Attitude, knowledge and ethical perception toward precision medicine among junior and senior medical students: Findings from one Malaysian medical school

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Background: Medical schools are escalating changes to meet the need for doctors competent to work in the era of precision medicine. Information on the current level of awareness of precision medicine among medical students can help effect the necessary changes in the medical curriculum. A cross-sectional comparative study was done to assess the knowledge, attitude and perception toward the practice of precision medicine among junior and senior medical students in a medical school in Malaysia.

Materials and Method: A survey instrument measuring attitude toward precision medicine, perceived knowledge of genomic testing concepts, and perception toward ethical consideration related to precision medicine, was distributed to junior and senior medical students. Comparisons were made between senior and junior medical students.

Results: Only about one-third of the 356 respondents had heard of precision medicine although 92.7% expressed interest to learn more about precision medicine. Overall, junior and senior medical students had positive attitude toward the adoption of genome-guided prescribing and precision medicine but were uncomfortable with their knowledge of genomic testing concepts. Both junior and senior students were largely well grounded in their understanding of ethical issues related to precision medicine.

Conclusions: Knowledge of precision medicine was low among junior and senior medical students. Although the students supported the use of precision medicine, they did not feel adequately prepared to apply genomics to clinical practice. Their perceptions on ethical issues related to precision medicine were sound. Seniority did not appear to influence the perceptions of the students.

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Introduction

Precision medicine is an emerging approach for disease treatment and prevention that takes into account individual variability in genes, environment, and lifestyle for each person.[1] It enables healthcare providers to tailor treatment and prevention strategies to people's unique characteristics, including their genome sequence, microbiome composition, health history, lifestyle, and diet.

Medical students, who are future doctors, may not be prepared for work in the era of precision medicine. In a study of 212 medical students in a US medical school, 80% of the students supported the use of precision medicine but only 6% felt their medical education had adequately prepared them.[2] In Malaysia, a survey of 1500 pharmacists and physicians showed they had poor to fair knowledge of pharmacogenomics with nearly 50% of them reported receiving no formal teaching on the subject matter in undergraduate school.[3] Medical schools have been accelerating changes in reshaping medical education in response to the challenge of producing doctors capable of working in a technologically-enhanced environment and to keep their curriculum relevant and up to date.[4-6]

The objective of this study is to assess and compare the knowledge, attitude and perception towards precision medicine and issues related to it, between medical students in their first and final years of clinical studies in a private medical institution in Malaysia.

Materials and Methods

Definition of precision medicine

Although often used interchangeably with 'personalised medicine', the term 'precision medicine' is preferred because it encompasses a wider scope wherein individuals can be classified into subpopulations that differ in their susceptibility to a particular disease or their response to as specific treatment. The term 'personalised medicine' is often misinterpreted as

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implying that unique treatments can be designed for each individual which is not entirely accurate.[7] In this paper, the broader meaning of precision medicine is implied when these two terms are used.

Study site and sample size calculation

This cross-sectional survey was conducted from 4th to 19th August 2016 at the clinical campus of the International Medical University (IMU), Malaysia. The inclusion criteria were medical students who were in their first clinical years (semesters 6 and 7, or 3rd year of medical studies) or final clinical years (semesters 9 and 10, or 5th year of medical studies). For the sake of brevity, the former and latter are referred to as junior and senior students, respectively. Junior and senior medical students were chosen for the purpose of comparison to determine if there were differences in their responses as the latter were presumed to have acquired more medical knowledge, skills and maturity.

The sample size required for statistical significance was calculated to be 202 assuming 95% confidence interval with 5% margin of error.

Survey tool and recruitment of students

The survey tool was a questionnaire that was divided into five sections. Section 1 contained questions designed to assess their awareness of what is precision medicine and from where did they first hear about precision medicine. Sections 2 and 3 contained questions adapted from the Evidence-based Practice Attitude Scale Adapting Genome-informed Interventions (EBPAS-GII) to assess their attitude and knowledge toward the practice of precision medicine.[2,8] Responses were registered using a 4-point Likert scale ranging from 1: not at all; 2: to a slight extent; 3: to a moderate extent and 4: to a great extent (Table 1). The section on attitude had 8 questions of which the first 4 questions (questions 1 – 4 in Table 1) were 'openness' items while the latter 4 (questions 5 – 8 in Table 1) were 'divergence' items. A brief description of what is precision medicine was incorporated into the survey tool between sections 1 and 2, so that students who responded that they have never heard of precision medicine may be aware of the definition's ambit before proceeding with the rest of the survey tool.

Section 4 assessed perception toward ethical considerations related to the issue of pharmacogenomics (Table 1) using the same Likert scale previously described. Section 5 contained two questions designed to determine the interest of students toward the learning of precision medicine and their preferred method of acquiring knowledge in precision medicine. The responses for this last item were not mutually exclusive as the students were allowed to pick one or more answers (Table 1).

Table 1: Survey tool to assess awareness, attitude, knowledge, ethical perception and learning preference toward the practice of precision medicine.

Area of assessment and response options *(in italics)*
Section 1: Awareness of precision medicine
1. Do you know what precision medicine is? *(Yes/No)*
2. If you have heard of precision medicine, where did you hear it from? *(Healthcare providers/lectures /internet/newspaper/ peers)*

Area of assessment and response options *(in italics)*
Section 2: Attitude toward adoption of genome-guided prescribing and precision medicine*
1. I would be willing to use new types of therapy or interventions to help my patients. 2. I would be willing to use a patient's genetic information to guide my decision in clinical practice. 3. I would be willing to try genome-guided prescribing tools that are created by researchers. 4. I would be willing to use genome-guided prescribing in my career. 5. I feel that clinical experience is more important than using a patient's genetic information to make decisions. 6. I would not be willing to prescribe different medications or doses of medications based on a patient's genetic information. 7. I feel that clinicians know better than academic researchers on how to treat patients based on a patient's genetic information. 8. I feel that research-based genome-guided prescribing tools are not clinically useful.
Section 3: Perceived knowledge of genomic testing concepts†
1. How comfortable are you in your knowledge about basic genomic testing concepts and terminology (e.g. molecular genetic test, chromosomal genetic test, biochemical genetic test)? 2. How comfortable are you in your knowledge about pharmacogenomics (a study of how genes affect a person's response to drug)? 3. How comfortable are you in your knowledge about genetic variation predisposing to common diseases (such as diabetes, kidney and heart disease)? 4. How comfortable are you in your knowledge about next generation sequencing (a DNA sequencing technology which can be used to capture a broad spectrum of gene mutation)?
Section 4: Perception toward ethical considerations related to precision medicine*
1. I feel that pharmacogenomics may be used to promote ethnic/racial stereotypes. 2. I feel that pharmacogenomics may broaden the healthcare gap between the rich and poor. 3. I feel that pharmacogenomics may lead to insurance discrimination. 4. I feel that pharmacogenomics may lead to employment discrimination.
Section 5: Preference for learning about precision medicine.
1. Are you interested in broadening your knowledge in precision medicine? *(Yes/No)* 2. If yes, what is your preferred method of learning? *(Pre-university course work/ undergraduate pharmacogenomics education/ postgraduate pharmacogenomics education/ seminar or workshop/ ward rounds)*

**Response options: 1: not at all; 2: to a slight extent; 3: to a moderate extent; 4: to a great extent*

†*Response options: 1: not comfortable at all; 2: not very comfortable; 3: comfortable; 4: very comfortable*

Prior to its distribution, the survey tool was piloted on 16 semester 8 students that were excluded from this study. These students were able to answer all the questions in the survey tool within 20 minutes and their responses were determined to be suitable for analysis.

Recruitment of students were done at their respective end-of-semester examination results day where all the students were expected to be present. The students were first briefed about the objectives of the survey before the hard copies of the survey tool were distributed. Participation was voluntary and written consent was obtained from the students. The students were allowed 20 minutes to complete the questionnaire without assistance.

Statistical analysis

Data was presented in mean or percentage where appropriate. Descriptive analysis was used to delineate the demographic data of the respondents. For the purpose of discussion, responses from the Likert scales were pooled into binary values, i.e. scores 1 and 2 were grouped as 'disagree' or 'uncomfortable' and scores 3 and 4 were grouped as 'agree' or 'comfortable' depending on the context of the item asked. The independent Student's t-test was used to compare the means between first year and final year students. A p value of <0.05 with 95% confidence interval was considered significant. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 20 for Windows 7.

Results

Demography and awareness of precision medicine

Two hundred and twenty five junior and 201 senior medical students, totaling 426, were eligible to participate in the study. One hundred and ninety junior and 166 senior students eventually participated in the study, giving response rates of 84.8% and 82.6%, respectively (Table 2). Approximately one-third of the students, 68 (35.7%) juniors and 62 (37.3%) seniors, have heard of precision medicine and they learned it from lectures, healthcare providers and the internet (Table 2).

Table 2: Awareness of precision medicine among junior and senior medical students (N = 356)

Items	1st YEAR (%)	FINAL YEAR (%)	TOTAL (%)
Number of students	190 (100)	166 (100)	356 (100)
Number of students aware of precision medicine	68 (35.7)	62 (37.3)	130 (36.5)
Source of information from which the students learned about precision medicine			
Healthcare providers	30 (15.7)	27 (16.2)	57 (16.0)
Lectures	51 (26.8)	42 (25.3)	93 (26.1)
Internet	29 (15.2)	17 (10.2)	46 (12.9)
Newspaper	18 (9.47)	10 (6.0)	29 (8.1)
Peers	11 (5.7)	9 (5.4)	20 (5.6)

Attitude toward adoption of genome-guided prescribing and precision medicine

The majority of junior and senior medical students agreed with the 'openness' items (questions 1 – 4 in Table 3) with junior students being more open compared to their seniors with regard to questions 2, 3 and 4: willingness to use a patient's genetic information to guide decision in clinical practice (164 (86.3%) vs 139 (83.7%), p = 0.001); willingness to try genome-guided prescribing tools created by researchers (153 (80.5%) vs 127 (75.5%), p = 0.023); and willingness to use genome-guided prescribing in their career (152 (80.0%) vs 127 (75.5%), p = 0.006). In the divergence items (questions 5 – 8 in Table 3), the majority of students, 148 (77.9%) juniors and 149 (89.8%) seniors, agreed with question 5 (I feel that clinical experience is more important than using a patient's genetic information to make decisions) and question 7 (I feel that clinicians know better than academic researchers on how to treat patients based on a patient's genetic information) with senior students feeling more emphatic compared to the junior students for question 7 (128 (77.1%) vs 120 (63.2%), p = 0.017). The majority of students disagreed with question 6 (I would not be willing to prescribe different medications or doses of medications based on a patient's genetic information) and question 8 (I feel that research-based genome-guided prescribing tools are not clinically useful) with junior students feeling more emphatic compared to the senior students for question 6 (128 (67.3%0 juniors vs 93 (56.0%) seniors, p = 0.007); and question 8 [145 (76.3%) juniors vs 112 (67.5%) seniors], p = 0.061). However, for question 8, the difference in responses was not statistically significant.

Perceived knowledge of genomic testing concepts

The majority of junior and senior students were uncomfortable with all the items in this section (Table 3). Statistical significance was present for responses in question 1 (How comfortable are you in your knowledge about basic genomic testing concepts and terminology?) and 2 (How comfortable are you in your knowledge about pharmacogenomics?) where junior students reported being more ill at ease compared to senior students (Question 1: 154 (81.0%) vs 121 (72.9%), p = 0.009; Question 2: 162 (85.3%) vs 133 (80.1%), p = 0.040); respectively).

Perception toward ethical considerations related to precision medicine

Both junior and senior students were almost equally divided with regard to the item in question 1 (I feel that pharmacogenomics may be used to promote ethnic / racial stereotypes). The majority of students agreed with the items in questions 2, 3 and 4 (I feel that pharmacogenomics may broaden the healthcare gap between the rich and poor; I feel that pharmacogenomics may lead to insurance discrimination; I feel that pharmacogenomics may lead to employment discrimination; respectively) with no statistically significant difference between junior and senior students (Table 3). The responses of junior and senior students did not differ significantly for all the questions in this section.

Table 3: Attitude, knowledge and ethical perception toward precision medicine.

Items	JUNIOR*			SENIOR*			
	Disagree	Agree	$\bar{x}$	Disagree	Agree	$\bar{x}$	P
Attitude toward adoption of genome-guided prescribing and precision medicine							
1. I would be willing to use new types of therapy or interventions to help my patients.	15	174	3.25	6	160	3.21	0.515
2. I would be willing to use a patient's genetic information to guide my decision in clinical practice.	25	164	3.20	27	139	2.98	0.001
3. I would be willing to try genome-guided prescribing tools that are created by researchers.	36	153	3.07	39	127	2.91	0.023
4. I would be willing to use genome-guided prescribing in my career.	37	152	3.07	39	127	2.87	0.006
5. I feel that clinical experience is more important than using a patient's genetic information to make decisions.	41	148	3.16	17	149	3.30	0.073
6. I would not be willing to prescribe different medications or doses of medications based on a patient's genetic information.	128	61	2.20	93	73	2.41	0.007
7. I feel that clinicians know better than academic researchers on how to treat patients based on a patient's genetic information.	70	120	2.76	38	128	2.95	0.017
8. I feel that research-based genome-guided prescribing tools are not clinically useful.	145	45	2.08	112	54	2.22	0.061
Items	**Uncomfortable**	**Comfortable**	$\bar{x}$	**Uncomfortable**	**Comfortable**	$\bar{x}$	**P**
Perceived knowledge of genomic testing concepts†							
1. How comfortable are you in your knowledge about basic genomic testing concepts and terminology (e.g. molecular genetic test, chromosomal genetic test, biochemical genetic test)?	154	36	1.78	121	45	2.01	0.009

2. How comfortable are you in your knowledge about pharmacogenomics (a study of how genes affect a person's response to drug)?	162	28	1.71	133	33	1.88	0.040
3. How comfortable are you in your knowledge about genetic variation predisposing to common diseases (such as diabetes, kidney and heart disease)?	111	79	2.26	93	73	2.38	0.154
4. How comfortable are you in your knowledge about next generation sequencing (a DNA sequencing technology which can be used to capture a broad spectrum of gene mutation)?	145	46	1.92	121	45	2.04	0.181
Items	**Disagree**	**Agree**	**$\bar{x}$**	**Disagree**	**Agree**	**$\bar{x}$**	**P**
Perception toward ethical considerations related to precision medicine							
1. I feel that pharmacogenomics may be used to promote ethnic/ racial stereotypes.	82	108	2.55	74	92	2.50	0.558
2. I feel that pharmacogenomics may broaden the healthcare gap between the rich and poor.	65	125	2.85	45	121	2.91	0.507
3. I feel that pharmacogenomics may lead to insurance discrimination.	46	144	3.07	34	132	3.10	0.739
4. I feel that pharmacogenomics may lead to employment discrimination.	72	119	2.83	52	114	2.89	0.508

*$\bar{x}$: mean score for this item derived from responses according to the Likert scale; *Number of respondents under each category. P value derived comparison of means between first and final year students using the independent Student-t test with 95% confidence interval.*

Preference for learning about precision medicine

Three hundred and thirty (92.7%) of the medical students surveyed said they were interested to broaden their knowledge in precision medicine. Thirty-three percent indicated seminars or workshops as the preferred source of knowledge transfer, 23% preferred learning about it after graduation (postgraduate education), 21% preferred learning about it during their undergraduate studies, 14% preferred to learn about it while on the job in the hospital (ward rounds), and 9% indicated they preferred to have learned about it before entering undergraduate medical school.

Discussion

The practice of medicine is increasingly technology-driven and technology-enabled. Technological advances in genomics and precision medicine demand that future doctors to be competent in the use of these new tools in their day-to-day clinical work. Traditionally medical institutions have been relatively slow to respond to the changes in medical practice and the medical curriculum of today may not be equipped to produce such doctors although many medical schools are already working together to accelerate change in medical education to meet the demands of future medicine.[9]

The IMU has an integrated system-based curriculum and uses a variety of approaches in its teaching-learning activities. Early exposure of medical students in the IMU to clinical experiences provides opportunities for them to appreciate the application of basic sciences in clinical practice. This study explored the attitude, knowledge and ethical perception of medical students of the IMU to identify potential challenges and opportunities for improvement in the IMU's medical curriculum to meet the demands of medical practice in the era of precision medicine. There were 356 respondents, with 190 junior students and 166 senior students.

Overall, in regard to openness to the adoption of genome-guided prescribing and precision medicine (items 1 to 4 in the assessment of 'attitude' in Table 3), both junior and senior students had positive attitudes even when this diverged from the usual practice except in two divergent items where both groups of students disagreed on: 'I feel that clinical experience is more important than using a patient's genetic information to make decisions'; and 'I feel that clinicians know better than academic researchers on how to treat patients based on a patient's genetic information' (Table 3). This is in contrast to the findings of Eden et al on medical students from a US medical school where the students were agreeable to all the items in the divergent questions regardless of the year of studies.[5] The US medical school students had received training in the traditional curriculum with didactic learning in the first two years and clinical training in the third and fourth year whereas IMU students were trained using a system-based approach with emphasis on early clinical exposure. The early clinical exposure may have influenced the rather pragmatic attitude of the IMU students for they recognised that clinical experience and acumen are important in the day-to-day clinical practice in Malaysia rather than being wholly dependent on information derived from the patients' genome. The relative lack of exposure of the IMU students to genome-based clinical decision making in the hospital where such facilities are relatively rare may also be a contributing factor.

Perceived knowledge of genomic testing concepts were low in both junior and senior students. In particular, the junior students were more unfamiliar with basic genomic testing concepts and terminology, and knowledge of pharmacogenomics compared to senior students ($p < 0.05$, Table 3). There were no differences between the two groups of students concerning their knowledge about genetic variation predisposing to common diseases, and their knowledge of genetic sequencing. This suggests that the students had inadequate exposure to pharmacogenomics in their medical education and the need for greater integration and emphasis of topics related to precision medicine into the IMU medical curriculum.

Despite the relatively low knowledge of pharmacogenomics, junior and senior students appeared to hold the same view about the possible ethical dilemma and concerns associated with precision medicine such as the broadening of healthcare gap between those who can afford and those who cannot; insurance discrimination and employment discrimination. There were no difference between the two groups of students in regards to these three items ($p > 0.05$, Table 3). Interestingly both groups of students appeared to be rather ambivalent (mean values at or near 2.5, Table 3) about whether pharmacogenomics may promote ethnic or racial stereotypes. Malaysia has a multicultural society and as such, racial or ethnic stereotyping is almost always inevitable especially when national policies appear to favor one ethnic group over other groups.[10] For these students, the impact of pharmacogenomics adding on to the existing ethnic stereotyping in Malaysia may be moot.

An overwhelming 92.7% of the students indicated that they wanted to learn more about precision medicine and most of them preferred to acquire the knowledge while they are still in medical school. This suggests that the students felt precision medicine is best learned by its integration into the existing medical curriculum and delivered via workshops, seminars and in clinical practice in the hospital wards.

The rapid pace of genomic discoveries and advances in translational research are slowly but gradually outpacing the ability of clinicians to include such information in their medical practices.[11] While some believed this education gap to be a potential rate limiting factor in the clinical adoption of genomics in medicine, others are of the view that the lack of visible interactive decision support systems, like an app on a mobile device, that can quickly interpret genomic data and translate them into practical clinical information that can be used by physicians, may indeed be the rate limiting factor.[12,13] The latter believed the medical fraternity would readily adapt to any changes in the practice of medicine in the future, just as it has successfully adapted in the past.[13]

Regardless of the views and despite the uncertainty about how or what is the practice model for genomics and precision medicine in the day-to-day routine clinical practice of the future, the general consensus is that clinicians and all other healthcare providers must begin preparing for such an eventuality.[14] This preparation must start from the premedical level, through medical school and residency and all the way to specialty training and should encompass the learning progression from basic concepts in genetics and genomics to describing the role of genetic variation in health and disease; on to the application of the learned skills and the formulation of differential diagnoses using information from genetic tests.[13] To this end, several professional institutions are in the process or have developed frameworks, guidelines and expected core competencies of genomics to be incorporated into the education of healthcare providers.[12] Some medical schools are already implementing novel approaches to help their students acquire competency in understanding and analysing raw genome-derived data such as the "Practical Analysis of Your Personal Genome" course where medical students were asked to analyse their own personal genome and learn about genomics in the process.[12]

To integrate the principles and application of medical genomics into the undergraduate medical curriculum will require the development of frameworks, guidelines and identified core competencies as well as methods for its delivery and evaluations; as well as taking into consideration the challenges to its implementation such as the lack of funding, infrastructure and expertise; and the slow adoption of genetic technology in clinical practice resulting in lack of good examples for students to emulate.[14]

Study limitations

A limitation of this study is that the survey tool was distributed to students in a single medical school in Malaysia. Therefore, the results from this study cannot be generalised to represent students from other medical institutions in the country. Additional assessment of the

survey tool in other medical institutions in the country would be advantageous. Another limitation is that this study was designed to measure perceived knowledge and ability in genomics. This may or may not actually correlate with actual knowledge and skills possessed by these students. Unintended bias may have occurred as the students were exposed to a brief description of precision medicine prior to answering certain related sections of the survey tool. Finally, the cross-sectional design of this study limits the ability to conclusively determine as to whether differences between junior and senior students can be attributed to their level of maturity or to the depth of their medical knowledge.

Conclusion

The interest in precision medicine was high and there was overall positive attitude among medical students in this study toward precision medicine. However, they did not feel prepared to practise precision medicine. Their perceptions on ethical issues were sound and may be invaluable to help them navigate the potential minefield of controversial issues related to precision medicine in their medical practice in the future. The results of this study suggest there may be a need to introduce and integrate the principles and application of genomics into the undergraduate medical curriculum in order to produce doctors that are able to work in an era of precision medicine.

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