**“Without responsibility, there is no uncertainty”:**

**Postgraduate students’ experiences of clinical uncertainty**

# Abstract

**Introduction:**

Uncertainty tolerance is an essential attribute of competent physicians. Uncertainty has been largely explored in senior physicians, yet few data are available in medical students. Exploring the experience of clinical uncertainty in senior residents and fellows could support educational efforts to develop training programs for uncertainty tolerance.

**Methods:**

We analyzed 3 semi-structured focus groups to explore trainees’ experience of clinical uncertainty. Analysis was performed using in-parallel deductive approach for coding according to Hillen’s “uncertainty framework”, and inductive approach to identify new emerging themes and subthemes. The relationships between emerging and existing themes were identified through axial coding.

**Results:**

We conducted 3 focus groups, involving 15 trainees from 5 medical schools in France. Students described three major themes of uncertainty: issue, responses, and moderators. Issues pertained to the clinical task or medical outcome at stake, and involved moral and ethics dilemmas as prominent situations, while uncertainty related to communication with patients or relatives, and related to optimal therapeutic strategy, were also described. Four major types of responses were identified: cognitive, emotional and behavioral immediate responses, and a delayed response. In behavioral responses, trainees reported shifting from analytic to intuitive reasoning processes to cope with uncertainty. Delayed response to uncertainty was identified as a key emerging subtheme, in which students described how they developed experiential learnings, while engaging through a reflection-on-action process. In moderators, trainees described how night shifts, and professional responsibilities endorsed despite being students, modulated their perception of uncertainty.

**Conclusions:**

Reflection on action was crucial for trainees to develop experiential learnings. Newly endorsed responsibilities inherent to the status of senior resident or fellow was a major moderator of uncertainty experience. Our results therefore support the need to promote reflexivity and to scaffold responsibilities in early medical curriculum to foster uncertainty tolerance in medical students.

# INTRODUCTION

Experiencing uncertainty, “the conscious, metacognitive awareness of ignorance”1 2 3 4 is inherent in medical practice. Among the variety of reactions to clinical uncertainty, many have proven detrimental on health care outcomes, including burnout among physicians, overuse of healthcare resources, or medical errors. 5 6 7 8 9 10Conversely, uncertainty may foster positive responses, such as innovating or developing expertise.11 12 The concept of “uncertainty tolerance” has been proposed and is now widely endorsed, to encompass the whole range of adaptive and maladaptive responses to uncertainty in clinical settings.13 10 14 15 Hillen et al have proposed a conceptual integrative framework to capture uncertainty tolerance:16 in accordance with the taxonomy initially proposed by Han et al,3 uncertainty is conceptualized as a metacognitive construct, pertaining to an object, *i.e.* a medical problem, and produced by the conscious individual perception of ignorance. Three stimuli related to the object can induce uncertainty: ambiguity *i.e.* the lack of reliability, credibility, or adequacy of information, complexity *i.e.* characteristics of information that limit understanding, or probability *i.e.* randomness or indeterminacy of future outcomes.16 The overarching concept of uncertainty tolerance is both the product of ignorance perception and individual’s responses to uncertainty. According to Hillen’s framework, uncertainty responses include three core domains: emotional, cognitive, and behavioral responses, the latter corresponding to regulation strategies to cope with uncertainty.17 Various individual or situational characteristics, referred as “moderators”, may act to influence either the subjective perception of or the responses to uncertainty.16

The ubiquity of uncertainty in modern clinical practice, and the vulnerability of medical students to maladaptive responses,13 18 19 suggest that clinical uncertainty (i.e the uncertainty related to aspects of patient care)20 is a major stake of medical education.78 Although several reports suggested a positive impact of early educational interventions developing uncertainty tolerance in medical students,21 22 23 24 medical curricula generally still present major shortcomings regarding students’ training to cope with uncertainty.25 Therefore, educational guidelines from many countries highlight the lack of training for uncertainty tolerance in undergraduate students, with ongoing calls for filling this gap.26 27 28 29

Although Hillen’s model construct provides a valuable framework to explore uncertainty tolerance in senior physicians, the transferability of this framework to medical students has not been evaluated. Moreover, exploring student’s perspective is mandatory to develop efficient curriculum that would best meet the students’ concerns, in accordance with a training needs assessment approach.30 31 Importantly, the way uncertainty experience is influenced by specific factors, such as being in a student position rather than in a senior doctor position, or appraising a work situation as a learning situation, rather than a professional environment, is still to be determined. Exploring the concept of clinical uncertainty in medical students in their last years of training, may also help to underscore important concepts related to upcoming medical responsibilities and decision making. Nonetheless, data regarding the experience of uncertainty from postgraduate students are scarce.

Therefore, this study aimed to explore how post graduate residents and fellows experience clinical uncertainty during their hospital placements, in order to enrich the referral construct with theses perspectives, further supporting forthcoming educational interventions to develop uncertainty tolerance among medical trainees.

# METHODS

## 2.1 Study design

Building on the “uncertainty in health profession” framework proposed by Hillen et al, and informed by a constructivist grounded theory approach,32 we interviewed 15 postgraduate students from various medical specialties , in 3 semi-structured focus groups involving between 4 and 6 students each, from January to March, 2022 (Table 1).

After receiving ethics approval, participants were recruited from 5 French medical schools across the country, using e-mail calls. After providing informed consent, they were invited to participate in 60- to 90-minute-long virtual focus groups.

## 2.2 Context

The French Medical curriculum entails 6 years of undergraduate education. Years 4 to 6 are considered clinical years, during which students undertake 3 months rotations in various hospital wards. Students graduate by the end of Year 6 through a nationwide contest, and their ranking allow them to select their final medical specialty. Thereafter, postgraduate students, or trainees, complete a 3 to 5 years-long clinical training, during which they undertake successive 6 months rotations in wards affiliated with their medical specialty.

## 2.3 Sampling

We purposively enrolled postgraduate students during their senior residency and medical fellowship, as we aimed to capture students’ experience of uncertainty from authentic workplace clinical situations. We enrolled post- rather than undergraduate students as in France, hospital placements of clinical years pregraduate students do not guarantee a sufficient exposure to complex professional situations, including uncertainty. We enrolled students from Year 7, to explore the influence of limited professional experience, and of the transition from early resident status to senior residents and fellows.24 Senior residents to junior doctor during their 7th to 11th years of training were also enrolled, to capture the influence of progression through curriculum on uncertainty experience. Such approach is in line with the contemporary view of uncertainty as a dynamic state, evolving over time.24 33 34 35 36 37 As we aimed to specifically focus on “Medical” clinical uncertainty experienced during hospital placements, General practice residents -who mostly trained outside hospital-, as well as Surgery residents/fellows, were excluded from this study. We enrolled students from various French medical school to leverage the differences that can be seen across universities regarding uncertainty-focused activities and trainings.

## 2.4 Data collection

Each focus group was facilitated by one investigator experienced in qualitative research along with two observers and note-takers. Focus groups were conducted using a specific standardized focus group guide. The focus guide was developed jointly by three investigators (NB, AL, YL), and was then reviewed by a fourth investigator (PP), and modified accordingly (supplementary data). The relevance of each question was tested and discussed with trainees with cognitive debrief. Participants were asked to discuss a personal specific situation encountered during an hospital placement, in which they experienced uncertainty.

Virtual focus groups were conducted and recorded online using GoogleMeet® software with respect to privacy and security standards, to account for pandemic restrictions and due to the multicenter design of the study. Verbatim were transcribed, anonymized and checked for accuracy. Focus guide and participants quotations were translated into English for publication purposes.

## 2.5 Analysis

Transcripts were analyzed using the rigorous and accelerated data reduction (RADaR) technique.38 Two approaches were used in parallel for analysis. A deductive approach was used for coding using Hillen’s framework,16 combined with Han’s taxonomy of regulation strategies for categorizing individual responses.17 Concomitantly, materials that did not fit into the reference framework were inductively analyzed, to identify emerging themes and sub-themes. Open coding was followed by an axial coding phase using a constructivist grounded theory approach, aiming to develop hypothesis regarding relationships between new and existing themes. Finally, selective coding was used for refining the new concepts into emerging themes. Constant comparisons were made between emerging themes and previous transcripts throughout analysis, to ensure the consistence of the new codes. Verbatim were analyzed following each interview, so the codes could be modified accordingly. Each verbatim was separately analyzed by two investigators (AL & NB). Several discussion rounds were held at each stage of analyses, and discrepancies were resolved by a third investigator (YL). New themes and sub-themes finally selected were discussed with an investigator who was not part of the coding process (PP).

## 2.6 Team reflexivity

Team discussions revealed that, while all investigators were senior medical teachers and graduated in medical education, their familiarity with the concept of uncertainty, and their own-professional experiences of this phenomenon, were diverse. Therefore, in a socio-constructivist perspective, the research team hold frequent and iterative meetings throughout the entire research, in which they shared their opinions, confronted their views, and reconsidered their positions. By doing so, the research team sought to take substantial benefit from their various perspectives, so they could stay open-minded to emergent concepts and novel ideas. Importantly, all team members were practicing physicians, with a daily clinical activity -including night shifts- assuming both patient-care and student bedside teaching in their respective departments. These attributes likely facilitated the interactions with participants during the interviews, and provided input for the interpretation of the data.

# RESULTS

All participants easily and rapidly reminded a clinical situation of uncertainty. They all acknowledged the high occurrence of uncertainty in their clinical activities, as illustrated by Student 1:

*“[Would you recall a remarkable situation encountered while on hospital placements, in which you felt uncertain?] Well, it’s difficult…there are so many!”* Student 1, Year 7

Deductive coding according to Hillen’s framework adequately encompassed the experience of clinical uncertainty in trainees, with three major themes being identified: i) Issue, ii) Responses and iii) Moderators (Table 2)**.** Within these themes, several emerging subthemes were further identified through inductive coding. The proposed definitions of themes and subthemes are presented in Table 2 (Supplementary data). Quotations (Q) illustrating each themes and subthemes are presented in Table 2.

## 3.1 Issues

From the senior residents and fellows’ perspectives, uncertainty raised from a clinical issue – i.e. the clinical outcome or task to be performed-, in combination with a lack of information due to complexity, ambiguity, or probability.

Moral and ethics were among the most frequently reported issues, including situations related to end-of-life. Uncertainty was related to the level of active care, and the risk of unreasonable obstinacy. These situations were associated with both complexity, and ambiguity, as sources of uncertainty as identified by Hillen’s framework (Q1).

*“I spent the first three months of my fellowship in an Internal Medicine department, where we had many COVID-19 patients, a large part of whom were aged, so we knew they would not be admitted in ICU… And I think my greatest uncertainty, and the most complicated situation, occurred during the second week of my rotation, when I had two seniors, with divergent opinions, and then one of them had to leave. So, I stayed with a chief who was quite reluctant to “let it go” when patients were at the very end of their lives, to withdraw oxygen support. So I found myself alone… discussing with the nursing team, not knowing what to do…”* Student 3, Year 7

In such situations, ethics issues were described as socio-cognitive conflicts, deriving from the confrontation between a scientific view (“what is technically possible?”), and a humanist, moral view of Medicine (“what would be the most appropriate/adapted management of the patient in the given situation?”). The social component was related to the source of uncertainty, which was the ambiguity resulting from the conflicting instructions of the supervisors.

Another central issue was communication, and more specifically the communication with patients’ relatives, probability and ambiguity being the most frequent sources of uncertainty in these situations (Q2). The task of communicating self-uncertainty to the patient or relatives was described as a particularly high-stake issue (Q3). Such tasks involved moral and ethics concerns, related to the best way and to what extent uncertainty has to be shared considering the patients, relatives and students’ own specific cultures, beliefs and concerns.

In therapeutic issues, participants described the difficulty to treat a patient with conflicting conditions (Q4). In these situations, uncertainty derived from complexity, as suggested with previous work conducted in clinical years student’s.20 Diagnosis issues were less frequently discussed by participants (Q5).

## 3.2. Responses

Responses to uncertainty included four themes: cognitive response, emotional response, behavioral response, and delayed response. All type of responses were closely interrelated, with important overlap and interconnexion between each response type (Figure 1).

In cognitive response, some participants reported uncertainty acknowledgement (Q6), while others described doubt as predominant cognitive appraisal (Q7). While aversion for uncertainty was frequently reported (Q8), some participants also described positive impact of uncertainty. In some cases, experiencing uncertainty fostered valuable behavioral responses such as increased clinical reasoning or seeking for new information with subsequent increased knowledge and newly acquired skills (Q9).

In emotional response (Table 3), students described various reactions such as panic (Q10)**,** sadness (Q11), guilt (Q12), or anger (Q13). A sensation of discomfort was reported, closely linked to anxiety or stress (Q14). Loneliness pertained to the issue of communicating self-uncertainty to patient’s relatives (Q15). Strikingly, almost all emotional reactions were described and considered “negative” or unpleasant.Some students even reported a feeling of incompetency, deriving from the frustration of not being able to make a decision (Q16).

Only one participant mentioned a feeling of satisfaction. Satisfaction derived from the positive perception of the action undertaken during the situation. This response could result from self-reflection on action process, but also from external positive feedback provided by a supervisor, overcoming the limits of student self-assessment accuracy39, which had previously been underscored in professional environment (Q17).40

As multiple emotions were frequently mixed, the emotional response of participants to uncertainty was better appraised as a continuum, as described by Student 11:

*“The people were are facing are expecting answers...what the patient wants to know, is how it's going to happen...yes, I find it very distressing, highly isolating and we feel deeply alone. And yeah, I find that my answer is not satisfactory -well- the answer I gave them at that moment was almost frustrating.”* Student 11, Year 9.

Behavioral responses pertained to the strategies used by students to regulate and cope with uncertainty. Information seeking aimed to reduce uncertainty, by collecting additional information through diagnostic testing, literature search, or expert consultation (Q18).

The “test of time” strategy, i.e. endorsing an expectative posture to collect additional information from disease evolution, was also reported, especially in case of therapeutic (Q19), or communication issues (Q20).

“Adjusting strategies” -targeting the perception of uncertainty itself- were also described. To that extent, participants reported decreasing their level of uncertainty by either reproducing knowns procedural sequences through pattern-recognition (Q21), or ignoring the source of ignorance (Q22). These two strategies led students to shift from an hypothetico-deductive, analytical process, to an intuitive, “experienced-based” reasoning, thus limiting the conscious deliberation that produces uncertainty. Accordingly, prototypes – a categorization of medical knowledge around representative exemplars41 42 were among the first-line strategies to regulate uncertainty:

*“In fact, we also manage uncertainty by analogy: we have seen that in these situations someone acted like this and we realized that this way of acting was the most appropriate one, so we try to reproduce that too... basically, I think that it is really the singularity of each situation that makes us being uncertain.” Student 10, Year 11*

Besides, strategies aiming to resist to the negative psychological effects of uncertainty were discussed. Participants reported that “taking a step back” from the situation helped them to regulate their emotional and behavioral responses to uncertainty (Q23), while others reported trying to defer decision when being uncertain (Q24).

Participants also reported adapting to uncertainty, by adjusting their goals in response to an irreducible uncertainty (Q25).Such adaptative response may be particularly demonstrative of an already well-developed uncertainty tolerance, and the complex sequence between uncertainty acknowledgement, emotional response, and adaptation to uncertainty as a final behavioral response, was best encapsulated by student 4, Year 11:

*“From the moment we accept that there will be uncertainty... we manage to feel more comfortable and to be less, I think, tetanized…we may be a little better at weighing the different elements that help us make a decision... because in fact, from the moment we start to be a little more experienced... we are able to identify several possible options, ... and generally there is not only one choice being all good and one another choice being all wrong, so it is all about being ready to take the one that we think as being the best at that time.”*

Relating with others allowed participants to protect themselves against the aversive psychological effects of uncertainty, by sharing with other professionals the decision responsibility or their experience. To that extent, paramedics as well as peers or supervisors, were considered as valuable resources (Q24, 25).

Delayed response was identified as key emerging subtheme, encompassing reactions related to cognitive, emotional and behavioral domains, but extending beyond the clinical situation or arousing once the exposure to stimulus had ended (Q28). This subtheme largely was largely linked to metacognition, as reflection was almost constantly described as “on action” rather than “in action”:

*“The anger...the fact that I was angry with myself...: I took the patient file, I brought it home. I went over it again for hours and hours, dissected it, to find out what I could have done, what I had missed, and also to realize that "this is how it is, I did the right thing, there were things, that in fact I couldn't know at that time...” Student 1, Year 7*

Accordingly, negatively connotated emotions -such as anger- were reported as fostering reflection, enabling students to identify the “unknowns unknowns” from which clinical uncertainty raised. Not only this delayed reflective response was described as ameliorating uncertainty tolerance, but also as fostering the development of new skills through experiential learnings (Q29).

## 3.3. Moderators

Two moderators deeply influenced uncertainty experience: being on a night shift,and assuming responsibilities while being a student.

In night shift, two subthemes were highlighted: loneliness, and the need for immediate action making in emergency.Loneliness was described as a limitation of either student’s external resources to cope with the difficulty of the decision-making process, and as altering self-confidence, because of the inability for the participants to obtain an immediate experimented approval. Consequently, loneliness was a strong moderator of uncertainty experience, directly influencing both the behavioral response i.e. the decision-making process, and the emotional response to uncertainty (Q30).In emergency situation,uncertainty stimuli were notably related to therapeutic issues (Q31). While the limited time available for reasoning in such situations and the absence of supervisor to support decision-making were both discussed, the influence of fatigue and other night shift-related hazards were not explicitly mentioned.

Post-graduate students in France are students in medical responsibilities with the ability to be first line prescribers. This specific status deeply affected their experience of uncertainty, as several fellows reported a situation requiring decision making on their own (Q32). Participants also reported an uncertainty related to hierarchical considerations about their status: a lack of self-confidence, or a “fear of being a bother” was described while explaining the tendency of student to side with their supervisors in case of disagreement (Q33). Anticipating mentor’s reaction as decision-making guidance was discussed, in accordance with the historically described student strategy of “psyching out instructors” (Q34).43Several uncertainty situations pertained to an ambiguity surrounding the status of being a senior resident or fellow, and the level of autonomy that was expected from students (Q35). Notably, nurses were also reported as a locus of this ambiguity (Q36).

Early career or transition phase (the first year following graduation or during rotations) were also mentioned as a period of constant uncertainty (Q37):

*“Well, uncertainty was a little bit every day, every day of my first three weeks, I think, where I couldn't do anything, everything was a discovery. And I couldn't do anything without my supervisors.”* Student 9, Year 7

Another moderator stemmed from students acquiring experiential learning throughout their last years of medical training, allowing them to better tolerate uncertainty (Q38), whereas lack of experience inversely influenced uncertainty tolerance (Q39). Consequently, participants reported a shift in their experience of uncertainty during these last years of medical training, influencing their emotional and behavioral responses:

*“I think we have gone from "I don't know what to do and I have no idea", to "I hesitate between two types of treatments/management" and "I don't know which one is the best one". But as a result, making a mistake, is perhaps less serious if we hesitate between these two things, well, we are perhaps more capable of intellectualizing it and reasoning about it, I think”. Student 5, Year 9*

Nonetheless, the evolution of uncertainty tolerance throughout residency and fellowship was not consistent among participants:

*“In these situations, I found that the more I progressed in medical training, the more I had doubts about how to react. I think that at the beginning, I acted more automatically and I had less doubts, but finally I faced more failures… And as I went along with the succession of failures, I accumulated more doubts.”* Student 7, Year 9

This example is thus consistent with previous work reporting student’s perception of failure whilst they transitioned from classroom to uncertain, clinical environment.44

Beside the accumulation of experiential learnings, participants also described the influence of their medical educational background on their tolerance of uncertainty, especially through simulated consultations trainings (Q40), and role modeling (Q41). Students also discussed the deleterious impact of their educational background on their uncertainty tolerance, even reporting a feeling of “betrayal” related to the lack of ambiguity, and of the “black or white” nature of tests and exams they had taken (Q42, 43). Besides, educators intellectual candor, i.e the ability of educators to disclose and explicit their own uncertainties to students, was reported as relevant for promoting uncertainty tolerance (Q43).

Finally, fellows highlighted the negative impact of institution hidden curriculum:

*“It is so regrettable that uncertainty is considered a negative thing from the very beginning of medical studies… from a chief's point of view, if the resident is uncertain, it is because he is not skilled enough. Actually, when we assume that we are in uncertainty, that we don't know, it's perceived as something negative, and I think it's a real pity, because that's precisely what we should be taught: how to react when facing uncertainty, what we can use as a resource, and that our superiors above all should make us understand that they are in uncertainty too.”*

Student 10, Year 11.

# DISCUSSION

Although Hillen’s framework encompassed all three major themes of clinical uncertainty experience in senior residents and medical fellows, we identified an important emerging subtheme, which was the delayed response to uncertainty. Delayed response stemmed from student’s desire to deepen their understanding of the situation, for ultimately developing new skills and promoting behavioral changes to cope better with similar situations in the future. Consistently, students reported engaging themselves into a reflection-on-action process, which was previously shown as enhancing the development of new skills.45 46 Accordingly, students made from their situation of uncertainty an opportunity to implement Kolb’s Learning Cycle to develop experiential learnings:47

*“Since that experience, I realized that in the end, ethical discussions were never completely "framed". And so when I had a new patient with a similar situation, I anticipated by going to discuss with my boss before he left, and by asking him "but if we ever have such and such an element that changes, how will our decision evolve? "In other words, I try to better anticipate the evolution, and my decisions.” Student 1, Year 7*

Hereby, Student 1 illustrated how he developed, from an uncertainty situation issued from an ethics dilemma, forward planning skills, which were found as important strategies to cope with ill-defined problems in both senior physicians and students.48

Experiential learnings were not only depicted as additional resources to cope with similar situations, but also as making sense of the situation, thus moderating final emotional and cognitive appraisals. Interestingly, the delayed emotions of anger and frustration were reported as supporting students’ engagement into reflexivity. Although delayed reflection might be seen as an emotional regulation strategy, anger or frustration may also pertain to student’s perception of task value.49Such an intense emotional response may reflect student’s engagement to achieve their clinical purposes,thus emphasizing the motivational and educational value of workplace-based training, as an authentic learning environnement.505152

While Stephens et al recently reported the broad experience of uncertainty in undergraduate students,20 53 our work focused on clinical uncertainty, defined as an uncertainty arousing from a professional situation, as the result of the combination of an issue (the professional clinical task to accomplish) with a source of uncertainty, in a specific hospital environment. We found night shifts and being a student as important moderators of uncertainty experience. Notably, both referred to the responsibilities which trainees had to endorse. Indeed, fellows in France are considered as “young doctors”, with the ability to prescribe, and make decisions by their own. Endorsing responsibilities was strongly reported as a source of stress, an overarching appraisal pertaining to both cognitive (aversion) and emotional (fear, uneasiness) responses. Night shifts were described as increasing the burden of responsibilities of trainees, in relation with loneliness which prevented them from using decision sharing as a regulation strategy. Moreover, the need for immediate action in emergency situation was described as a high-stake, stress producing issue, in accordance with previous works.54 Stress generation in uncertainty seems therefore of major concern,55 due to the deleterious impact of stress on physician’s performance.56 57

While being a student was found to be associated with a lack of self-confidence, causing a reluctance in engaging or assuming self- decision making,58 references were also made to the ambiguity surrounding fellows’ status, pertaining to their prerogatives and to what was expected from them. If such uncertainty was previously reported as a major determinant of the experience of being a student, in a Swedish population of undergraduate students59, this subtheme was more anecdotal in our study. This could be explained as trainees enrolled in our work were post-graduate, and consequently more experienced students, who undertook sufficiently long placements to allow them to fully establish their self- position into the medical team. In line with this, Stephens et al. described educational uncertainty (i.e, student uncertainties about what they need to learn and how to learn it) as the dominant uncertainty stimulus among clinical years students.20 In this study, students appraised their clinical placements mostly as learning, rather than professional, environments. In our work, trainees mainly described their clinical environments in terms of professional situations, taking them to a position of responsibility. Likely, the complete clinical immersion which begins after graduation entails a shift in trainees’ experience of uncertainty, raising the hypothesis that the growing responsibilities endorsed during their last years of training, act as a major moderator of clinical uncertainty. This was resumed by Student 12, Year 8:

*“In any case, as long as we have no responsibility, we have no uncertainty”*

Weather these emerging responsibilities issued from the change in student status after graduation, or from patient-centered, professional concerns, is still to explore.

Subthemes such as concerns for ameliorating oneself as a doctor through reflexivity, assuming new responsibilities, communicating with patients and relatives, or referring to ethics and moral to best match with the patient’s interest and perspective, deeply influenced uncertainty experience, all of them being related to the broad concept of professionalism.6061 To that extent, promoting professionalism teaching in post graduate medical education may be a valuable strategy to help trainees to address these issues, therefore enhancing their uncertainty tolerance.

According to previous findings, clinical experience was found as a strong moderator of uncertainty experience, through its influence on clinical reasoning. 48 62 63 By relying on their prior experiences, trainees described shifting from an analytic to an intuitive process, based on the prototypes they had encoded.42 Therefore, “pattern-recognition” was a frequently employed behavioral response for adjusting uncertainty, identifying clinical experience as a key internal resource to cope with uncertainty. If the wider use of pattern recognition as experience increases could be seen as developing expertise,64 this also raises the concern of increasing the risk of medical errors. Indeed, decreasing conscious deliberation through intuitive reasoning overuse has been found to be associated with clinical reasoning bias.65Accordingly, Ilgen et al. advocated that the injunction of “generically tolerating uncertainty” could decrease self-monitoring while encouraging lack of vigilance in students, entailing risk for premature closure.66 Therefore, the framework of “feel comfortable with uncertainty” was proposed,66 to better encompass the influence of determinants such as the cyclical nature of reasoning in uncertainty, or forward planning skills, on global uncertainty experience. To that extent, our results are in line with henceforth considering the concept of “feel comfortable in uncertainty” for educators to support the development of clinical reasoning in uncertainty in trainees.

## 4.1 Limitations

Our small sample size may have limited the breadth of our results. Nonetheless, data saturation was reached, our research aims were relatively narrow, (exploring a single construct), and our analysis were theory informed. We therefore consider our population provided sufficient information power.

Besides, the investigators were known from some participants as educators. However, none of the authors were involved in either teaching or assessment of participants during the study period.

Lastly, a common pitfall in focus group interviews is that student might be reluctant to share personal, emotional or challenging situations, with other participants. We assume this was not the case in the present study, as the rich interactions all along the 3 interviews allowed participants to discuss their emotions, own-limits or failures.

## 4.2 Implications for medical education

The emerging subtheme of delayed responses prompts the need for an extended follow-up of fellows after the acute situation of uncertainty is over. Repeated debriefing may be helpful for preventing students from adverse reactions to uncertainty, and maximizing the educational benefits of such situations. In this perspective, a longitudinal approach involving mentorship would be relevant, referencing to the model of longitudinal integrated clerkship curriculum.67 The wide use of pattern-recognition for decision making in uncertainty calls for iteratively exposing students to uncertain, complex, contextualized learning situations throughout their curriculum. Doing so, educators should nonetheless aim to directing students’ attention towards the potential bias associated with exclusively intuitive reasoning. To that extent, (semi)authentic learning environment such as simulation-based trainings, and hospital placements, may provide valuable learning situations**.**23 As a first step, a didactic approach of prototypic workplace situations would be warranted to identify key uncertainty learning situations. In line with the EPA perspective,68 such authentic uncertainty situation could serve as basis for developing aligned uncertainty-focused trainings and assessments. Moreover, promoting reflexivity all along the medical curriculum would support both the objective of students’ professionalization, and skills development through experiential learnings. A special attention should be made to reflection in action, which was rarely reported by fellows.Scaffolding students’ responsibilities during their clinical years should be promoted, as endorsing responsibilities was a major moderator of uncertainty experience. Finally, our findings support that role modelling involving sharing uncertainty experiences between educators and learners would be a valuable teaching strategy, in accordance with other studies reporting the powerful impact of educators “intellectual candor” on students’ clinical uncertainty tolerance. 53 69

## 4.3 Implications for future research

Future research should be directed toward a better understanding of the influence of situational specificities on individual’s reactions. Such effort could help identifying the most adapted response to a given situation, which could be further promoted in medical students. Accordingly, our results call for further insights on the influence of uncertainty on clinical reasoning. The moderating factors responsible for stress as a response to uncertainty would equally benefit from in depth-explorations. Finally, the influence of clinical experience on uncertainty tolerance would need to be explored with a longitudinal approach throughout residency and fellowship, to better understand and explain the discrepancies observed between participants in our work.

# CONCLUSION

Building on Hillen’s integrative framework, we identified three themes encompassing senior residents and medical fellow’s experience of clinical uncertainty: medical issues, responses, and moderators. Importantly, a delayed cognitive, emotional and behavioral response to uncertainty was found, encouraging supervisors to extend their supervision beyond the acute situation. Reflection on action was found to be a key emerging subtheme, fostering experiential learnings, whereas students lack of experience or self-confidence, and ambiguity surrounding their role, negatively influenced their experience of uncertainty.

Our findings demarked from those previously obtained in younger clinical students, as newly endorsed responsibilities, inherent to senior resident and fellow status, were identified as a strong moderator of uncertainty experience.

Consequently, future efforts to develop uncertainty tolerance in medical students should promote early exposure to uncertainty with scaffolding of responsibilities, in both non-workplace and workplace-based learning situations. Since professionalization is closely linked to uncertainty experience, and acknowledging the ubiquity of uncertainty in modern medical practice, such efforts are of upmost importance given the social responsibilities of medical schools to train competent professionals.

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None

AUTHOR CONTRIBUTIONS

All authors designed the study protocol, and recruited participants. NB, AL and YL collected data. All authors participated to data analysis and interpretation. NB, AL and YL drafted the papers, and all authors critically proofread the successive versions of the manuscript. All authors approved this final version of the manuscript to be published and agree to be accountable of this work.

ETHICS STATEMENT

Ethical approval was received from Rennes University Hospital Ethics committee (Approval n°21.178).

DATA AVAILABILITY STATEMENT

Our ethical approval did not include provisions for transferring the primary data, because of their potentially identifying nature.

**Captions**

**Figure 1**. Integrative framework of clinical uncertainty experience in medical residents

In this model, uncertainty emerges from a source of uncertainty, occurring while facing a medical issue, which is the concrete outcome which represents the object of ignorance. The subsequent individual responses to uncertainty is captured in three domains, which are cognitive, emotional and behavioral response. A delayed response was identified in several participants, which mainly be related to reflexivity, fostering experiential learnings throughout fellowship, thus ameliorating subsequent tolerance of uncertainty.

As many participants reported the repetition of situations of uncertainty throughout the last years of medical training, our framework is designed as an iterative process. Therefore, the connections between core elements are bidirectional, illustrating the modulating effects of past experiences on future situations. As a result, clinical uncertainty experience in medical fellows is set as an overarching principle, encompassing the evolution of uncertainty tolerance throughout the various clinical situations encountered during the last years of medical training, in accordance with previous works considering uncertainty tolerance as a dynamic state**.** 24 33 34 35 36 37

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