The impact of clinical uncertainty in the graduate medical education (GME) learning environment: A mixed-methods study

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**ABSTRACT**

**Background:** Uncertainty is ubiquitous in medicine. Studies link intolerance of uncertainty to burnout, ineffective communication, cognitive bias, and inappropriate resource use. Little is known about how uncertainty manifests in the clinical learning environment. We aimed to explore the perceptions and experiences of uncertainty among residents and attendings.

**Methods:** We conducted a mixed-methods study including a survey, semi-structured interviews, and ethnographic observations during rounds with residents and attendings at an academic medical center. The survey included three validated instruments: Physicians’ Reaction to Uncertainty Scale; Maslach Burnout Inventory 2-item; and Educational Climate Inventory.

**Results:** 35/60 (58%) of eligible residents and 14/21 (67%) attendings completed the survey. Residents reported higher anxiety due to uncertainty than attendings, higher concern about bad outcomes, and greater reluctance to disclose uncertainty to patients. Residents reported increased symptoms of burnout (p < .05). Perceiving the learning environment as more competitive correlated with reluctance to disclose uncertainty (r = −0.44; p < .01). Qualitative themes included: recognizing and facing uncertainty, and consequences for the learning environment. Observations revealed senior clinicians have greater comfort acknowledging uncertainty.

**Conclusions:** Medical curricula should be developed to promote recognition and acknowledgement of uncertainty. Greater acknowledgement of uncertainty, specifically by attendings and senior residents, may positively impact the clinical learning environment.

**Introduction**

Uncertainty is ubiquitous in clinical practice (Ghosh 2004), and can be a source of substantial discomfort for clinical providers and learners alike, leading to efforts to mitigate or eliminate it (Simpkin and Schwartzstein 2016). Tolerance of uncertainty has been identified as an important attribute for physicians – linked to effective communication, resource use, and rates of depression and burnout (Kruglanski and Webster 1996; Cooke et al. 2013; Bhise et al. 2018; Simpkin et al. 2018).

The US Accreditation Council for Graduate Medical Education (ACGME) and the UK General Medical Council (GMC) have identified the tolerance and management of uncertainty as a core competency for residents (Hicks et al. 2014; General Medical Council 2018). The CANmeds framework also describes complexity, uncertainty, and ambiguity in clinical decision-making as key concepts for the role of a medical expert (Frank et al. 2015). Uncertainty in medicine has also gained prominence in the medical education research, with calls to develop and evaluate novel curricula (Hall 2002; Simpkin and Schwartzstein 2016; Gheihman et al. 2020) Few formal curricula exist for teaching the management of uncertainty in clinical decision-making, although there are recent examples and frameworks proposed to guide curricular development (Olson et al. 2018, 2019; Helou et al. 2020). The interrelatedness of uncertainty with well-established educational domains of clinical reasoning (Norman 2005), clinical decision-making (Croskerry 2017), and shared decision-making (Spatz et al. 2017), highlights its importance for the clinical learning environment. Further, there is suggestion that provider reactions to uncertainty may be a factor in diagnostic error, a major public health problem.

Despite increased attention to uncertainty in medical education, and specifically graduate medical education (GME), there is little known about how uncertainty is
There is a significant relationship between characteristics of the clinical learning environment and perceptions of uncertainty in clinical practice among trainees.

There is increased reluctance in residents to disclose uncertainty compared to attendings; reluctance to disclose uncertainty is associated with higher burnout symptoms and perceiving the learning environment as competitive and stressful.

Comfort with and acceptance of clinical uncertainty grows with years in training; senior clinicians have a role to play in teaching about clinical uncertainty and creating a learning climate with psychological safety to promote disclosure.

Trainees should be encouraged to reflect upon their own responses to uncertainty, and attendings can model this behavior through open and curious discussion.

There is a need to design, implement, and evaluate curricula addressing knowledge and skills for tolerating, managing, and communicating clinical uncertainty.

perceived and experienced by trainees in the clinical learning environment. To address this gap, we used a mixed-methods approach to measure and explore how uncertainty among residents and attending physicians interacts with perceptions of the clinical learning environment in GME. We report our findings, triangulated from a quantitative survey of combining three validated scales, semi-structured interviews, and in-person ethnographic observations of residents and attendings.

Methods

We used a mixed-methods study to explore the perceptions and experiences of uncertainty in GME. Data collection involved one quantitative (survey with validated measures) and two qualitative (semi-structured interviews and ethnographic observations) components.

Study setting and participants

This study was conducted in the Internal Medicine and Medicine-Pediatrics Residency Programs at the University of Minnesota (UMN), a large, multisite training program with thirty categorical medicine, ten medicine-pediatrics, and two medicine-dermatology trainees per year. Subjects (residents and attendings) were eligible to participate if they rotated on the hospital medicine service at the main academic medical center training site during the study period. Recruitment occurred from June to October 2017. General information regarding the study was emailed to the eligible residents and attendings, who voluntarily elected to participate in one or more components of the study.

Ethical approval

Institutional Review Board approval was obtained from the affiliated academic institutions (UMN IRB #00000518 and Harvard Medical School (HMS) IRB #17-0941).

Survey measures

The survey was developed using expert consensus and was a composite of three validated instruments: (1) Physicians’ Reaction to Uncertainty Scale (PRUS) (Gerrity et al. 1990); (2) Maslach Burnout Inventory 2-item (MBI-2) (Maslach et al. 1997; West et al. 2009); and (3) Educational Climate Inventory (ECI) (Krupat et al. 2017). This is the first use of these measures in this novel combination. We used separate surveys for residents (Appendix A in Supporting Information) and attendings (Appendix B in Supporting Information).

Physicians’ reaction to uncertainty

The PRUS was developed to measure affective reactions to uncertainty in clinical situations across four subscales (Gerrity et al. 1990); it has been validated in the medical setting (Gerrity et al. 1995; Allison et al. 1998). Item responses occur on a 6-point Likert scale ranging from “strongly agree” to “strongly disagree”. Higher values indicate a higher degree of uncertainty-related stress.

Maslach Burnout Inventory

Burnout was assessed using two single-item measures of emotional exhaustion and depersonalization adapted from the 22-item MBI (Maslach et al. 1997), which has been shown to stratify risk of burnout in physicians (West et al. 2009). Responses occur on a 7-point Likert scale with options ranging from “never” to “daily.” Responses of “weekly” or more were considered to meet the criteria for high burnout (West et al. 2009). Following instructions in the MBI manual (Maslach et al. 1996), we converted the MBI-2 into a continuous numeric variable (scores ranging from 1 to 14) for use in correlation analysis (Eckleberry-Hunt et al. 2018; Rotenstein et al. 2018).

Educational Climate Inventory

The ECI is an instrument for assessing the climate of the learning environment from performance orientation to mastery and learning (Krupat et al. 2017). Originally designed for undergraduate medical education use, we modified the ECI questions to reflect the context of GME. To our knowledge, this is the first use of the ECI in resident (GME) and attending populations. Instrument modifications were reviewed by experts and pilot tested with residents and attendings prior to data collection. Respondents selected answers on a 4-point Likert scale ranging from “strongly agree” to “strongly disagree.” Scores included total score and subscales for competitiveness and stress; centrality of learning (mastery vs. performance orientation); and passive learning and memorization (Krupat et al. 2017).

Surveys were distributed to participants at faculty meetings, resident morning report, and noon conferences. Data were entered into an anonymous electronic dataset.
**Statistical analysis**

Standard descriptive statistics characterized the sample. To test for differences between group reactions to uncertainty, burnout, and the educational climate, we performed two-tailed t tests. Pairwise correlation further assessed relationships between the ECI scores, symptoms of burnout, and PRUS subscales. We assessed the distribution of our continuous variables, and as appropriate performed transformations. An alpha-value of 0.05 was used for comparisons. Analyses were performed with STATA (Version 14, StataCorp LP, TX).

**Semi-structured interviews and analysis**

Eligible residents and attendings were invited to participate in 40-min semi-structured individual interviews. Participants were sampled in a stratified manner to include adequate representation of stages of training (post-graduate year) and years of practice (newly in practice to later career attendings). The semi-structured interview guide (Appendix C in Supporting Information) was developed to specifically explore residents’ and attendings’ perspectives on clinical uncertainty and its interaction with the learning environment, while encouraging open exploration of these topics.

All interviews were audio recorded, transcribed, and de-identified prior to analysis. Transcripts were analyzed using a qualitative inductive approach with an iterative coding process (Corbin and Strauss 2008), to identify themes in the participants’ experiences. Using open coding software Dedoose (Version 8, Los Angeles, CA: SocioCultural Research Consultants, LLC), three investigators (M.J., G.G., H.T.) independently generated a list of codes after reviewing four interview transcripts. The initial coding framework was applied to the remaining transcripts and underwent an iterative process of modification over several discussion meetings (Hsieh and Shannon 2005). Discrepancies were resolved through consensus, with revision and consolidation of codes. We checked for trustworthiness of themes by sharing example quotes under each theme with the three senior faculty authors (G.S., A.O., A.S.) (Strauss and Corbin 1990).

**In-person ethnographic observations and analysis**

We employed ethnography as a method to observe the social dynamics taking place in the daily clinical work of residents and attending physicians (Mays 2000). The principal observer (M.J., at the time a dually enrolled medical and Master’s in Medical Education student with ethnographic training) took the role of a shadowing medical student during the study period. In this way, immersion in the team and participation of the observer minimized contamination of the workings of the team. Participants were aware of being observed; however, they did not know the purpose of the study.

Direct observation occurred over 14 days in June 2017. Teams observed consisted of a faculty attending physician, senior resident (PGY-2 or PGY-3), and junior resident (PGY-1). The observer wrote brief written records of events and impressions captured by key words and phrases, followed by detailed field notes composed immediately following each day of observation (Emerson et al. 2011). Descriptions were open-ended, and focused on interactions among team members as well as communication between the team and other healthcare providers and patients. Observations were continued until review demonstrated saturation. Field notes were stored in a secure online databank.

Through an inductive approach, the de-identified field notes were iteratively coded by the observing author using Dedoose, with refinement of the coding framework as patterns emerged. After the complete list of codes were compiled, two investigators independently reviewed the code agreement with the field notes (M.J., A.S.), and against prior research in similar settings (Emerson et al. 2011). Discrepancies were resolved through discussion until consensus was reached.

**Results**

**Survey respondent demographics**

Thirty-five of 60 eligible residents (58% response rate of those rotating at the study site during the study period) and 14 of 21 eligible attendings (67% response rate) participated. Table 1 lists demographic characteristics of respondents.

| Survey Respondent Demographics |
|--------------------------------|
| Residents | Attendings | Total |
| N         | Gender | Mean age [SD] | Gender | Mean age [SD] | N | Observations (60 h total) |
|-----------|--------|---------------|--------|---------------|---|-------------------|
| 35        | M/F    | 29 [8]        | 32 [7] | 49            | 23 |

**Validated scale responses for residents vs. attendings**

On the PRUS, residents reported higher anxiety due to uncertainty than attendings (19.0[3.6] vs. 15.6[5.0], p < 0.05, respectively), greater concern about bad outcomes (10.6[2.6] vs. 7.6[1.7], p < 0.05), and greater reluctance to disclose uncertainty to patients (7.6[1.7] vs. 6.1[2.6], p < 0.05) (Table 2). There was a non-significant trend toward residents being more reluctant to disclose uncertainty. Comparisons with rates in prior literature are included in Table 2.

**Factors associated with reluctance to disclose uncertainty**

We found that more time in years since graduating medical school among the whole study population was associated

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Table 1. Description of survey respondents (n = 49), semi-structured interviews (n = 15), and observed physicians (n = 23) at a single academic medical center during June–August 2017.
with a lower reluctance to disclose uncertainty ($r = 0.40$, $p < .01$). In further association analysis, we explored correlations between the reluctance to disclose uncertainty and symptoms of burnout and ratings of the learning environment, broken down by resident and attending samples (Table 3).

For our sample (residents and attendings), a reluctance to disclose uncertainty was significantly correlated with symptoms of burnout. Subsequent sub-sample analyses showed no significant associations for residents and attending sub-samples alone.

Perceiving the learning environment as more competitive and stressful strongly correlated with a reluctance to disclose uncertainty for the whole sample. The other two subscales for the learning environment, centrality of learning and mutual respect and passive learning and memorization, remained significantly associated with disclosure among attendings in our sample, but not residents.

### Semi-structured interview thematic analysis

Fifteen individual semi-structured interviews were performed with residents ($n = 7$) and attendings ($n = 8$). Among interviewees, 53% were female. Inductive analysis revealed six major themes which captured participants’ perceptions of uncertainty and the clinical learning environment. These six themes were organized into two major categories: (1) recognizing and facing uncertainty; and (2) consequences for the learning environment, as described below (Table 4).

#### Category 1: Recognizing and facing uncertainty

**Reconciling classroom learning experiences with frontline patient care.** Both residents and attendings stated that they encountered uncertainty for the first time upon entering clinical training in the later years of medical school or beginning residency. “Real world” clinical presentations often did not fit simple patterns learned from multiple choice questions or lectures, and that aligning these real-world cases with classic or prototypical descriptions of disease learned in the classroom was challenging. The transition from the emphasis on test-taking in classroom education to the complexity of the clinical learning environments was a key time for recognizing uncertainty.

**Anxiety due to uncertainty.** The major feeling provoked by uncertainty in the clinical environment was anxiety. Residents and attendings both stated there is reluctance to disclose uncertainty due to fear of embarrassment or an undermining of one’s competence.

As a result of this anxiety, participants described feeling either stuck and "paralyzed" in a state of inaction, or eager to act quickly in order to avoid or terminate the feeling of uncertainty. Participants recognized these behaviors could have negative consequences (e.g. coming to a diagnosis too
quickly eliminates uncertainty but promotes premature closure and diagnostic error). More adaptive responses included leaning into uncertainty to guide teaching, turning to others for advice, and gathering additional information (e.g. additional history, appropriate testing) or requesting formal consults to address and resolve uncertainty.

**Comfort growing with experience.** Residents and attendings described their comfort with uncertainty increasing over time as a result of experience and feedback on outcomes of prior cases. This phenomenon was described more by senior residents as compared to interns, and especially among attendings. This growing comfort allowed more vocal acknowledgement of uncertainty, and a desire to teach others to accept uncertainty as inherent to medicine.

**Category 2: Consequences for the learning environment**

**The desire to “save face”.** Residents at all training levels wanted to be perceived as competent, and many felt vocalizing uncertainty could leave them vulnerable to being perceived as less competent. In response to this threat of potential negative judgment and repercussions, some trainees felt a need to hide individual uncertainty in order to “save face”.

**Role modeling in the learning environment.** Perceiving the learning environment as competitive or stressful, termed “unsafe” by some participants, led residents to hide their uncertainty in order to appear competent. By contrast, trainees noted that a safer or less stressful learning environment was one in which attendings dealt openly and effectively with uncertainty. Trainees said observing this role modeling was both educational and comforting, helping them recognize appropriate reactions and choose to follow their example in the future.

Some residents and attendings noted a cultural shift in recent years that has invited more open discussions of uncertainty among colleagues and teams. Thus, participants perceived greater interest and support among physicians in being more open with one’s own uncertainty and “thinking out loud” together about complex cases. Promoting such openness among staff physicians was felt to help create a safer learning environment for trainees.

**No formal curriculum.** In addition to reflecting on the cultural and attitudinal barriers to embracing and disclosing uncertainty, participants noted that strategies for recognizing and coping with uncertainty were absent from their formal training. Many residents and attendings did not feel equipped to handle discussions of uncertainty with their
teams or with their patients and expressed interest in formal training to develop this important competency, believing it to be a necessity for practice.

**Ethnographic results**

Direct observations totaled 60 h, and involved eight attending physicians, 15 residents (PGY 1–4), and many other healthcare team members (e.g. consult physicians, interdisciplinary team members, other healthcare professionals). Three themes emerged describing how the clinical learning environment shapes the management of uncertainty: (1) attending physicians explicitly “call out” and acknowledge uncertainty; (2) resident physicians (the learners) primarily report basic facts, and sometimes “hide” uncertainty; and (3) the urgency of the situation modifies the team’s approach to managing uncertainty (Table 5).

**Attending physicians explicitly “call out” and acknowledge uncertainty**

Senior team members, especially attending physicians, were often observed discussing uncertainty explicitly. The offering of facts was observed to be the role of the trainee (learner), while assessment and judgment was primarily the role played by more senior clinicians. When uncertainty was expressed by faculty or senior residents, it was usually followed by actions including calling for more information, reviewing evidence-based guidelines, or articulating key points in medical decision-making. At times uncertainty was explicitly acknowledged but remained unaddressed. Faculty or senior residents appeared to be more comfortable tolerating than junior members (as evidenced by their voice trailing off or facial expressions of anxiety in more junior members).

**Resident physicians (the learners) primarily report basic facts, and sometimes “hide” uncertainty**

Junior residents (PGY-1) were rarely observed to explicitly express uncertainty. Rather, juniors focused primarily on reporting basic elements and facts of the patient presentation. However, through other behaviors, such as responding to closed-ended questions with “Yeah,” avoiding elaborating on explanations or discussing ambiguities, and talking around direct questions addressed at them by senior team members, they appeared to be working to hide possible gaps in their knowledge or personal points of uncertainty.

**The urgency of the situation modifies a medical team’s approach to uncertainty**

The urgency of a medical situation modified the team’s approach to uncertainty. This was expressed through more pressing language often calling for urgent evaluation and immediate care, sometimes with the aid of other specialties. While critical circumstances raised tension, sharing uncertainty openly in such situations often helped build camaraderie, increased input from all team members, and created shared purpose in addressing the challenging situation.

**Discussion**

Equipping learners to deal with uncertainty is increasingly recognized as a major goal for medical education and clinical training (Hicks et al. 2014; Frank et al. 2015; Simpkin and Schwartzstein 2016; General Medical Council 2018). Our study identifies a significant relationship between characteristics of the clinical learning environment and perceptions of, and reactions to, uncertainty among graduate medical trainees and attending physicians. Our findings demonstrate increased reluctance in residents to disclose uncertainty compared to attendings. Compounding this, greater reluctance to disclose uncertainty is associated with higher burnout symptoms as well as a perception of the learning environment as more competitive and stressful. Our survey findings were reinforced, and elaborated on, through semi-structured interviews and ethnography. In interviews, attending physicians described growing comfort with disclosing uncertainty over time. Ethnographic observations confirmed this when senior physicians explicitly addressed uncertainty whereas junior trainees avoided doing so. Interviews with residents suggested that they experienced pressure to hide uncertainty to avoid negative judgment or repercussions. Our results highlight the need for more explicitly addressing uncertainty in the GME learning environment for both teachers and learners.

A failure to disclose uncertainty not only affects clinical care but may also in turn affect physicians’ mental health. Indeed, Simpkin et al. (2018) reported lower tolerance of uncertainty correlates with depression and burnout in

| Theme | Sample field notes and observations |
|-------|-------------------------------------|
| (1) Attending physicians explicitly “call out” and acknowledge uncertainty | During this patient encounter the intern was very concise and unwilling to show ambiguity in their language with the patient. However, the attending seems much more willing. On one occasion she said from the corner of the room “we don’t really know” in response to a patient question. This is the first time she had spoken in the entire patient encounter apart from introductions. As we walked through the different cases they grapple with uncertainty often. It is typically the attending who explicitly acknowledges it.

| (2) Resident physicians (the learners) primarily report basic facts, and sometimes “hide” uncertainty | The senior resident asks the intern what the overall goals are for this patient to return home. The intern hangs upon this question, and lets silence insert itself into the team’s conversation. The intern avoids discussing goals, and instead mentions medication changes. The intern also does not offer any evaluation for discharge, avoiding answering the explicit question asked and avoiding discussing their personal uncertainty.

| (3) The urgency of the situation modifies a medical team’s approach to managing uncertainty | Uncertainty is dealt with swiftly by pursuing more objective information (e.g., imaging) in the face of “red flag” symptoms of a serious condition that needs to be ruled out immediately, despite a “gut feeling” against its likelihood. I ask the resident how she decided to order the urgent MRI? She responded “urinary retention is one of the red flags of back pain” suggesting that this one piece of information is all that is needed to prompt ordering the test.

*Table 5. Ethnographic themes and representative field notes on communicating uncertainty from observing clinical teams at a single academic medical center, June 2017.*
pediatric residents. We also found reluctance to disclose uncertainty correlated with higher symptoms of burnout in our sample. Residents and attendings may be susceptible to the double harm of both increased anxiety from uncertainty itself and the emotional exhaustion and depersonalization that characterize burnout. Given the epidemic of burnout among physicians (Dyrbye et al. 2018), further investigation of this relationship is warranted.

In our qualitative analysis, we explored what factors inhibited residents from disclosing uncertainty, and what factors could support disclosure. In interviews, residents described a sense of discomfort and anxiety due to uncertainty and a perceived need to “save face.” In our observations of teams on the wards, we saw that junior residents seldom expressed uncertainty, especially if they felt disclosing could lead to negative judgment or illuminate gaps in knowledge. This was consistent with survey results where perceptions of the clinical learning environment as stressful or more competitive were associated with higher reluctance to disclose. By contrast, learners who perceive their learning environment as more mastery-oriented exhibit greater curiosity, are more motivated to learn, attain higher levels of achievement, and experience lower rates of burnout (Krupat et al. 2017).

Attending physicians in our study described an evolution toward growing comfort with uncertainty over time. On the PRUS, attendings rated themselves as having less anxiety due to uncertainty, less concern about bad outcomes, and were less reluctant to disclose uncertainty. We also found on correlation analysis that more time in years since graduating medical school was associated with a lower reluctance to disclose uncertainty, consistent with participants’ subjective experience. Similarly, in our observations of teams on the wards, we found that if uncertainty was addressed explicitly, it was by figures with greater traditional authority (attendings and senior residents) as compared to more junior trainees.

Senior clinicians’ greater comfort with, and more prominent role in, acknowledging uncertainty explicitly represents an opportunity for teaching and culture change and highlights the importance of role modeling for setting the culture of the clinical learning environment (Benbassat 2014; Gheihman et al. 2020, Lawton et al. 2019). By sharing their knowledge and experiences, attending physicians can help normalize uncertainty as an inherent part of medicine. Indeed, we learned in our interviews with residents that the major factor influencing junior trainees’ willingness to disclose uncertainty was observing a senior role model doing the same. Other studies have shown experience to correlate with tolerance of uncertainty and decreased risk aversion, although the ultimate effect on patient safety is not known (Lawton et al. 2019).

Trainees should be encouraged to reflect upon their own responses to uncertainty (and their ability to tolerate it) (Weissenstein et al. 2014; Olson et al. 2018), discuss uncertainty openly with colleagues and patients, develop follow-up plans, and seek more information or support (Gheihman et al. 2020). Although there is a real concern that seeking additional diagnostic testing or imaging to resolve uncertainty may have unintended consequences of inappropriate over-testing (Bhise et al. 2018; 2018), a potential benefit of slowing down in the face of uncertainty is avoiding cognitive biases (e.g. premature closure) (Tversky and Kahneman 1974; Trowbridge 2008) and diagnostic error (Graber et al. 2005). Faculty can role model an acceptance of uncertainty and their own curiosity (Hundert et al. 1996; Gheihman et al. 2020), signaling explicitly the importance of addressing uncertainty as an inherent part of the learning process. Faculty development programs should aim to equip faculty to do so (Hall 2002; Helou et al. 2020).

An implication of our findings is that the behaviors and language of attendings may help improve the psychological safety of the learning environment and contribute to a cultural shift that promotes transparency and embracing uncertainty (Hundert et al. 1996; Simkin and Schwartzstein 2016). Psychological safety (Edmondson 1999) is critical for creating high-functioning teams that deal effectively with uncertainty and high-risk situations (Delizonna 2017), both of which are common in clinical care. In a psychologically safe environment, team members feel able to “speak up” without fear of negative consequences, which facilitates communication and learning (Benbassat 2014). By contrast, an unsafe learning environment leads to poor learning outcomes, and also to reduced quality and safety that may directly impact patient outcomes (Nemthard and Edmondson 2006). Promoting a psychologically safe educational climate (Rosenbaum 2019) in which learners and teachers are free to identify and discuss knowledge gaps and other sources of uncertainty without judgment or reprisal is fundamental. Our results illustrate that members of a learning environment may experience that environment differently, and steps can be taken by senior members to create a fertile soil for learning. Specific behaviors and language of attendings may promote a “culture change” (Bearman et al. 2021, Watling et al. 2020). Future work is necessary to define this concept in its application to uncertainty and to understand its effectiveness.

A formal introduction to clinical uncertainty may aid students in transitioning from “textbook medicine” in the classroom to negotiating “real-world medicine” encountered on the wards, where uncertainty is ubiquitous (Luther and Crandall 2011). Formal curricula and accompanying faculty development should be designed and evaluated to determine best practices for teaching uncertainty. The optimal content and pedagogy for such curricular innovations are not well known, and future work is needed. Specifically, future research could investigate whether explicit instruction regarding uncertainty in medicine is effective as compared to the tacit learning of uncertainty that occurs in mastery-oriented learning environments. Coursework in uncertainty in medicine should also develop residents’ and attendings’ competency in communicating uncertainty with colleagues and with patients (Gordon et al. 2000; Bhise et al. 2018).

Our results are limited by convenience sampling in a training program at one academic medical center and it is unclear to what extent they generalize across other centers or specialties. Survey responses are self-reported and thus susceptible to social desirability bias. To address this, we used measurement scales with strong validity and collected responses in a confidential manner. Participant behavior may have changed as a result of being observed. As such, participants were not told the purpose of the study and
ethnographic observations took place prior to survey distribution and semi-structured interviews. We tested only for associations in our study design and cannot draw conclusions about causality. Our study is strengthened by its mixed-methods approach, which gives us confidence in our results. Three distinct methods applied in the same setting and same population allowed for triangulation and internal validation.

**Conclusion**

The perception of a stressful and competitive clinical learning environment is associated with graduate medical trainees’ anxiety in facing uncertainty, symptoms of burnout, and reluctance to disclose uncertainty. Residents and attendings agreed there is a need to explicitly address uncertainty and develop strategies to tolerate and manage it in an adaptive manner. In addition to positive role modeling by senior clinicians, a formal curriculum addressing uncertainty in medical school and residency may have beneficial downstream effects on residents’ clinical learning, professional development, and wellbeing, and in turn on the clinical learning environment in GME and potentially patient quality and safety.

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The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

**Prior presentations**

Johnson MW, Gheihman G, Thomas H, Simpkin A, Schiff G, and Olson A. Facing uncertainty in the GME learning environment: perceptions and experiences of internal medicine residents and attending physicians at a US academic medical center. Poster presented at: Diagnostic Error in Medicine 10th International Conference; 5 November 2018; New Orleans, LA.

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**Authors contributions**

Mark W. Johnson led the design of the study, conducted data collection by distributing surveys, and completing semi-structured interviews and ethnographic observations, led data quantitative and qualitative data analysis, drafted the manuscript and tables and figures, and completed all revisions and final review of the paper. Mark W. Johnson performed all duties of the primary author together with Galina Gheihman. Galina Gheihman contributed significantly to data analysis and framework creation, drafted the manuscript and completed all revisions and final review of the paper. Galina Gheihman performed all duties of the primary author together with Mark W. Johnson. Horatio Thomas contributed to data analysis and revised the final paper. Gordon Schiff advised on the design of the study and data collection, supervised data analysis and framework creation, as well as reviewed and revised the final paper. Andrew P.J. Olson advised on the study design, facilitated data collection on-site, supervised all data analysis, and contributed significantly to the revision of the final paper. Andrew P.J. Olson performed all duties of the senior author together with Arabella Simpkin Begin. Arabella Simpkin Begin advised on the design of the study, supervised all data analysis, and contributed significantly to the review and revision of the final paper. Arabella Simpkin Begin performed all duties of the senior author together with Andrew P.J. Olson.

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**References**

Allison JJ, Kiefe CI, Cook EF, Gerrity MS, Orav EJ, Centor R. 1998. The association of physician attitudes about uncertainty and risk taking with resource use in a medicare HMO. Med Decision Making. 18(3):320–329.

Bhise V, Meyer AND, Menon S, Singhal G, Street RL, Giardina TD, Singh H. 2018. Patient perspectives on how physicians communicate diagnostic uncertainty: an experimental vignette study. Int J Qual Health Care. 30(1):2–8.

Bhise V, Rajan SS, Sittig DF, Morgan RO, Chaudhry P, Singh H. 2018. Defining and measuring diagnostic uncertainty in medicine: a systematic review. J Gen Intern Med. 33(1):103–115.

Bhise V, Rajan SS, Sittig DF, Vaghani V, Morgan RO, Khanna A, Singh H. 2018. Electronic health record reviews to measure diagnostic uncertainty in primary care. J Eval Clin Pract. 24(3):545–551.
