BMC Medical Education

RESEARCH Open Access

Role of medical students in a pediatric oncology precision medicine clinic

Haley Schluterman[1*], Lindsay Zumwalt[1] and Anish Ray[1,2]

Abstract

Precision Medicine (PM) is revolutionizing patient care by integrating biomedical data, lifestyle factors, and environmental influences to guide treatment plans, particularly in the field of oncology. With its growing utility, there is a pressing need to ensure that recent medical graduates are competent in this field. This study examines the impact that involvement in a Precision Medicine Clinic (PMC) has on medical students' education and career plans. Surveys were distributed to medical students who presented at PMC meetings with the goal of assessing comfort, confidence, and perceived benefit of involvement, along with qualitative feedback. Results indicated increased comfort and confidence in PM and in the interpretation of Next Generation Sequencing (NGS) following involvement in PMC and a positive influence on future career plans. Qualitative responses highlighted enhanced critical thinking skills and career exploration. These findings underscore the significance of integrating hands-on PM experiences into medical education to effectively prepare future healthcare professionals for the medical landscape in which they will be working. Limitations include potential biases from retrospective survey responses, revealing an opportunity for future prospective surveys. This study offers a valuable framework for institutions seeking to incorporate PM into medical education curricula.

Keywords Precision medicine, Medical education, Next generation sequencing, Medical student

Introduction

Precision Medicine (PM) adopts an innovative method by considering the distinctive combination of genetics, lifestyle, and environment for each patient. Tailored medical interventions are then informed by the specifics of an individual's case. PM has been described as a cyclical process with continuous efforts to become more precise and applicable to clinically relevant models [1]. This method deviates from a traditional one-size-fits-all method and focuses on each individual's genetic makeup and how it may impact responsiveness to treatment, metabolism, dosages, and side effects.

In recent years, significant effort has been dedicated to understanding tumor biology, particularly in elucidating pivotal driver mutations that precipitate oncogenicity and how they can guide targeted therapy. Next Generation Sequencing (NGS), the foundation of PM, is a complex process that includes DNA sequencing and analysis/interpretation of mutations and variants found [2]. In addition to guiding therapy, NGS can also aid in improving disease categorization and monitoring the genetic evolution of oncogenicity.

Healthcare professionals with more experience with cancer PM tests have been found to hold more positive attitudes and express fewer concerns about guidelines, evidence, reliability, cost, and more [3]. Reluctance to the adoption and implementation of PM may be due to the concern of limited knowledge and confidence which in turn may be based on lack of exposure during training.

*Correspondence:
Haley Schluterman
h.m.schluterman@tcu.edu
[1] Anne Marion Burnett School of Medicine at Texas Christian University, Fort Worth, USA
[2] Cook Children's Medical Center, Fort Worth, USA

Previous survey-based research has shown that the majority of third and fourth-year medical students were uncomfortable with topics within PM,however, 92.7% of the students surveyed were interested in broadening their knowledge in PM [4]. In order to potentiate the implementation of PM, exposure to healthcare professionals in their early stages of education is crucial.

Due to the speed at which medical advancements are made, it has been a challenge to keep abreast with all facets of new information. In fact, only 21% of undergraduate curricula include PM topics [5]. Adding exposure to new technological advances in medicine proves to be a difficult endeavor due to the vast amount of information already in undergraduate medical education. Several institutions have made efforts to incorporate PM into their medical school curriculum through varying approaches. One such approach involved faculty at the University of Arizona College of Medicine-Phoenix (COM-P) revising the pre-clerkship curriculum to include interdisciplinary active learning sessions about PM with the goal of ensuring their graduates are proficient in the use of pharmacogenetic data and advanced clinical decision support systems. In the first two years, they received an average score of 4.9/5 from student evaluations, demonstrating that this curriculum was perceived as helpful by the students [6]. A different initiative by the Edward Via College of Osteopathic Medicine embraced a hands-on approach to introducing PM in the anatomy lab curriculum through DNA sequencing of pre-embalmed blood samples from cadaveric donors. This provided the students with real-world examples of the potential relationship between genomic variants and disease risk [7].

The Precision Medicine Clinic (PMC) at Cook Children's Medical Center (CCMC) was established in 2021 and has since evolved to incorporate comprehensive genetic sequencing results with the ultimate goal of offering universal NGS testing and personalized treatment for pediatric cancer patients. Every patient in the PMC who undergoes genetic sequencing is placed on the presentation schedule. Patients were referred to the PMC at the discretion of the pediatric oncologists. There were no set referral criteria. Most patients who were referred tended to have solid tumors, poorer prognosis, or relapsed cancers. Currently, PMC meetings serve as a centralized platform for compiling, discussing, and providing recommendations on patient cases. PMC meetings involve presenting a case of a single patient, followed by discussions and inquiries. Typically, a medical student volunteer prepares and presents the report, a distinctive aspect of CCMC's clinic that encourages students to delve into research on innovative therapies and clinical trials. At CCMC, there exists no pediatric residency or fellowship program, which allows for fourth-year elective medical students to function at a higher educational level. Each report includes a concise patient history, clinical course overview, relevant lab findings, NGS test results, and a summary of treatment options based on those results. Treatment options may include standard therapies, targeted therapies, and clinical trials based on independent review of available literature directed at mutations found in the NGS reports. Attendees of these meetings include oncologists, researchers, pharmacists, molecular pathologists, medical students, and a medical science liaison from the testing platform(s). Alongside NGS results and patient education materials, the presentation is then uploaded into the EMR for access by the patient and their family. The document undergoes editing to incorporate team discussions or recommendations. Patients referred to PMC clinic typically attend 1-2 clinic visits post-meeting to discuss results and treatment options. (Fig. 1).

In this project, we present a unique and immersive approach to introducing PM into clinical rotations through the integration of medical students into the PMC clinic and participation in presenting at these interdisciplinary meetings. Our study will further investigate both qualitative and quantitative measures of the impact of PMC involvement and presentations on medical education and seek further enhancement of the educational experience.

Methods

The process of participating in the PMC conference begins when the medical student enrolls in the Pediatric Hematology/Oncology elective during their fourth-year rotations. This is an optional elective that is made available to all students on a lottery basis if there is more interest than positions available. On their first day at the hospital, students meet with the department's head attending and receive a schedule for the month. This schedule includes a designated day for the PMC conference and a research day prior to the presentation, during which the student is excused from clinical duties (see Fig. 2). Students are provided with a comprehensive set of resources via email, including a folder containing previous student PMC presentations, presentation templates, relevant articles, and the specific patient case they will be presenting. Additionally, they receive the genetic sequencing results for that patient of the PMC consult. It is then the student's responsibility to interpret the genetic sequencing report, research relevant literature concerning the patient's diagnosis and available treatments, and create a presentation based on their findings. Students are carefully mentored throughout the process to ensure they are understanding the material and expectations appropriately. Students are given approximately one to

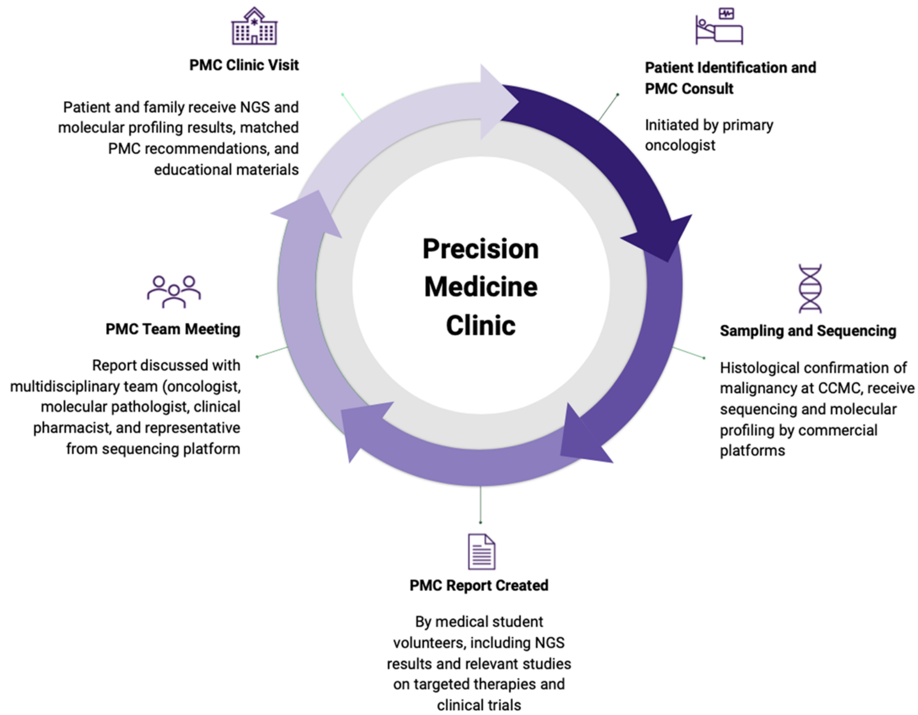

Fig. 1 Flow of Precision Medicine Clinic (PMC) at Cook Children's Medical Center (CMCC)

draft

August 2024

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
4	5 AM – ONC clinic PM – Inpt ONC	6 AM/PM – ONC clinic *Ask where "Problem List" is for PMC prep* 12:30 – N/O Tumor Board 1:30 – Case Conference	7 7:45am Onc Team meeting 12:30 AYA Educational Rounds Research- Precision Medicine prep	8 AM – ONC clinic PM – ONC clinic 12:00 Molecular Tumor Board 2:30 Precision Medicine	9 Heme	10
11	12 Research- Precision Medicine prep	13 AM/PM – ONC clinic 12:30 – N/O Tumor Board 1:30 – Case Conference	14 7:45am Onc Team meeting Heme	15 N-ONC 2:30 Precision Medicine	16 Heme	17
18	19 Research- Precision Medicine prep	20 AM/PM – ONC clinic 12:30 – N/O Tumor Board 1:30 – Case Conference	21 7:45am Onc Team meeting Genetic Onc	22 AM – ONC clinic PM – ONC clinic 2:30 Precision Medicine	23 Grapevine	24
25	26 Research- Precision Medicine prep	27 AM/PM – ONC clinic 12:30 – N/O Tumor Board 1:30 – Case Conference	28 7:45am Onc Team meeting AM – ONC clinic PM – Vascular clinic	29 Heme 2:30 Precision Medicine	30 AM – ONC clinic PM – Inpt ONC	31

Fig. 2 Student schedule for elective including PMC research days and presentation days.

two weeks to construct their presentation and report card, after which they have the opportunity to review it with the attending physician or research personnel on campus. Once final revisions are made, the students present their work in weekly hybrid in-person/virtual PMC team meetings. During and after the presentation, attendees are encouraged to ask questions. Each presentation including discussion lasts around 30-45 minutes. The student then receives feedback at the conclusion of the session. If their schedule permits, the student is able to join the PMC clinic visit for the patient they presented on in the PMC meeting.

A cumulative list of all previous medical students who have rotated through the CCMC hematology/oncology department and presented at PMC meetings was obtained through a clinical rotation schedule by medical education faculty at the hospital over the last few years. An online-based survey was then created through the Qualtrics platform specifically for this study and has never been utilized prior or published elsewhere. A copy of this survey is provided in the supplementary materials. Qualtrics is an online survey tool where users can build and distribute surveys, collect responses, and analyze response data, all from within the same platform. The first (quantitative) section of the survey included a set of seven questions assessing comfort and confidence with PM and NGS before and after PMC presentations, integration into the team, impact on future career plans, and the benefit it had on the participant's medical education on a scale of 1 to 10. The second (qualitative) part of the survey involved three open-ended questions regarding the perceived impact on medical education in general, skills learned through PMC presentations, and quality improvement questions. An email with the online-based survey link was sent to each medical student for their voluntary participation with disclosure of information regarding the use of their data for the study. The participants were informed that there would be no incentive or penalty for completing or not completing the survey. A determination was made by the Institutional Review Board at Cook Children's Medical Center that this project was consistent with quality improvement and as such was exempt from formal IRB approval for both human participants and consent to participate.

At the 1-week mark from originally sending out the surveys via email, those participants who had not completed the survey were sent a final reminder email. At the 2-week mark, a total of 15 completed surveys were received from the prior participants. Finalized responses to the survey were then analyzed based on an average score out of 10 for each question, as well as common themes found within the open-ended questions.

Results

Since January 2022, PMC has conducted over 75 meetings with 36 students presenting at one or more meetings. Student participants included, but were not limited to, those enrolled in fourth year pediatric hematology/oncology clinical electives from two medical schools in Fort Worth, TX. Of these 36 students, 15 participated in the Qualtrics survey sent.

From the quantitative section of the Qualtrics survey, as seen in Figure 3, the average level of comfort with PM and NGS increased from a score of 2.7 before presenting at PMC meetings to a score of 7.2 after. Similarly, the confidence in future ability to interpret and use NGS increased from an average score of 2.4 to 6.9 before and after involvement in PMC meetings, respectively. Students felt strongly integrated into the PMC team with an average score of 8. The majority believed that

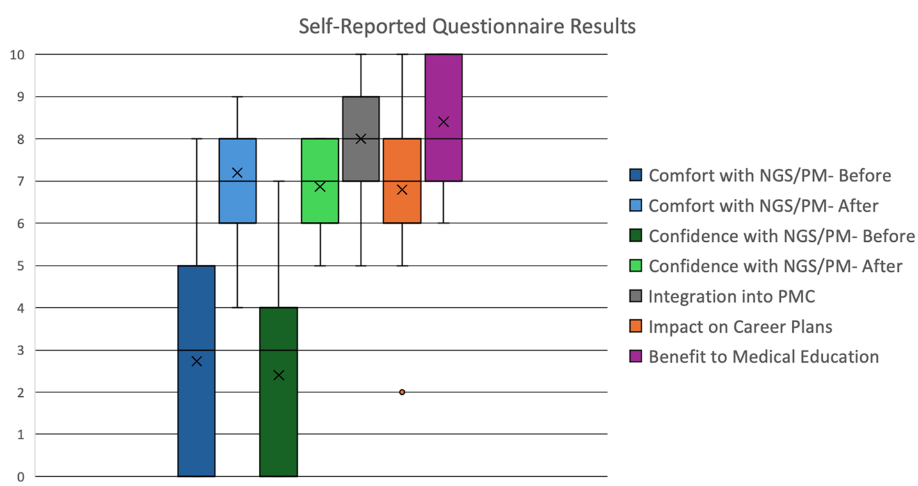

Fig. 3 Self-Reported Questionnaire Results

involvement in PMC had a significant impact on future career plans, with an average score of 6.8. Additionally, a mean score of 8.4 for perceived benefit to medical education suggests a strong conviction in personal advantage to participation.

From the qualitative section of the Qualtrics survey, a student remarked "I did not even know that precision medicine existed before my rotation." A significant recurring theme pertaining to the impact of presenting at PMC meetings on medical education was the contribution to published manuscripts [8–10] and enhanced personal research experience. Many students highlighted that their experience of presenting at PMC meetings equipped them with skills such as interpreting genetic findings, conducting independent research on primary literature, and generating clinically relevant insights. A summary of the common themes and illustrative quotes from student responses can be viewed in Table 1 below.

Discussion

This article provides a framework for medical schools, residency programs, and hospitals alike to adopt when considering incorporating PM and NGS into student curricula. By providing hands-on experiences and interdisciplinary learning opportunities, medical schools can better equip future healthcare professionals to navigate the challenges and opportunities presented by PM in clinical practice.

The goal of medical student involvement in this clinic was to enhance their medical education and increase exposure to PM. The results obtained from the Qualtrics survey provide appropriate, albeit limited evidence of the positive impact PMC had on the involved medical students. Student participation not only robustly engages students but challenges them to think beyond what is taught in traditional curriculum; a skill required in the ever-expanding world of medical knowledge. Participation in presentations has also led to career exploration, scientific inquiry, and student-led research initiatives. The increase in scores before and after for both confidence and comfortability with PM and NGS indicates not only exposure but also a tangible enhancement in students' grasp of these concepts. Additionally, the high ratings of integration into the PMC team and the perceived influence on future career plans underscore the effect PMC has on shaping students' professional trajectories. Finally, the highest scoring section regarding the benefits to medical education strongly indicates the effectiveness of medical students' participation in PMC.

Equally compelling are the qualitative insights from the survey, which highlight the transformative nature of PMC participation. Many students expressed discovering PM for the first time during their rotation, emphasizing the clinic's role in initial exposure. The opportunity to contribute to published manuscripts, engage in independent research, and refine presentation skills underscores PMC's multifaceted impact on students' educational journey. Areas for improvement identified by students are crucial to the continual evolution and quality improvement of PMC. Most feedback focusing on preparation and understanding of how PMC presentations work can be easily addressed by standardization of having students

Table 1 Role of Medical Students in a Pediatric Oncology Precision Medicine Clinic

Common Theme	Comment Type	Illustrative Quote(s)
Skill Development	Positive	"Increased confidence speaking in front of professionals/experts in the field, summarizing and synthesizing key information"
Knowledge Acquisition	Positive	"I learned how to interpret next-gen sequencing results and use the results to search the literature regarding targetable treatments." "I found it helpful to dive into the PMC presentations because it was a good learning tool to study up on different cancer mechanisms/tumor markers."
Career Enhancement	Positive	"I am considering pediatric hem/onc as a career more strongly as a result of PMC" " I talked about it many times during my residency interviews, and it was included as an activity on my [residency] application." "From a medical school and residency application standpoint, becoming involved with the PMC allowed me to contribute to seven manuscripts, all of which were published in peer-reviewed journals. I was also able to present multiple posters at the annual ASPHO and Cook Children's Research Appreciation conferences."
Mentorship and Collaboration	Positive	" It was a new experience to conduct a virtual presentation with people I did not know and have no relationship with. I would say it was valuable learning opportunity!" "I appreciated Dr X's guidance on the talk as well as the previous presentations that were done that I could use as reference." "Working with other students on the presentation was helpful"
Organization	Constructive	"Having better organization such as knowing who would be in attendance, people arriving late, issues with the mic/speaker, etc. would have been helpful."

sit in on a PMC meeting prior to their own presentations and having dedicated time to go over their presentation with an attending physician.

While the results of this study are promising, it is essential to acknowledge its limitations. One such limitation includes the small sample size as only a fraction (n = 15) of 36 total participants responded to the survey. This precluded any descriptive statistics to be measured from the quantitative portion of the survey. An additional limitation lies in the retrospective nature of the student survey responses as there was only a post-elective survey. Consequently, their answers, particularly concerning perception prior to involvement in PMC conferences, may carry inaccuracies or biases. Moreover, as the survey targeted students who engaged in the curriculum several years ago, there exists a potential for recall bias. To mitigate these limitations and biases, we propose the future direction of providing pre- and post-surveys to medical students rotating and participating in PMC conferences. This strategy aims to offer a more precise and accurate depiction of perceptions and beliefs, both prospectively and retrospectively. Future research and ongoing evaluation of educational interventions in PM are warranted to ensure that medical education remains aligned with the latest advancements in healthcare.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-024-06603-8.

Supplementary Material 1

Supplementary Material 2

Authors' contributions

L.Z. and H.S. made equal contributions to the writing of the main manuscript text, including figures and survey creation, and are therefore dual first authors. All authors reviewed the manuscript.

Funding

No funding was received for this research.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Not applicable as all responses received via Qualtrics survey were based on voluntary participation.

A determination was made by the Institutional Review Board at Cook Children's Medical Center that this project was consistent with quality improvement and as such was exempt from formal IRB approval for both human participants and consent to participate.

Consent for publication

Not applicable as all responses were voluntary and anonymous.

Competing interests

The authors declare no competing interests.

Received: 6 June 2024 Accepted: 23 December 2024
Published online: 21 February 2025

References

1. König IR. et al. What is precision medicine? Eur Respir J. 2017;50(4).
2. Qin D. Next-generation sequencing and its clinical application. Cancer Biol Med. 2019;16(1):4.
3. Vetsch J, et al. Healthcare professionals' attitudes towards cancer precision medicine: a systematic review. Semin Oncol. 2019;45(3):291–303.
4. Koh KC. et al. Attitude, knowledge and ethical perception toward precision medicine among junior and senior medical students: Findings from one Malaysian medical school. Big Data Analytics 2017;10.
5. Plunkett-Rondeau J, Hyland K, Dasgupta S. Training future physicians in the era of genomic medicine: trends in undergraduate medical genetics education. 2015. Elsevier.
6. Heise CW. The integration of precision medicine into a medical school curriculum. J Precis Med. 2021;7(2).
7. Anandakrishnan R, et al. DNA sequencing of anatomy lab cadavers to provide hands-on precision medicine introduction to medical students. BMC Med Educ. 2020;20(1):437.
8. Sharma I, et al. Utilization of genomic tumor profiling in pediatric liquid tumors: a clinical series. Hematol Rep. 2023;15(2):256–65.
9. Liu A, et al. Molecular tumor boards: The next step towards precision therapy in cancer care. Hematol Rep. 2023;15(2):244–55.
10. Swilling A, et al. Lessons learned: utilization of a reference laboratory for targeted sequencing of pediatric tumors at a single institution. J Pediatr Hematol Oncol. 2023;45(2):63–9.

Publisher's Note