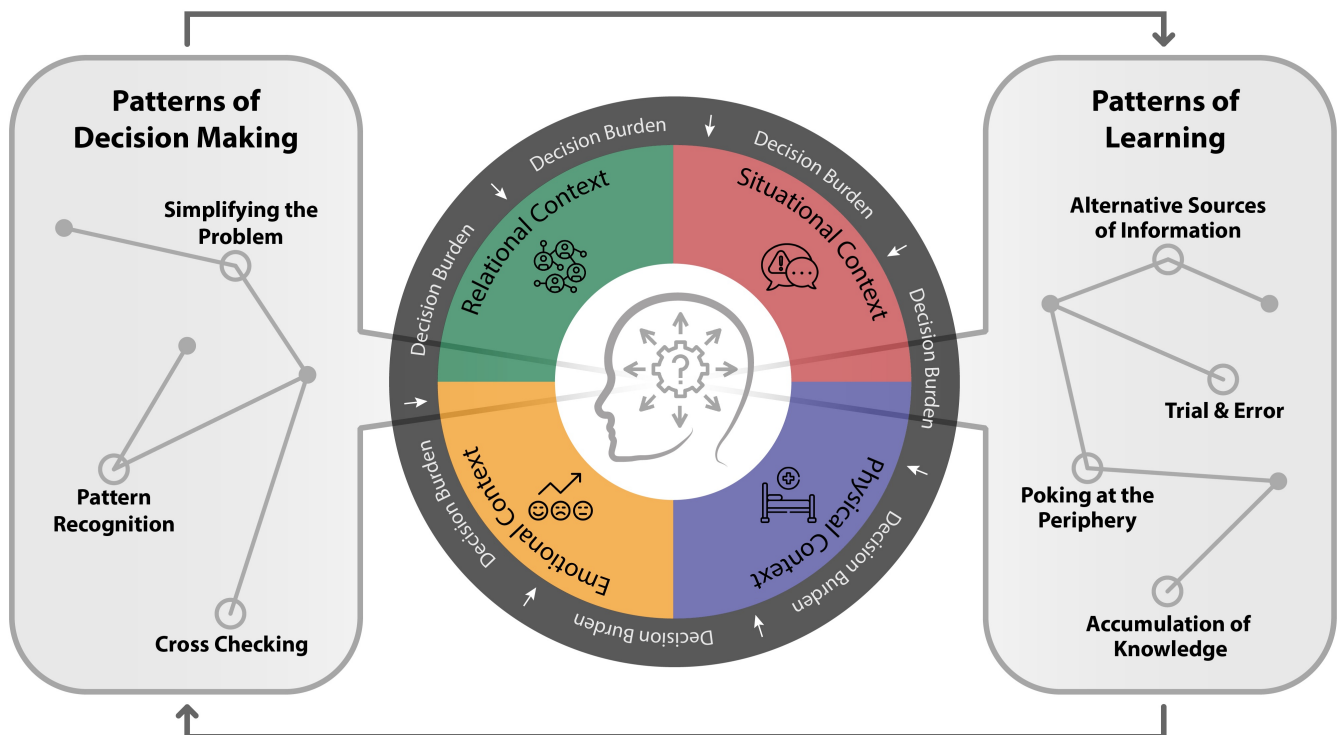

FIGURE 1 Visual representation of results of the inductive analysis: We represent the influence of context and decision burden that brought to light the various patterns of decision making and learning in the complex and uncertain clinical environment of the pandemic. The physician at the center of this representation navigated decision making amid uncertainty that spanned several types of clinical contexts (i.e., physical, emotional, relational, and situational).

each other and from our own experiences, as was evident in our participants' interviews. Constructivism, as a theory, postulates that learners use their experience and their reflections on that experience to construct new knowledge.[26] This theory is brought to the forefront when dealing with uncertainty and complexity. Per situated learning, the experiences of our participants were influenced by the constantly changing physical, emotional, relational, and situational contexts during the pandemic. Participants created a mental model to approach a patient with Covid-19 but had to adapt that model constantly given new information. In addition, mental models had to be created to problem solve each of the contextual uncertainties they faced—whether it was physical (i.e., a change in the configuration of the ED), emotional (i.e., a family insisting on unproven therapies), relational (i.e., team member dynamics and opinions), or situational (i.e., discussing prognosis with family members with little evidence to support answers).

Our results highlight the pervasiveness of incidental learning in uncertainty and complexity.[27] With no clear evidence at hand, in the midst of ambiguity and conflicting messages, learning could not be planned or goal directed, but rather emerged incidentally through engagement in the task within a social context. These findings echo previous research, such as that by Taber et al.,[28] in which paramedics and firefighters developed the "ability to respond to emergent situations, adapt policy into practice, and navigate through the gray areas and organized chaos of their professions." At the same time, "when all things anticipated or thought known dissolve, and when a firefighter or paramedic stands alone or with a comrade needing to make just the right decision, another kind of active, creative, fast-as-lightning learning must be deployed."[28] Learning arises intuitively or via unconsciously acquired tacit knowing. We described this learning as trial and error, though it sometimes bordered on experimentation. For example, one physician decided not to intubate immediately but tried a different approach while closely evaluating results and actively discussing observations with team members. In a similar study of incidental learning in a complex clinical context, Harner[29] found that lack of knowledge forced people into incidental learning in the moment.

Elements of adaptive expertise are also noted in our data. Participants were confronted with novel problems related to Covid-19, they were called upon to apply their existing knowledge when possible through pattern recognition (i.e., routine expertise), and they also transferred this knowledge to new problems to create novel solutions (i.e., adaptive expertise).[14,15,30] Learning in our study demonstrated a reliance on heuristics and pattern recognition; yet participants also had to use their specialized knowledge to seek out variations in treatment as well as other innovative solutions. Interestingly, Merritt et al.[15] describe several conditions that optimize learning for both adaptive expertise and the in-the-moment, process-specific skills of IIL that were identified in our study. These include learning from a wide range of examples, challenging learners to develop new approaches, and learning through repeated application of both routinization and innovation.[31,32]

Our findings have the potential to inform curricula in undergraduate medical education (UME). Historically, there has been a focus on preparing medical students for uncertainty in clinical practice by focusing on efforts that bolster students' confidence and tolerance for uncertainty. For example, Mangione et al.[33] examined whether exposure to the humanities was associated with lower reported qualities that are detrimental to physician well-being, including intolerance of ambiguity. Before it was dropped from the Medical School Graduation Questionnaire in 2021, the Association for American Medical Colleges routinely collected data on student perceptions of uncertainty through the Tolerance for Ambiguity (TFA) scale. The TFA was designed to predict one's ability to cope with situations of uncertainty.[34-36] Recent literature, however, suggests that the emotional and somatic responses from working through uncertainty often serves as a catalyst to solve problems. This awareness has raised the possibility of uncertainty tolerance being an epiphenomenon of competence[37,38] in managing uncertainty—meaning tolerance for uncertainty emerges naturally as agents in the clinical environment appraise the internal and external resources and skills they rely on to navigate complexity and uncertainty.

Our data identify several concrete skills and behaviors educators should consider when designing programming that prepares trainees to make decisions during times of heightened uncertainty. The goal of training should aim to strengthen learners' ability to gauge the uncertainty of a situation and determine their likelihood of being successful (or not) when facing new problems that emerge in practice. Through these experiences, learners may develop the capacity to tolerate uncertainty and accrue the skills to manage it effectively.[37,38] Given that tolerance of uncertainty and tolerance of ambiguity are not stable attributes, but rather expand with increasing confidence, educators have the opportunity to focus on learners' ability to effectively manage uncertainty (i.e., first acknowledging and appraising situations of uncertainty, followed by identifying and practicing strategies to navigate uncertainty).

Training in health professions education should prepare learners to engage in IIL when working in complex clinical environments.[12] Curriculum design must focus on the development of abilities that will support the exploration of creativity in the context of IIL. To support decision making in the face of ambiguous, nonroutine situations, students in the health professions require the distinct abilities to seek available knowledge, craft innovative solutions and possibilities, and take intuitive leaps to choose the best possible option. Equally important, students will require the ability to reason through problems abductively—to move from *sensemaking* (i.e., the ability to make observations and deductively and inductively reason) to *sensebreaking* (i.e., the ability to apply imagination and experiment in practice).[9] Thus, uncertainty becomes a catalyst for learning.

Including pedagogies in a curriculum that foster participatory learning, such as problem-based learning and case-based learning (CBL), can equip students with the skills to search for and appraise new knowledge and scaffold their own self-directed learning.[8,39]

As an example of this approach, at our medical school, we have successfully integrated CBL cases that prompt students to navigate various types of uncertainty (e.g., stochastic, diagnostic, prognostic) in the preclinical curriculum. Immersing students in design sprints builds skills in design thinking and action learning, which support the implementation and testing of novel solutions.[8,40] Participating in routine patient safety initiatives, such as failure modes and effects analyses, can help students assess the intended and unintended consequences of their actions.[41] At our medical school, we have included small-group faculty-facilitated debriefings that take place between core clerkships that prompt students to reflect on and discuss their recent clinical experiences. One session is solely dedicated to discussing how students experienced and navigated uncertainty.

LIMITATIONS

Crucial to understanding our findings, however, is dissecting the limitations of our study, which include sampling and recall biases. Firstly, we interviewed physicians from two departments at one academic hospital setting. This choice produced a sampling bias as participation in the study was limited to one hospital. When approaching physicians in those two departments, two authors (DP and UV) were colleagues of participants, hence adding to the sampling bias due to our convenience sampling strategy. Because of this familiarity, however, we believe interviewees were more likely to share and critically reflect on their lived experiences, which is an essential criterion for qualitative research and critical incident studies.[42]

Secondly, we interviewed physicians in the summer of 2021, about 15–18 months after the first Covid-19 patients arrived at our hospital. The temporal distance between critical incidents and the interview may have produced difficulties in recalling the incident. Acknowledging this recall bias, we understand that our study includes both a more or a less accurate recall of what happened during the critical incident, capturing what physicians thought in the moment. In addition, our study captures reflection on action[43] in the form of reconstructions on decision-making reasoning and lessons learned that only transpired at the point of the interview. There is a possible upside of temporal distance to a critical incident, as physicians may have had the opportunity to ruminate on their lived experience and actively engage in meaning making through conversations with colleagues, family, and friends.

CONCLUSIONS

During uncertain and complex times, physicians ground their decision making on prior knowledge and experience; peer, team, and family consensus; available literature albeit anecdotal; and their instinct to do no harm. The informal and incidental learning that occurs during these times is centered around thoughtful experimentation (i.e., trial and error), poking at the periphery of a problem while trying to push boundaries to create new knowledge, and building on prior experience. Strategically using this information to build curriculum in undergraduate medical education can improve learner familiarity with uncertainty and provide them with the tools to use uncertainty as an impetus for learning in the clinical arena.

CONFLICTS OF INTEREST STATEMENT

The authors declare no conflicts of interest.

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REFERENCES

1. Patel P, Hancock J, Rogers M, Pollard SR. Improving uncertainty tolerance in medical students: a scoping review. *Med Educ.* 2022;56(12):1163-1173. doi:10.1111/medu.14873
2. Gruppen LD, Irby DM, Durning SJ, Maggio LA. Conceptualizing learning environments in the health professions. *Acad Med.* 2019;94(7):969-974. doi:10.1097/ACM.0000000000002702
3. Gheihman G, Johnson M, Simpkin AL. Twelve tips for thriving in the face of clinical uncertainty. *Med Teach.* 2020;42(5):493-499. doi:10.1080/0142159X.2019.1579308
4. Watkins KE, Marsick VJ. Re-cognizing informal learning in the workplace. In: Chapman D, ed. *Proceedings of the Academy of Human Resource Development: Conference of the Americas.* Academy of Human Resource Development; 2014.
5. Wagter JM, van de Bunt G, Honing M, Eckenhausen M, Scherpbier A. Informal interprofessional learning: visualizing the clinical workplace. *J Interprof Care.* 2012;26(3):173-182. doi:10.3109/13561820.2012.656773
6. Marsick VJ, Watkins KE. Informal and incidental learning. *New Dir Adult Cont Edu.* 2001;2001(89):25. doi:10.1002/ace.5
7. Hafler JP, Ownby AR, Thompson BM, et al. Decoding the learning environment of medical education: a hidden curriculum perspective for faculty development. *Acad Med.* 2011;86(4):440-444. doi:10.1097/ACM.0b013e31820df8e2

8. Papanagnou D, Watkins KE, Lundgren H, Alcid GA, Ziring D, Marsick VJ. Informal and incidental learning in the clinical learning environment: learning through complexity and uncertainty during COVID-19. *Acad Med.* 2022;97(8):1137-1143. doi:10.1097/ACM.0000000000004717

9. Watkins KE, Marsick VJ. Informal and incidental learning in the time of COVID-19. *Adv Dev Hum Resour.* 2021;23(1):88–96. doi:10.1177/1523422320973656

10. Marsick VJ, Watkins KE. Introduction to the special issue: an update on informal and incidental learning theory. *New Dir Adult Cont Edu.* 2018;2018(159):9-19. doi:10.1002/ace.20284

11. Watkins KE, Marsick VJ, Wofford MG, Ellinger AD. The evolving Marsick and Watkins (1990) theory of informal and incidental learning. *New Dir Adult Cont Edu.* 2018;2018(159):21-36. doi:10.1002/ace.20285

12. Tonelli MR, Upshur REG. A philosophical approach to addressing uncertainty in medical education. *Acad Med.* 2019;94(4):507-511. doi:10.1097/ACM.0000000000002512

13. Herzog L. COVID-19: unveiling the role of uncertainty in medical education. *MedEdPublish.* 2020;9(1):166. doi:10.15694/mep.2020.000166.1

14. Bohle Carbonell K, Stalmeijer RE, Könings KD, Segers M, van Merriënboer JJG. How experts deal with novel situations: a review of adaptive expertise. *Educ Res Rev.* 2014;12:14-29. doi:10.1016/j.edurev.2014.03.001

15. Merritt C, Santen SA, Cico SJ, Wolff M, Pusic M. Punctuated equilibrium: COVID and the duty to teach for adaptive expertise. *West J Emerg Med.* 2021;23(1):56-58. doi:10.5811/westjem.2021.11.55268

16. Etikan I. Comparison of convenience sampling and purposive sampling. *AJTAS.* 2016;5(1):1. doi:10.11648/j.ajtas.20160501.11

17. Flanagan JC. The critical incident technique. *Psychol Bull.* 1954;51(4):327-358. doi:10.1037/h0061470

18. Viergever RF. The critical incident technique: method or methodology? *Qual Health Res.* 2019;29(7):1065-1079. doi:10.1177/1049732318813112

19. Watkins KE, Ellinger AD, Suh B, Brenes-Dawsey JC, Oliver LC. Further evolving the critical incident technique (CIT) by applying different contemporary approaches for analyzing qualitative data in CIT studies. *Eur J Train Dev.* 2022;46(7/8):709-726. doi:10.1108/EJTD-07-2021-0107

20. Branch WT. Use of critical incident reports in medical education. A perspective. *J Gen Intern Med.* 2005;20(11):1063-1067. doi:10.1111/j.1525-1497.2005.00231.x

21. Miles MB, Huberman AM, Saldana J. *Qualitative Data Analysis: A Methods Sourcebook.* Vol 408. 4th ed. SAGE Publications, Inc; 2019.

22. Varpio L, Paradis E, Uijtdehaage S, Young M. The distinctions between theory, theoretical framework, and conceptual framework. *Acad Med.* 2020;95(7):989-994. doi:10.1097/ACM.0000000000003075

23. Glaser BG, Strauss AL. *Discovery of Grounded Theory: Strategies for Qualitative Research.* Aldine Transaction; 2006. doi:10.4324/9780203793206

24. Kinoshita Y. *Modified Grounded Theory Approach.* Koubundou; 2007:306.

25. Lundgren H, Bang A, Justice SB, et al. Conceptualizing reflection in experience-based workplace learning. *Hum Resour Dev Int.* 2017;4:305-326. doi:10.1080/13678868.2017.1308717

26. Cruess RL, Cruess SR, Steinert Y. Medicine as a community of practice: implications for medical education. *Acad Med.* 2018;93(2):185-191. doi:10.1097/ACM.0000000000001826

27. Marsick VJ, Watkins KE, Scully-Russ E, Nicolaides A. Rethinking informal and incidental learning in terms of complexity and the social context. *JALKI.* 2017;1(1):27-34. doi:10.1556/2059.01.2016.003

28. Taber N, Plumb D, Jolemore S. "Grey" areas and "organized chaos" in emergency response. *J Workplace Learn.* 2008;20(4):272-285. doi:10.1108/13665620810871123

29. Harner MD. *Incidental Learning in a Complex Clinical Workplace.* ProQuest LLC; 2013.

30. Mylopoulos M, Steenhof N, Kaushal A, Woods NN. Twelve tips for designing curricula that support the development of adaptive expertise. *Med Teach.* 2018;40(8):850-854. doi:10.1080/0142159X.2018.1484082

31. Bransford JD, Schwartz DL. Rethinking transfer: a simple proposal with multiple implications. *Rev Res Edu.* 1999;24:61. doi:10.2307/1167267

32. Mylopoulos M, Brydges R, Woods NN, Manzone J, Schwartz DL. Preparation for future learning: a missing competency in health professions education? *Med Educ.* 2016;50(1):115-123. doi:10.1111/medu.12893

33. Mangione S, Chakraborti C, Staltari G, et al. Medical students' exposure to the humanities correlates with positive personal qualities and reduced burnout: a multi-institutional U.S. Survey. *J Gen Intern Med.* 2018;33(5):628-634. doi:10.1007/s11606-017-4275-8

34. Geller G, Grbic D, Andolsek KM, Caulfield M, Roskovensky L. Tolerance for ambiguity among medical students: patterns of change during medical school and their implications for professional development. *Acad Med.* 2021;96(7):1036-1042. doi:10.1097/ACM.0000000000003820

35. Geller G, Tambor ES, Chase GA, Holtzman NA. Measuring physicians' tolerance for ambiguity and its relationship to their reported practices regarding genetic testing. *Med Care.* 1993;31(11):989-1001. doi:10.1097/00005650-199311000-00002

36. Caulfield M, Andolsek K, Grbic D, Roskovensky L. Ambiguity tolerance of students matriculating to U.S. medical schools. *Acad Med.* 2014;89(11):1526-1532. doi:10.1097/ACM.0000000000000485

37. Ilgen JS, Watsjold BK, Regehr G. Is uncertainty tolerance an epiphenomenon? *Med Educ.* 2022;56(12):1150-1152. doi:10.1111/medu.14938

38. Ilgen JS, Regehr G, Teunissen PW, Sherbino J, de Bruin ABH. Skeptical self-regulation: resident experiences of uncertainty about uncertainty. *Med Educ.* 2021;55(6):749-757. doi:10.1111/medu.14459

39. Loyens SMM, Magda J, Rikers RMJP. Self-directed learning in problem-based learning and its relationships with self-regulated learning. *Educ Psychol Rev.* 2008;20(4):411-427. doi:10.1007/s10648-008-9082-7

40. Thakur A, Soklaridis S, Crawford A, Mulsant B, Sockalingam S. Using rapid design thinking to overcome COVID-19 challenges in medical education. *Acad Med.* 2021;96(1):56-61. doi:10.1097/ACM.0000000000003718

41. Chiozza ML, Ponzetti C. FMEA: a model for reducing medical errors. *Clin Chim Acta.* 2009;404(1):75-78. doi:10.1016/j.cca.2009.03.015

42. Anderson V. Criteria for evaluating qualitative research. *Hum Resource Dev Q.* 2017;28(2):125-133. doi:10.1002/hrdq.21282

43. Schön DA. *The Reflective Practitioner: How Professionals Think in Action.* Basic Books Inc.; 2017. doi:10.4324/9781315237473

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.