















## ORIGINAL CONTRIBUTION

# Precision medicine within health professions education: Defining a research agenda for emergency medicine using a foresight and strategy technique (FaST) review

Teresa M. Chan (she/her) MD, MHPE, MBA<sup>1,2</sup>  | Brent Thoma MD, MA, MSc<sup>1,3</sup>   |  
 John T. Finnell MD, MSc<sup>4</sup>  | Bradley D. Gordon MD, MS<sup>5,6</sup>   | Susan Farrell MD<sup>7</sup> |  
 Martin Pusic MD, PhD<sup>8</sup>  | Daniel Cabrera MD<sup>9</sup>   | Michael A. Gisondi MD<sup>10</sup>  |  
 Holly A. Caretta-Weyer MD, MHPE<sup>11</sup>  | Christopher Stave MLS<sup>12</sup>  | Felix Ankel MD<sup>5,6</sup>  

<sup>1</sup>School of Medicine, Toronto Metropolitan University, Toronto, Ontario, Canada

<sup>2</sup>Division of Emergency Medicine, Division of Education & Innovation, Department of Medicine, McMaster Education Research, Innovation, and Theory Centre, Faculty of Health Sciences, McMaster University, Hamilton, Ontario, Canada

<sup>3</sup>Department of Emergency Medicine, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

<sup>4</sup>Clinical Emergency Medicine, Indiana University, Bloomington, Indiana, USA

<sup>5</sup>Emergency Medicine, Regions Hospital, Saint Paul, Minnesota, USA

<sup>6</sup>Emergency Medicine, University of Minnesota, Minneapolis, Minnesota, USA

<sup>7</sup>Emergency Medicine, Harvard Medical School, Boston, Massachusetts, USA

<sup>8</sup>Pediatrics and Emergency Medicine, Harvard Medical School, Boston, Massachusetts, USA

<sup>9</sup>Emergency Medicine, Mayo Clinic, Rochester, Minnesota, USA

<sup>10</sup>Department of Emergency Medicine, Stanford School of Medicine, Stanford, California, USA

<sup>11</sup>Department of Emergency Medicine, Stanford University School of Medicine, Palo Alto, California, USA

<sup>12</sup>Stanford University, Stanford, California, USA

## Correspondence

Teresa M. Chan, School of Medicine,  
 Toronto Metropolitan University, 350  
 Victoria Street, Toronto, ON M5B 03,  
 Canada.

Email: [teresa.chan@medportal.ca](mailto:teresa.chan@medportal.ca)

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Stanford University Department of  
 Emergency Medicine

## Abstract

**Background:** Precision medicine, sometimes referred to as personalized medicine, is rapidly changing the possibilities for how people will engage health care in the near future. As technology to support precision medicine exponentially develops, there is an urgent need to proactively improve our understanding of precision medicine and pose important research questions (RQs) related to its inclusion in the education and training of future emergency physicians.

**Methods:** A seven-step process was employed to develop a research agenda exploring the intersection of precision and emergency medicine education/training. A literature search of articles about precision medicine was conducted first, which informed the creation of future four scenarios in which trainees and practicing physicians regularly discuss and incorporate precision medicine tools into their discussions and work.

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Based on these futurist narratives, potential education RQs were generated by an expert panel. A total of 59 initial questions were subsequently categorized and refined to a priority list through a nominal group voting method. The top/priority questions were presented at the 2023 SAEM Consensus Conference on Precision Medicine, Austin, Texas, for further input.

**Results:** Eight high-value education RQs were developed, reflecting a holistic view of the challenges and opportunities for precision medicine education in the knowledge, skills, and attitudes relevant to emergency medicine. These questions contend with topics such as most effective pedagogical methods; intended resulting outcomes and behaviors; the generational differences between practicing emergency physicians, educators, and future trainees; and the desires and expectations of patients.

**Conclusions:** Emergency medicine and emergency physicians must be prepared to understand precision medicine and incorporate this information into their “toolbox” of thinking, problem solving, and communication with patients and colleagues. This research agenda on how best to educate future emergency physicians in the use of personalized data to provide optimal health care is the focus of this article.

## INTRODUCTION

Precision health is defined as a set of techniques including genomic, biological, environmental, and public health and other data to precisely predict, prevent, and cure patients.<sup>1</sup> Precision emergency medicine is the purposeful use of big data and technology to safely, efficiently, and authentically deliver acute care for individual patients and their communities.<sup>2</sup> By tailoring medical treatments and interventions to the individual, informed by their unique genetics, environment, and lifestyle, precision medicine represents an evolution from evidence-based medicine, which places a greater emphasis on the efficacy of treatment determined by population-level research.<sup>3</sup> This new approach to care represents a once-in-a-generation paradigm shift facilitated by advancements in technology that could revolutionize our specialty.<sup>2</sup> However, we must prepare our emergency medicine workforce to fully realize its potential applications.

The adoption of novel or cutting-edge innovations in medical education and health care has historically lagged behind society's embrace of new technologies.<sup>4–6</sup> However, patients, populations, and institutions will soon come to expect that the practice of precision emergency medicine will be in the “toolbox” of all emergency physicians. Its incorporation into emergency medicine practice will be challenging due to a lack of consensus on the future of precision emergency medicine, a historic deficit of technical training for physicians, a shortage of physicians with expertise in this area working within medical education, and physician skepticism of the necessary analytic tools.<sup>2</sup> These challenges are compounded by a paucity of empirical studies exploring education and precision emergency medicine. These issues make it difficult to know where to begin when it comes to teaching the fundamentals of precision emergency medicine to all emergency physicians and health care workers in our field.

To date, is unclear how precision medicine will be harnessed in emergency medicine, making it especially difficult to engage in teaching and preparing learners for adapting to this uncertain future. It is crucial for us to consider how we should prepare our educators to teach precision emergency medicine now, to ensure future physician competence in this emerging paradigm. While scoping<sup>7–9</sup> or systematic reviews<sup>10</sup> are useful for the purposes of aggregating already published wisdom, few techniques have been used to look forward (“futurecast”) to develop forward-facing strategies for better studying a phenomenon. Foresight activities in other industries are often used to explore future facing issues or establish strategic plans.<sup>11,12</sup>

The goal of this project was to create a future-facing 10-year research agenda in precision emergency medicine for health professions educators, with the primary outcome being a set of education research questions (RQs) that must be answered in the coming decade. We also provide a roadmap for the evolution and teaching of precision emergency medicine developed using an innovative consensus-building methodology that draws from multiple fields.

## METHODS

Due to the paucity of literature around emergency medicine-related health professions education (HPE) on the topic of precision medicine, our authorship group felt that this would be an opportunity to design a new type of technique to develop a research agenda for an emerging field. In this paper we present our design and application of a novel knowledge synthesis for generating RQs that we have named the “Foresight and Strategy Technique” (FaST). Prior consensus conference techniques have relied on a mixture of literature synthesis, expert panels, and/or voting within the consensus

conference itself.<sup>13-15</sup> The FaST relies on all of these historical methods, but adds an element of future casting through futuristic stories used as a prompt to stimulate new RQs.

## Design and conceptual framework

Employing a constructivist paradigm, we conducted a FaST, which contains seven key steps: (1) literature review; (2) brainstorm of scenarios; (3) vignette construction; (4) RQ brainstorm; (5) RQ organization into knowledge/skills/attitudes (KSA) framework and voting; (6) item reduction via voting; and (7) consensus conference.

## Study setting

As part of the 2023 SAEM Consensus Conference on Precision Emergency Medicine, an international team of health professions educators was assembled as an expert working group. The team leads (TMC, FA), designed a seven-step process (as previously described) led by the two principal investigators that was conducted from December 2022 to May 2023. The team met three times but were also connected digitally by online collaboration tools to ensure continuity and momentum maintenance.

## Participants

We recruited a diverse group of experts from the specialty of emergency medicine who were both knowledgeable about health technology medicine and experienced educators ( $n = 10$ ) engaged with our international society. One co-lead (FA) acted as the recruiter and selected individuals with a known education research and scholarship track record. Inclusion criteria included thought leadership in HPE, learning analytics, informatics, and emerging technology.

## Literature review

An academic librarian (CS) was recruited to assist the team in conducting the literature review. The search strategy is detailed in Box 1. The literature search was conducted in OVID Medline (includes In-Process, In-Data-Review, and Other Non-Indexed Citations). The search covered database inception to December 2023 and yielded a total of 695 papers (see Appendix S1 for details of the search strategy). As this search was not the focus, but rather the source of inspiration for the prompting vignettes, we did not perform an exhaustive search, but rather focused on gaining maximal variability in the types of topics found. A pilot search with the same keywords within Google Scholar (up to 200 search results) did not reveal any additional topics and as such the complete OVID Medline draw was deemed sufficient.

### BOX 1 Example journaling by team co-leads during the literature review process

1. Critical appraisal and judicious integration of tech in the face of precision medicine and artificial intelligence (AI)/big data—Scenario could be from any of the below scenarios—but will really focus on that microsituation of having a learner/team discussion around too much data and how the various data points integrate into clinical decision making and how this might be at odds with the “old skool” EBM type approaches.
  - a. Learner perspective
  - b. Program director/associate program director perspective about the worries of creating the right curriculum
  - c. Combination of the above two (maybe two scenes).
2. Communication/collaboration/patient care and AI—Physician Assistant reviewing a case with an experienced seasoned clinician—Notes that the routine Algo/MLA within the new electronic health record suggests a certain course of care, but patient states that’s not their personal preference.
3. Health systems design—A senior trainee (who maybe wants to become a health informatics or precision medicine expert) is working on a project and meets with their advisor about their review of present data streams, possible integration, and a vendor that is selling them new AI tech. The trainee is leading the project to “validate” the AI algorithm within their data set but is running into troubles and worries that they do not have a great grasp on things. The advisor for the project also has problems with the “validation” and wonders if its them or that the tech is bad and cannot be integrated into their system. Wishes to meet with the head of the company to discuss more. Both the trainee and the advisor meet with their home information technology people to collaborate and then with the vendor to determine compatibility. Lots of jargon being thrown around ...
4. Educational governance—ABEM board member is discussing these competencies with someone from the Royal College of Physicians and Surgeons of Canada specialty committee and has heard that in Canada, they are having a hot debate about whether evaluation for deployment of AI tech is something they expect as a core competency of all physicians or something that should be left to a fellowship and/or area of focused competency (macrocredential). They note that a number of universities are creating microcredentials to teach these skills in the absence of some national strategy (e.g., Massachusetts Institute of Technology, Stanford)
5. What changes might we make to the Model of Clinical Practice of Emergency Medicine in the era of Precision Medicine?

These papers were then curated by one of the co-leads (TMC) into four thematic categories and 16 subcategories of papers: (1) clinical precision medicine, (2) precision medicine literature from other health professions, (3) medical education and HPE, and (4) other. [Table 1](#) depicts the breakdown of the numbers of papers in each section.

The team of investigators were divided into teams of three or four and asked to review the literature retrieved from the search to scan the title and abstracts (and possibly read full text if desired) to spot trends within their sections of the literature involving precision medicine that might result in changes in clinical care or educational in emergency medicine.

## Knowledge elicitation and foresight activity

### Priming and ideation

In November–December 2022, we then asked the team to think of future scenarios. We asked them to be inspired by the literature they were sent and engage in a foresight activity where they would journal and reflect upon what they anticipated might happen in the near-to-medium future (less than 10 years) involving precision medicine including but not limited to genomics, big data/algorithms, and other themes uncovered in the literature review. [Box 1](#) shows some of the initial thoughts from the team co-leads (FA, TMC).

### Scenario generation

In January of 2023, the team was brought together to brainstorm future scenarios based on their reading of the literature.

#### *Creative elaboration*

There was no a priori filtering of themes during this elaborative phase. All members of the team were invited to attend either one or two brainstorming sessions where they could suggest ideas and partial thoughts, riff on others' ideas, etc. During this elaborative phase, we adhered to best practices of brainstorming, evoking the idea of “Yes and ...” (which is the norm in creative endeavors such as medical improv) and asked all participants to save their filtering for later steps.

#### *Vignette construction*

Based on the brainstorming notes, three members (TMC, FA, BT) of the team with experience in vignette and scenario construction were assigned one cluster of themes to turn into a futuristic story. [Table 2](#) provides an abstract and the full text of each story. We used the literature to inspire what features and precision medicine technology to put into the vignette stories. We sought to construct each of these to reflect a future state that might someday occur. In each case, the author wrote a fictional vignette about the future and then the vignette was reviewed by the other two colleagues within the vignette writing triad (TMC, FA, BT).

## Research Question generation

Based on the cases, groups of three or four individuals were asked to complete a brainstorming grid that asked them to think about Research Questions (RQs) that were prompted by each vignette. These vignettes were then used by the team to inspire what RQs would need to be answered between now and that future state, to ensure that we had good evidence for the activities and actions within each scenario. The initial team had 1 week to engage, but all members of the team

**TABLE 1** Breakdown of papers from the literature review for the 2023 SAEM Consensus Conference subgroup on HPE and precision medicine.

Topic	Subtopic	Number of papers
Clinical precision medicine	Clinical EM precision medicine	4
	Medical (excluding oncology)	13
	Oncology	11
	Surgical	4
	Psychiatry	7
	Diagnostics	13
	Genomics and genetics	22
	Applications for clinical work, not tied to specialties	68
Precision medicine literature from other health professions	Public and population health	4
	Pharmacology and pharmacy	32
	Nutrition	3
	Nursing	7
	Dentistry	2
Medical education and HPE	General medical education	29
	Undergraduate medical education	22
Other	Digital apps	1

Abbreviation: HPE, health professions education.

TABLE 2 Summaries of Vignettes created for the 2023 SAEM Consensus Conference subgroup on HPE and precision medicine.

Story Abstract	Story
Case 1 is about the intersection of clinical informatics and human cognition. In this case, we meet a medical student who is having trouble integrating all the sources of information about a patient that are newly available to her.	<p>It was about an hour into their shift, and Divya was feeling a bit overwhelmed with her case. As a third-year medical student in her emergency medicine clerkship, she felt like a fish out of water. Her current patient, Mr. Simone, had come to the emergency department because his cardiologist had messaged him on his smartwatch about being in new-onset atrial fibrillation. This was a commonplace enough presentation, and Divya was pretty familiar with the workflow for these cases. She'd seen two similar referrals in her past shift—although one patient's remote monitoring device had ended up creating a false alert, since the AI-driven algorithm in the monitoring system had been “confused” by a combination of motion artifact and premature atrial complexes.</p> <p>That said, today, she had headed into undiscovered territory since she ended up clicking on the <i>Personalized Medicine</i> tab within the electronic health record (E). In that tab, she immediately gained access to the patient's complete genomic profile and noticed that the medications that were being suggested by the institutional protocol within the E would only be about 25% effective for Mr. Simone.</p> <p>“How are you doing, Divya?” asked Dr. Lesidi Andile. “Are you reading to review the case?”</p> <p>Divya nodded tentatively. “I guess so ...?”</p> <p>“If you need more time ...”</p> <p>Divya shook her head. “No, I'm just a bit overwhelmed by all the information ... but I can provide you with an overview of the story and my physical exam, at least.” Divya went on to regale her attending with the tale of Mr. Simone and his struggles with intermittent palpitations. He'd been resistant to smart monitoring (due to his skepticism of the companies stealing and leaking data) but his cardiologist had affirmed to him that this would be helpful to him in making a diagnosis. Reluctantly about 1 week ago he started wearing a smartwatch with heart rate monitoring and remote analysis capabilities. About 2 hours ago, he had been notified by both the smartwatch's on-board AI and then a direct message from his cardiologist via the device that he should go to the nearest emergency department.</p> <p>“This patient has all this genomic data and predictions about their drug metabolism, and I was trying to integrate all of that into my plan. You see, the protocol we've got for new-onset A. Fib. that was suggested is saying that we should start an anticoagulant for this patient due to his increased risk of stroke, but also notes that a rate control agent might be beneficial—but according to their personalized medicine pharmacological data, the drugs they can afford are really old and will only be about 25% effective!”</p> <p>Dr. Andile nodded sagely. “Sounds like you have conflicting information from several sources—what medications does the pharmacy chatbot suggest for this patient's management?” Divya pulled up that tab within her EHR interface, displaying the probabilistic matches that had been suggested by the chatbot in question. “These choices don't look great to me—to be honest, I had to look up what half of these were—like <i>metoprolol</i> and <i>diltiazem</i> are medications from <b>LAST CENTURY</b>.”</p> <p>Dr. Andile smiled. He still remembered last century but was amused by Divya's reaction. “Ok, so maybe it's time to consult the pharmacogeneticist on call then?”</p> <p>“Hmmm ... yeah, I guess ...” Noting her lukewarm response to the suggestion, Dr. Andile probed a bit further. “Do you feel comfortable with initiating that consultation? I will be right there alongside you—you can make sure to initiate a group chat and loop me in so they know you're not just willy-nilly consulting them.”</p> <p>Divya nodded and smiled. “Yeah, last time I messaged the Pharm. Gen. team the fellow really gave me a hard time. They told me that it was inappropriate for me to have asked them such a simple question and then told me never to consult them again.”</p> <p>Dr. Andile shook his head, slightly exasperated. With all of these new tech and expertise, interprofessional skills were still something that all trainees needed to be coached on, regardless of the level. “Well,” stated Dr. Andile, “I will be right there in the message string next to you, and I'll make sure to loop in their attending if the fellow does that again! They were probably just a bit grumpy because they get so many real-time requests these days.”</p>

(Continues)

TABLE 2 (Continued)

Story Abstract	Story
<p>Case 2 is where you will meet an ED quality director who is seeking to advance the health systems learning in her local ED by installing a new NLP-driven technology that seeks to provide quality insights and suggestions to nudge people toward success. Her hospital board members beg to differ ...</p>	<p>Dr. Anna Ibrahim is the emergency department (ED) Director of Quality and Patient Safety for the flagship facility of the multinational Amalphab Health System, a joint venture between two very important big-tech firms <i>Amazon</i> and <i>Amphab</i> focused on providing data informed care and precision medicine. Amalphab's motto, "standardized outcomes, individualized care," has been embedded in the organization's mission, vision, and values and is the driving forces behind, strategic, and annual plans and key performance indicators. In fact, this is one of the reasons that Dr. Ibrahim was so thrilled to be hired in the E after her national library of medicine informatics fellowship following her emergency medicine residency.</p> <p>During her first few years, Dr. Ibrahim revamped the ED quality improvement process, helped the department achieve national standards for sepsis, stroke, and myocardial infarction care; contributed to rising regional patient satisfaction scores; and introduced value-based initiatives decreasing CT usage and admissions of less than 24h duration. During this time, the department became an early adopter of precision medicine to help personalize care, standardize outcomes, and increase value. Dr. Ibrahim was the site director for a multisite study using a third-party plug-in for their electronic health record system to use NLP to scan all clinical charts and provide both individualized and group-based metrics and advice about their quality of care, stewardship, and precision care (QSP). As a result of this project, clinicians receive a continuously updated QSP scorecard with embedded learning modules for improvement potential customized to the clinician's performance. The ED had used the departmental QSP score to inform departmental clinician development work. The third-party plug-in has now been commercialized under the name <i>PreciChart</i>.</p> <p>After receiving a ringing endorsement from our emergency medicine leadership team, Dr. Ibrahim presented the ED journey using <i>PreciChart</i> at the medical executive committee (MEC) where the CEO of the hospital asked her to make the pitch again to their hospital board.</p> <p>***</p> <p>Two weeks later, Dr. Ibrahim confidently flipped through her presentations to the hospital board. They had convened on Zoom teleconference, which always made it hard to read the room.</p> <p>"... and that is why <i>PreciChart</i> will represent a major leap in ED quality improvement and empower us to engage in the leading edge of precision care!" she exclaimed confidently.</p> <p>Anna felt ardently that <i>PreciChart</i>'s AI-driven learning system could really usher in continuous improvement within their precision ED. She wanted the Amalphab Health System to establish itself as an <i>early adopter</i> of this technology and continue its leadership within the health care technology implementation space.</p> <p>"I guess I'm more skeptical about this technology," shrugged the health system's chief wellness officer. "It just feels so 'big brother' for the machine to be reading every chart and extracting quality metrics. I worry about the morale of our ED physicians regularly ... I just can't see this helping with that."</p> <p>"I agree," stated the chief recruitment and retention officer. "I heard that one of the hospitals a few cities over in Palo Alto deployed this and within 6 months they were facing a veritable revolt because the clinicians felt <i>PreciChart</i> was too overbearing."</p> <p>"I also have concerns that this technology has not yet received full approval from the FDA," noted the chief technology officer. "In the fine print, the contract states that we would have to file for a special exemption to ensure that we were only using this for research purposes to even gain access. I really think we have to be more careful and critical before we adopt a new technology like this. I know they often hide behind nondisclosure agreements and the veil of intellectual property, but the data we require for full-scale implementation across a unit is now much higher after recent legislation. I'm just not sure this is ready for prime time yet."</p> <p>Dr. Ibrahim felt deflated. She had thought that <i>PreciChart</i> was an important next step in their growth as a learning organization and that she had made a good argument in her presentation that technology like <i>PreciChart</i> would begin to dominate health care and serve as the basis for continuous licensure, credentialing, certification, and education. She wondered if her mistake was that she needed more training in health technology appraisal.</p>



TABLE 2 (Continued)

Story Abstract	Story
Case 3 is where you will meet an assistant program director who is discussing advanced qualifications for health technology. The educational ecosystem seems increasingly complex, and upskilling has never been easier ... What is the best advice for advanced training to ensure career success in trainees? What about those in practice?	<p>When his residents started asking him about "precision medicine fellowships," he knew it would be the next big thing. Dr. Trey Grandon has been an associate program director and program director for the past 20 years. The last time he remembered this much interest and enthusiasm around a topic was during the early days of ultrasound when you could not step between two of his senior residents without tripping over the cord of a probe.</p> <p>This time was different regarding the degree of uncertainty regarding the best way to pursue this new field. Some of his more recent grads that he had pegged to do quality improvement fellowships had instead pursued degrees in clinical informatics, while one of his current residents was applying to do a research fellowship and PhD in applied genomics. Perhaps unsurprisingly, even the medical students had caught on—they had an applicant this year that completed their MD/PhD with a focus on machine learning and artificial intelligence. He had been most surprised to speak to one of his colleagues, Dr. Michelle Weiler, after she returned from a sabbatical that she had used to pursue a precision medicine microcredential. He was meeting her today to discuss what she had learned and what she thought it would mean for the future of emergency medicine education.</p> <p>"It's bonkers out there right now, Trey," she said, as she sat down for their meeting. "The people that are working in this field—they come from everywhere. Some are physicians, of course, but others have shifted into it after doing advanced degrees in computer science. Others have pivoted from completely different areas after earning a few stacks of 'microcredentials' via Coursera. Trey, one of the people I'm working with, was a realtor last year, a realtor!"</p> <p>"Incredible," Trey said, as he tried to absorb this information and consider the implications for his training program. "What do you think this means for us? Should we be incorporating something into the program? Or trying to develop our own fellowship?" he asked.</p> <p>"I'm not sure ..." she acknowledged, soberly. "On the one hand, that is how we've always done things—isn't it? Sprinkle parts of the latest innovation throughout our curriculum while building more involved programs for trainees that want to specialize. But I'm not sure if that is the correct approach this time. I can tell you one thing for sure: the people I am working with have much more respect for <i>what you can do</i> than for <i>what degrees you have earned</i>. They really flipped my world upside down."</p>

(Continues)

TABLE 2 (Continued)

Story Abstract	Story
Case 4 is where you will witness some exchanges between two learners and an attending physician in the age of the digital teaching assistant. Love it, hate it, or learn to live with it—what do you think will be your fate?	<p>"This is so, so, so cool!!" remarked Jun Yoo as he walked out of an intermediate zone assessment bay.</p> <p>"Well, thank you, Jun Yoo," a voice replied from his phone. "I'm here to assist you to learn better from your patients and clinical learning environment. As your personalized digital teaching assistant, I aim to improve patient care by helping you to know your patients better and optimize your clinical processes."</p> <p>"Thanks, Arixac! You definitely helped me ask better history questions of Mr. Rodriguez in Room 15. I would have been totally lost about what questions to ask next without you! What's next for us?"</p> <p>"Well, Jun Yoo, let's head over to your computer workstation where I've started to scaffold a template for your note. Because you are still at the medical student entry competency level, I have taken the liberty of jotting down some basic notes based on the conversation I was able to overhear in the room, but it will be up to you to complete the note. I have also outlined some basic suggestions for initial orders that you can review and then discuss with your attending."</p> <p>"Wow, Arixac! What did the residents and faculty do before you existed?"</p> <p>"They would have done similar things—I was built based on modeling top teachers in North America. My behaviors and coaching are based on some of the best clinical teachers that have existed in recent memory."</p> <p>"Ok, so I'll go chart and then present to my attending physician. Do you think I can practice my case presentation with you before I talk to them?"</p> <p>"But of course," stated Arixac. "It would be my pleasure to assist you in optimizing your case presentation."</p> <p>"That's great! This is just so cool!!"</p> <p>Overhearing the conversation, Dr. Chavez-Smith sighed and shook their head. "The novelty will wear off soon, Jun Yoo ..."</p> <p>"Hmmm? What do you mean Dr. Chavez-Smith?"</p> <p>"Well, as a resident, Arixac starts to feel more like a hindrance rather than a help," they stated. "Today I turned it off for 5 minutes during my shift and I immediately got a push notification from my program director that I have not yet been approved to engage in AI-teaching assistant-optional shifts."</p> <p>"You are still a first-year resident Chavez-Smith—don't worry, your competencies will develop and your capabilities will grow," stated the attending physician, Dr. Brigitte Waldorf. "I know that the Arixac system can feel like it's overbearing at times, but honestly, as a new attending physician, I have to admit it's augmented my patient care over the years and I still turn to it at times. No one can help summarize a chart like Arixac does—the NLP algorithms have really helped to pull together information from all over the city, and it's way more efficient than trying to data-dredge and read everything. I still usually check things over a bit with the patient and their primary care doc via instant chat though—but it's such a time saver."</p> <p>"Hmmm, I've not used that function yet ... maybe there are nuances to the Arixac system that I haven't discovered yet," admitted Chavez-Smith.</p> <p>Dr. Waldorf nodded. "Yeah, just like back in the day I'm sure docs had to learn to use electronic health records properly, there's a learning curve for these new augmented intelligence systems. That said, I'm one of the Arixac SuperUsers so if you have some suggestions for improving user experience I could certainly invite you to speak to the committee the next time we have a telemeeting?"</p> <p>Chavez-Smith smiled. They had so many ideas, and was interested in augmented education. "Yeah, I would love that. Thanks for the offer. But for now, Arixac is nudging me to reassess all my patients."</p> <p>"Sounds good," said Dr. Waldorf, nodding sagely. She then turned her attention to Jun Yoo. "Hey, so let me know when you're done your charting and want to review. But just one more fun fact: Did you know that once upon a time we used to actually <i>chart on paper</i>?"</p>

Abbreviations: HPE, health professions education; NLP, natural language processing.



were invited to add to the grids in a generative way. Appendix S2 is a sample grid that was used to help prompt the generation of RQs. Again, participants were discouraged from filtering and were encouraged only to add to the brainstorming rather than critique or delete. Limited editing and clarity seeking were allowed (e.g., grammar, questions as comments). Each group was asked to fill out a standard grid split up by the KSA framework for various levels of learning (trainee, faculty, health systems, governance) and an “other” category was added to ensure we caught all the novel ideas.

### Consensus method: A modified nominal group method

After the RQ grids were created, the co-leads amalgamated the brainstormed RQ lists and organized them by KSA and other categories for each of the learning levels. This activity resulted in a complete list of RQs that were edited for duplication and redundancy, then voted on independently by the 10 authorship team members. Each member of the team was allowed to vote “yes” for up to 10 questions, and then they were given up to six vetoes that they could deploy to eliminate items that they deemed inappropriate or problematic. This process resulted in a reduced list of items that were then brought forward to the 2023 SAEM consensus conference in Austin, Texas, on May 15, 2023, to engage in a broader discussion with knowledge users, experts, clinicians, and other consensus conference participants.

### Ethics

This was a knowledge synthesis study and thus exempt from institutional review board oversight.

## RESULTS

The team generated four divergent futuristic scenarios envisioning ways learners and educators might encounter precision medicine. This yielded a robust research agenda. The brainstorming team developed 109 candidate RQs from these scenarios, ranging from 21 to 41 questions per vignette. Twenty-eight questions investigate knowledge elements required in the age of precision medicine, 25 questions explore the skill set required to practice precision medicine, and 21 examine future attitudes toward precision medicine. Thirty-five questions were categorized as “other” and did not align with the KSA framework. A subset of the team then edited the complete list down, merging or eliminating similar items, and editing the list down to 59 items (19 knowledge, 14 skills, 14 attitudes, and 12 other).

All authorship group members were each given 10 votes and one veto to distribute across the various potential RQs. A final asynchronous voting and veto process narrowed the list to the top nine questions before the conference. We ultimately presented only

those items that had received both multiple positive votes and no veto designations.

Thematically, the questions harvested identify micro-, meso-, and macrosystems challenges. Multiple questions aim to explore the relationship of humans with machines and the skills that might prove necessary to maximize patient or learner benefit while minimizing harm. Offering training to individuals to identify and mitigate bias in inputs, outputs, and algorithms appeared as a theme within the scenarios and RQs. Structurally, the “separateness” of precision medicine from routine medicine emerged as a theme. An example in the educational domain questions whether there is a separate clinical practice model of precision medicine distinct from the existing Model of Clinical Practice of Emergency Medicine or whether the former should be incorporated into the latter. Similarly, questions about changes to learning architecture and the structural artifacts of accreditation, certification, and licensure were identified.

At the 2023 SAEM consensus conference, the eight penultimate RQs were presented, and feedback was sought from the authorship group to develop a set of items based on our preparatory work (see Appendix S3 for details of the voting within our team). At the 2023 SAEM consensus conference, a subgroup of consensus conference attendees were given a chance to further refine or add items—which was the design of the consensus conference, with multiple simultaneous working groups, allowing attendees to help refine content within a domain that they were most expert or interested. One additional item was contributed by participants, and then these items were collectively refined and voted upon by a subgroup within the consensus conference proceedings. The items in their refined form are described in Table 3.

The top nine items were then voted upon by the entirety of the consensus conference attendees. The top three items were reported within the 2023 SAEM precision medicine consensus conference summary paper by Strehlow and colleagues<sup>2</sup> as representing the main education themes. The final top three items that were endorsed by the education implications of precision medicine consensus conference group are depicted in the infographic (Box 2).

## DISCUSSION

This consensus conference and the statements originating from this report are aimed to address the foundational issue of how HPE will participate in the development and dissemination of precision emergency medicine through a combination of discovery, instructional design, evaluation, and agenda setting.

Precision emergency medicine implies a novel approach to the creation and delivery of health care constructed on the individual's genetics, environment, lifestyle, personal values, and choices and focus on prevention as well as treatment. This framework informs the essential themes that education science needs to identify as well as use as scaffolding. HPE instructional designs need to consider heavy emphasis on the contextual application of knowledge and the new technologies and costs associated with this approach. The main

**TABLE 3** Refined list of RQs developed at the 2023 SAEM Consensus Conference by the subgroup on HPE and precision medicine.

1. What is the curriculum about interacting with nonhuman agents? (e.g., machines)
2. What techniques are best for teaching fusion skills in UME and GME settings? e.g., trainers, explainers, and sustainers ref <https://www.forbes.com/sites/insights-intelai/2018/07/17/what-are-the-new-jobs-in-a-human-machine-world/?sh=1af6723263e3>
3. How do we critically appraise the real-time usage of AI algorithms for each individual patient? How will we know when something doesn't apply?
4. What will be the impact on the relationship between the system leadership and the professional staff as the result of AI monitoring performance?
5. What do governance bodies (e.g., CME, continuing certification) perceive as their role in fostering entry of these ideas/competences into education?
6. How will you teach trainees to be able to still act, reason, or think in the absence of precision medicine tools?
7. How does invisibility and seamlessness of key technologies (AI-driven suggestions, alerts, data synthesis from personalized data) affect cognition, decision making, behavior, and learning?
8. How might we educate clinicians and trainees alike to understand, identify, and mitigate potential biases within the technologies needed for precision EM? (Including racial, SES, gender biases)

Abbreviations: AI, artificial intelligence; CME, continuing medical education; GME, graduate medical education; HPE, health professions education; RQ, research question; SES, socioeconomic status; UME, undergraduate medical education.

challenge of HPE and precision emergency medicine is that intense liminal friction exists in the space between a traditional domain of medicine with its embedded instructional systems and a new developing clinical paradigm with a rhizomatic instructional system.

Educational science and research are informed/constrained by the structural issues of curriculum development and implementation and the assessment of skills acquisition; to this, the nature of future scenarios—where the KSA as well as the precise nature of the domain are highly uncertain and fluid—demands a different approach as well as reconsideration of the destination. Given this fluidity and the need for substantive innovation in this domain, our research agenda should inform potential funding agencies in emergency medicine to create new grant opportunities based on our findings not only for the science of precision emergency medicine but for the education of the future workforce who will practice in this dynamic environment.

The uncertainty about the future, especially the content and the characteristics of the domain of precision emergency medicine, calls for a specific approach to appraise the field and create recommendations for a prioritized agenda. This group developed a new method we described as Foresight and Strategy Technique (FaST). This organizing/brainstorming/agenda-setting tool is based on the larger framework of strategic foresight, as this method seems appropriate for problems with high uncertainty. The emphasis is on scanning and gauging the

### BOX 2 Top three RQs from the 2023 SAEM Consensus Conference on Precision Medicine: HPE subgroup

1. How will you teach trainees to be able to still act, reason, or think in the *absence of precision medicine tools*? What is the *role of humans* in medicine and what skills do those humans need in the setting of AI algorithms? Master adaptive learning?
2. How do we incorporate the patient voice in how we train physicians around precision medicine? For example, which one of the skills to train physicians (understander, explainer, collaborator, advocate, skeptic) are most important for learners to master from a patient's point of view?
3. What techniques are best for teaching so-called “fusion skills” in undergraduate and graduate medical education settings to best prepare our trainees for a 21st century workplace? Is there a developmental framework for trainees at different levels? How does it change decision science?
  - a. For example, typology—trainers, explainers, and sustainers.
  - b. Depending on the background of the learner's stage in medical training versus their computer usage.
  - c. Teaching people to finding information and conveying information.
  - d. For example, ECG algorithms—ignore, incorporate other info, etc.

environment, identification of current and future trends, discerning the assumptions, development of an impact assessment, and consideration of multiple scenarios and creation of a set of priorities. The goal of this technique is not to develop certitudes but to provide decision making resiliency and prepare an organization for major change.

The consensus statement work group met as a team of international HPE educators between 2022 and 2023. Using a FaST approach, the team designed a seven-step process for scenario and RQ generation. Ultimately, high-priority questions were identified, and they are outlined below, highlighting critical themes in the development of HPE for precision emergency medicine as well as for medicine in general.

The themes are predicated on a high degree of incertitude about the knowledge and the domain aimed to be covered by education, that is, precision emergency medicine as well as the digital framework that will be created to achieve this new clinical paradigm. The most obvious incertitude is the challenge of developing a mature curriculum for a set of scientific, clinical, and policy knowledge that is still unfinished and is likely to change rapidly. Compounding this matter is the unknown nature of the roles learners are going to play in the industry, the unclear relation between learners and teachers, and the certain yet to be defined role of the interactions between

humans and nonhuman agents (AI algorithm, robots, digital devices, and tools). The ability to teach and assess these new fusion skills in an ever-evolving learning and practice environment presents novel hurdles for educators to overcome.

The next order of challenges is based on the need to develop clear and explicit guidelines related to nature and goals of assessment of these new educational objects. How are we going to assess the competency and performance of learners in a space where they rely significantly on technology for knowledge and decision-making support? Do these changes call for a complete redesign of the goals of HPE? Should the nature of education move exclusively to human traits (emotion, compassion, guidance) instead of data activities (knowledge retrieval, decision making)? How is competency interacting with nonhuman agents evaluated? What theoretical framework will inform that competency? What metrics will be used? As a corollary for the above, we have unclear governance and a lack of a regulatory framework to support any of these conceptual issues. A major structural aspect will be the requirement to work simultaneously on creating a theoretical framework, instructional system, specific curriculum, governance, and antibias-enforcement tools for HPE in precision emergency medicine.

This is a herculean labor for the educational academy in emergency medicine and academic medicine in general. The task at hand is to create a new curriculum marked by highly contextual knowledge, uncertainty, and rapid change. Considering our FaST approach and a strategic foresight mindset, we should focus on the space between established curricular creation tools such as the Kern and Hutchinson's six-step method<sup>16</sup> or CLAIM<sup>17</sup> and the skills necessary to address precision emergency medicine and its digital implementation. The effort should emphasize creating tools for educators and learners to adapt to these changes instead of creating static and rigid systems to achieve ephemeral objectives.<sup>18</sup>

Other industries (e.g., engineering<sup>19</sup> and human resources<sup>20</sup>) have faced similar challenges, and they have steered into concentrating on fusion skills, that is, the ability to interact with modern technologies and concepts, more than the specific information, tools, and products. This is an approach that likely will need to be adopted in HPE and serve as a scaffold for newer instructional designs.

Our working group has identified specific priority questions to influence, prioritize and set the agenda related to HPE and precision emergency medicine. The overarching goals are to find future trends and create resilience within the academy establishment while adopting this framework. We believe implementing this agenda will decrease the overall cost of instructional systems, mitigate the rapid changing clinical fields, supply a clear and timely workforce analysis, better allocate resources available, ultimately improve accountability, and rally public and governance support for a revolution in HPE.

## CONCLUSIONS

We created recommendations for a strategic research agenda for health professions educators to create a training framework for the

health professions and physician workforce about precision medicine in the coming decade. The Foresight and Strategy Technique (FaST) review is a creative and productive method for generating research questions within nascent and emerging fields that do not have foundational or deep bodies of evidentiary literature. In this Foresight and Strategy Technique review, we have generated a list of 109 potential research questions that were refined with the help of the attendees of the 2023 SAEM Consensus Conference on Precision Medicine. These research questions will be crucial to explore in the coming years, with a specific focus on the education and training of future physicians in the knowledge and use of precision medicine in patient and population care and institutional improvement.

## CONFLICT OF INTEREST STATEMENT

T. Chan reports salary from Toronto Metropolitan University for her role as Dean of the School of Medicine and Vice President Medical Affairs. During the time of the conduct of this research, she also received travel funding from her work with the McMaster Education Research, Innovation, and Theory (MERIT) group and teaching stipends for from the Office of Continuing Professional Development. She also discloses that in the past three years she has received various unrelated research grants, teaching honoraria, and speakership fees from academic institutions (Harvard Medical School, International Association of Medical Sciences Educators, Ontario College of Family Physicians), physician organizations (Association of American Medical Colleges, Canadian Association of Emergency Physicians, Society for Academic Emergency Medicine, the Royal College of Physicians and Surgeons of Canada, Medical Council of Canada), and governmental sources (Government of Ontario, Virtual Learning Strategy eCampus Ontario program). D. Cabrera reports funding from Diagnostic Robotics (Israel), Quai.md (Israel), and Osler Diagnostics (UK). B. Thoma reports salary from Toronto Metropolitan University for his role as Interim Associate Dean of Postgraduate Medical Education within the School of Medicine. He is also a clinician-educator for the Royal College of Physicians and Surgeons of Canada. The other authors declare no conflicts of interest.

## ORCID

Teresa M. Chan  <https://orcid.org/0000-0001-6104-462X>

Brent Thoma  <https://orcid.org/0000-0003-1124-5786>

John T. Finnell  <https://orcid.org/0000-0002-6281-6238>

Bradley D. Gordon  <https://orcid.org/0000-0002-5026-5854>

Martin Pusic  <https://orcid.org/0000-0001-5236-6598>

Daniel Cabrera  <https://orcid.org/0000-0002-5891-0459>

Michael A. Gisondi  <https://orcid.org/0000-0002-6800-3932>

Holly A. Caretta-Weyer  <https://orcid.org/0000-0002-9783-5797>

Christopher Stave  <https://orcid.org/0000-0001-8232-3994>

Felix Ankel  <https://orcid.org/0000-0002-7329-5095>

## TWITTER

Brent Thoma  Brent\_Thoma

Bradley D. Gordon  BradleyGordonMD

Daniel Cabrera  cabreraerdr

Felix Ankel  felixankel

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## SUPPORTING INFORMATION

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

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