Student perspectives on health informatics in a medical curriculum: A case study

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Abstract

Introduction: Health informatics (HI) is the study and practice of technology used to improve the quality and efficiency of healthcare. Formal HI teaching lacks visibility in most Australasian medical schools. In this study, medical students collected data from their peers and recent graduates on the teaching and learning of HI to inform development of a needs-based integrated HI curriculum.

Methods: This mixed-methods case study of our medical degree program used clinically relevant vignettes to explore student confidence and opinions on HI. Current HI learning was benchmarked against recommendations. Recent graduates from University of Otago Medical School participated in an online survey (n = 26), and five focus group interviews of final-year medical students (n = 17) were carried out by a peer student.

Results: More than half of the participants surveyed felt confident in most HI topics, though many were less confident in telemedicine, evaluating electronic resources for patient use, data communication and data storage. Most students recalled learning some HI principles and agreed these should be integrated within their degree. Students highlighted that HI curriculum development should consider students' self-identity as digital natives and the need for clinically situated, relevant and authentic learning to avoid tensions between theoretical HI concepts and clinical environments.

Conclusion: Medical students are critical consumers of potential HI curriculum content and expressed clear preferences for clinically relevant and up-to-date HI content. Key challenges in developing an HI curriculum will be ensuring a student-centered, authentic, contemporary and future-focused curriculum, with relevance demonstrated to digital native students.

Keywords: health informatics; medical students; curriculum; digital health; ehealth

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Introduction

Health informatics (HI) is the study and practice of technology-based healthcare that aims to improve human health using technology to optimise knowledge, information and data (Gray, 2016). It is concerned with the underlying science of information, data, systems, models and communication processes (Coiera, 2015). Health professionals must now be able to effectively use health technologies, such as electronic health records, and undertake telehealth. They should also be able to optimise, share, store and retrieve data for problem solving and decision making. Furthermore, they should be able to critically appraise and adopt into practice, if suitable, new information and communication technologies from mobile apps to machine learning (Gray et al., 2014; Williams & Grainger, 2020). Despite these benefits, use of technology can be challenging and frustrating for some individuals if they do not understand the underlying science (Fridsma, 2018). Being competent in HI knowledge and skills will not only better equip healthcare professionals to use technology safely but also help them to understand its limitations and impacts on practice. It will also enable them to use emerging technologies such as artificial intelligence (AI) and genomic medicine in clinical practice (Topol, 2019).

Despite widespread use of HI in clinical practice, and agreement by medical education leaders on its importance, its inclusion in formal medical degree curricula is largely invisible (Edirippulige et al., 2018; Giunti et al., 2019; Walpole et al., 2016). In Australia, reasons for the absence of HI from medical school curricula include competing demands for curriculum time, lack of appropriate teachers and no expectations for HI inclusion from the accrediting bodies (Edirippulige et al., 2018). Globally, there remains uncertainty about what HI skills medical students should be taught and what pedagogies are most appropriate (Aungst & Patel, 2020). Given the ubiquity of technology in clinical practice and high likelihood of an increasingly complex digital healthcare landscape, a contemporary and flexible formal HI curriculum should be a priority (Fridsma, 2018).

Our aim was to seek the views of students to inform the development of an HI curriculum. While educators' perspectives are important for curriculum design, student opinion is invaluable to ensure an engaging, effective and authentic curriculum (Poncette et al., 2020). Student views are particularly useful in informing curriculum design that addresses aspects of learning outside the formal (stated and intended) curriculum and captures aspects of behaviour, relationships and interactions within the clinical learning environment and organisational structures of those learning environments (Hafferty, 1998; Storrar et al., 2019). We wished to better understand our students' perspectives on the existing HI content within our medical undergraduate degree. Our research questions were:

1. Did our students feel confident in applying HI competencies in their clinical work?
2. Did the students recall the formal or taught HI curriculum of our program?

3. What were our students' opinions about learning HI competencies in their degree and how did they view themselves as learners of HI?

To address these research questions, we describe an intrinsic single case study that used a mixed-methods and interpretative approach.

Methods

Study design

The phenomenon of interest was medical student experience of learning HI during their primary medical degree at the University of Otago. The underpinning approach was naturalistic rather than experimental (Patton, 2015). The purpose was exploratory, retrospective and atheoretical (Cheek et al., 2018), and the epistemological approach was interpretative (Crowe et al., 2011). We used a single-case study design with a two-phase convergent mixed-methods approach (Creswell et al., 2011). This approach was appropriate to explore such a phenomenon in depth in its natural context (Crowe et al., 2011). The case study was also primarily intrinsic (Stake, 1995) since the subject was local and the experience of student learning was within our primary medical degree program. We used systematically developed HI topics (McGlade et al., 2001) grouped into six domains as a benchmarking framework (Table 1). We have previously used this model to benchmark existing HI curricula between Australia, Canada and the UK.

Table 1

*Benchmarking Framework of Key Health Informatics Competency Domains and Health Informatics Topics**

	Competency Area of Health Informatics	Topics
1	Managing data and information	Use of electronic health records Accessing data from different health services, e.g., private/GP/public Patient portals Email and texting
2	Knowledge engineering and decision support	Finding and using appropriate decision support tools
3	Data security and confidentiality	Storing data Sending/communicating data, e.g., via email
4	Evaluating software and systems	Evaluating resources for patient use Using new systems, e.g., e-prescribing
5	Searching online information sources and databases	Formulating appropriate questions Developing a search query from a question to maximise search Determining where to search for information Critically evaluating online sources for clinical and patient use

	Competency Area of Health Informatics	Topics
6	Communication and the internet	Personal social media use Medical blogging Social media for disseminating health information/education, e.g., hospital FB pages Texting/email with patients Social media interaction with patients Telemedicine

* Adapted from McGlade et al. (2001)

Context and participants

The University of Otago medical degree (MB ChB) is a 6-year program. Most students are admitted after completing first-year health sciences, with about 25% admitted as postgraduates. Years 2–5 are similar to those of many 4-year programs, while the final year has students fully embedded within clinical teams as trainee interns (TIs). For the case study, we recruited participants who have both recent experience of the existing University of Otago curriculum and practical experience of the application of HI from TIs, postgraduate Year 1 (PGY1) and Year 2 (PGY2) prevocational intern doctors working in Aotearoa New Zealand (AoNZ).

Curriculum stocktake

The learning outcomes of the University of Otago MB ChB curriculum and level of learning by graduation are described in our "Curriculum Map" (https://medmap.otago.ac.nz/ui/). To describe the formal stated curriculum for our students, a senior academic with teaching and research expertise in medical education and HI (RG) systematically searched the University of Otago MB ChB Curriculum Map with all the words and phrases in the key competency areas of HI from the comparative benchmarking framework and recorded the identified learning outcomes (Table 1). Table 2 shows the learning outcomes along with levels of learning at graduation mapped to the six key competencies of the benchmarking framework.

Postgraduate survey

In 2018, University of Otago MB ChB graduates from the previous 2 years were invited to participate in a bespoke survey. The graduates working as interns were recruited through snowball sampling with survey distribution through a shareable Qualtrics link on the MB ChB 2016/2017 class Facebook groups. Basic demographic data were collected. The anonymous survey was open for 1 month crossing July/August 2018.

Table 2

University of Otago MB ChB Learning Outcomes and Level of Learning at Graduation Mapped to the Benchmarking Framework of Key Health Informatics Competency Domains

Health Informatics Competencies	Learning Outcomes in University of Otago Curriculum	Level of Learning at Graduation (Knows about, Knows how, Does, Applies)
Managing data and information	Professional practice outcome: Exchange of essential clinical information (health records through electronic media) within interprofessional teams	Applies
	Clinical skills outcome: Using fax and email communication appropriately	Does
	Clinical skills outcome: Maintenance of patients' electronic records	Applies
	Research and scholarship: Essential computer literacy skills Online medical data repositories, including numerically coded data	Applies
Knowledge engineering and decision support	Professional practice outcome: Decision-making tools, e.g., guidelines and decision support software to foster application of best available evidence in delivering quality healthcare	Applies
Data security and confidentiality	Research and scholarship: Essential computer literacy skills Data security and confidentiality risks of electronic records, photographs and social media and of electronic methods of data storage and of electronic communication with patients and colleagues	Applies
	Professional practice outcome: Exchange of essential clinical information (health records through electronic media) within interprofessional teams	Applies
Evaluating software and systems	Nil found	
Searching online information sources and databases	Science, research, and scholarship outcome: Systematic literature search for best available evidence about disease causation, frequency, diagnosis, prognosis and treatment for individual patients and for patient populations	Applies
	Research and scholarship: Essential computer literacy skills Digital/computer skills for research and scholarship related to medical practice	Applies
	Research and scholarship: Essential computer literacy skills Online digital repositories for research and scholarship	Applies
Communication and the internet	Professional practice outcome: Practitioners' use of social media and other internet platforms	Applies

The survey included student recall of their HI learning experiences and subsequent level of confidence in applying skills and competencies associated with six domains of HI (Table 1) and their opinions on the relevance and need to teach the identified HI skills and competencies during their medical degree.

We developed the survey *de novo*. Since medical students may struggle to interpret HI jargon and require context to understand terminology (Fernando & Lindley, 2018), clinical vignettes were developed to illustrate the practical application of the six HI competency domains (Appendix 1). To ensure relevance, the vignettes centred on the role of a newly graduated doctor and existing technology used in NZ hospitals. Each vignette was developed by a final-year medical student (HT) based on actual experiences in the clinical setting and edited by three doctors who are also medical educators (DK, TW, RG). The newly graduated intern survey participants were provided with the vignettes for each of the six HI competency domains and asked to rate their agreement with the statement *"I feel confident in applying concepts and principles in my clinical practice relating to …"* (HI topic, from Table 1), selecting from a 5-point Likert scale of "strongly agree", "somewhat agree", "neither agree or disagree", "somewhat disagree" or "strongly disagree". A follow up question asked if they recalled formal or informal teaching on each competency (Yes/No) and invited a free-text comment.

Focus groups

To explore the opinions and experiences of current students in detail, five focus groups of final-year medical students were conducted. Each focus group was led by a final-year medical student (HT). By way of training, the senior author (RG) provided the student researcher with readings on focus groups and their facilitation, discussed the student researcher's understanding of these, role played aspects of interviewing with the student and discussed each focus group with the student researcher after data collection. Student participants were provided with pre-reading, which included the vignettes used in the survey. Interview questions focused on each of the six HI competencies with reference to the clinical vignettes. Students were asked how well they felt their learning at medical school had prepared them for use of the HI skills in practice, how important these HI topics are and how they would like to be taught these HI topics (Interview schedule, Appendix 2).

Convenience sampling was used to recruit the focus groups via medical student Facebook groups, with each group of participants consisting of 3–4 students. As the underpinning approach for the study was naturalistic, informational redundancy was the key determining factor for sample size sufficiency (Lincoln & Guba, 1985), coupled with researcher judgement in light of the purpose of the data usage (Sandelowski, 1995). Each focus group meeting was recorded on a password protected smartphone and transcribed.

Data analysis

Survey data were managed and demographic summaries were produced via Microsoft Excel and SPSS. Likert scales were summarised by response count as a percentage of total using R studio and associated packages (Bryer & Speerschneider, 2016; R Core Team, 2021).

All free text (survey and focus groups) were combined for analysis, managed in Excel and analysed based on the 6-step thematic analysis (TA) method, as described by Braun and Clarke (2006). Free-text comments from the survey and transcriptions of focus groups were coded by two medical students (HT, AO). By way of training, the senior author (RG) provided the student researchers with readings on thematic analysis, discussed student understanding of these and then reviewed and refined initial coding with the students. As coding progressed, themes were identified by grouping codes together. Codes were then reviewed by the interviewer (HT) and project leader (RG) and subsequently grouped into themes. Theme definitions were confirmed and quotes were selected that illustrated each theme.

The study was approved by the University of Otago Human Ethics Committee, Human (D18/244). Written informed consent was obtained before participation.

Results

Declared curriculum

The University of Otago MB ChB curriculum stocktake identified learning outcomes in five of the six competency areas. No learning outcome in our curriculum mapped to "evaluating software and systems". Within the competency area of "communication and the internet", there were no learning outcomes related to the topic "telemedicine" (Table 2). Graduates were expected to have the level of learning of "does" or "applies" for all identified learning outcomes.

Table 3

Survey Respondent Demographics

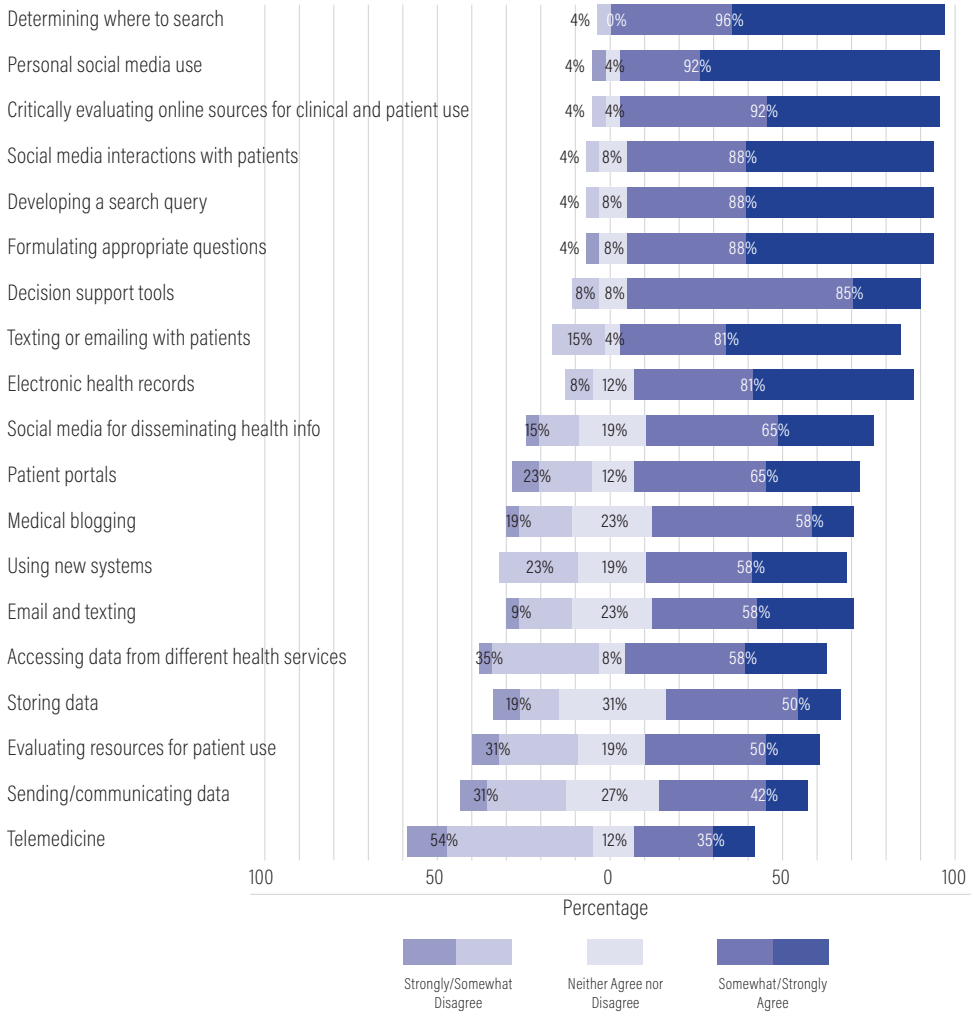
	PGY1 n = 14 (54%)	**PGY2** n = 12 (46%)	**TOTAL** n = 26
Age, years			
21–25	8	6	14
26–30	5	5	10
31–35	1	1	2
Gender			
Male	6	5	11
Female	8	7	15

Survey results

The survey was completed by 26 University of Otago postgraduate prevocational intern doctors (PGY1 n = 14, PGY2 n = 12). Since the snowball sampling approach was via student social media, we cannot determine with certainty the response rate. Just over half were female (58%, 15/26), with 14/26 (54%) of participants aged between 21 and 25 years and a range of 21–35 years (Table 3).

Figure 1

Extent to Which Student Participants Agree That They Are Confident in Applying Health Informatics Competencies From Vignettes in Clinical Practice



Most survey participants indicated that they were confident (above 50% "strongly agreed" or "somewhat agreed") in applying the majority of HI competencies (Figure 1). However, more than half of participants indicated they lacked confidence ("strongly disagreed" and "somewhat disagreed") in the use of telemedicine, and almost a third responded the same way for questions regarding sending/communicating data and evaluating resources for patient use. Further, around a third of the participants answered neutral ("neither agree nor disagree") responses for the questions on data communication and storage. This corresponds with just 7/26 (27%) of the participants' recall of the inclusion of data communication and storage topics within the domain mapped to "data security and confidentiality" in the taught curriculum (Table 4). Indeed, graduate doctors' recollection of the inclusion of HI competency domains in their taught curriculum varied from a low of 3/26 (12%) for finding and using decision support tools to 26/26 (100%) for searching online information sources and databases (Table 4). Consistent with an absence in the declared curriculum, no participants recalled taught curriculum on evaluating software and systems. Most graduates were supportive of the inclusion of the suggested HI topic areas, with a relatively high percentage of participants agreeing on inclusion of all 19 proposed topics (Table 4).

Table 4

PGY1 and PGY2 Survey Participant Recall of Formal (Taught) Curriculum and Topics for Inclusion in Formal Curriculum

Competency Area of Health Informatics	Topic	Participants Recalling Formal Curriculum, n (%)	Participants Agreeing Topic Should Be in Formal Curriculum, n (%)
Managing data and information	Use of electronic health records	14 (54)	17 (65)
	Accessing data from different health services, e.g., private/GP/public		18 (69)
	Patient portals		16 (62)
	Email and texting		19 (73)
Knowledge engineering and decision support	Finding and using appropriate decision support tools	3 (12)	18 (69)
Data security and confidentiality	Storing data	7 (27)	21 (81)
	Sending/communicating data, e.g., via email		23 (89)
Evaluating software and systems	Evaluating resources for patient use	0 (0)	17 (65)
	Using new systems, e.g., e-prescribing		15 (58)

Competency Area of Health Informatics	Topic	Participants Recalling Formal Curriculum, n (%)	Participants Agreeing Topic Should Be in Formal Curriculum, n (%)
Searching online information sources and database	Formulating appropriate question	26 (100)	23 (89)
	Developing a search query from a question to maximise search		24 (92)
	Determining where to search for information		23 (88)
	Critically evaluating online sources for clinical and patient use		25 (96)
Communication and the internet	Personal use of social media	21 (81)	18 (69)
	Medical blogging		13 (50)
	Social media for disseminating health information/education, e.g., hospital FB pages		16 (61)
	Texting/email with patients		23 (88)
	Social media interaction with patients		22 (84)
	Telemedicine		18 (69)

Focus group and survey qualitative data

Student characteristics

Seventeen final-year medical students (TIs) participated in five focus group interviews. Most participants were female (13/17, 76%), and most had entered the medical degree via the undergraduate entry pathway (14/17, 82%).

Themes

Thematic analysis of the survey free text and focus group interviews identified an overarching tacit agreement with the need for medical students to graduate with skills and knowledge in HI. Students reported that some areas and skills were already covered sufficiently in the curriculum, such as "managing data and information", "data security and confidentiality", "searching online information" and "communication and the internet". Areas students identified as scantly, if at all, covered included "knowledge engineering and decision support" and "evaluating software and systems".

There were three key themes relating to how students viewed themselves as learners of health informatics and digital skills in the current learning environment (representative quotes in text, with additional quotes available in Table 5). The first theme was the "medical digital native". Medical students viewed themselves as digital natives who had highly developed skills for use of information and communication technology skills:

> *I think people from our generation can figure those things out.*

They were also confident in their ability to apply these skills to unfamiliar new technology in the healthcare setting without formal teaching:

> *I think the [medical] degree hasn't prepared us, but we're a generation that is confident with technology therefore feel able to do it fairly well.*

Similarly, they felt confident to apply generic skills and knowledge, such as critical appraisal or principles of privacy and confidentiality, to digital tools:

> *I think our generation's actually quite good at searching for information and picking out which ones are good.*

The second theme captured "students' strong preference for relevant, experiential, clinically situated learning":

> *For me, it's just [hospital] dependent. You learn when you get there to do the job. … That would be what I'd be happiest with.*

If formal teaching was necessary, students felt it should be delivered at a time when the relevance was clear:

> *I think a tutorial where you have these kinds of vignettes is quite useful, because it makes you think of what you would actually do in the situation. … It's not super useful to have someone spurt out a lecture to you.*

Students expressed that they could learn while on clinical placement either formally, such as how to use site-specific electronic health records, or informally via role modelling from near-peer junior doctors:

> *I think house surgeons or registrars [junior doctors] showing you how to access this information.*

Students also felt that detailed knowledge of certain HI topics should not be the responsibility of individual clinicians but instead shared across the broader organisational structure:

> *I'm not sure house officer time is best spent individually evaluating apps for patients to use. It would be better to have a list of reputable [hospital] endorsed apps or to leave it in CNS [clinical nurse specialist] hands.*

The third theme captured "the risk of disconnect with tension created when taught curriculum and clinical experiences were at odds". Discomfort, ambivalence and/or concern were created when the principles and knowledge in a declared and taught curriculum were not observed in the contemporary clinical environment:

> *I feel like the teaching would be advice for a perfect system, which we don't really have so we just have to deal with what we've got.*

This may be the case if a curriculum teaches outdated or different technology products, expects clinical environments to have fit-for-purpose, up-to-date information technology software or if the skills and attitudes taught by the curriculum are not modelled by clinicians:

> *It would be difficult for the theoretical teaching to reflect the daily practices that take place on the wards.*

Hospitals and health services may not be equipped with systems that allow clinicians to follow health informatics best practice, which affects the perceived value when teaching focuses on best practice without reference to actual clinical practice:

> *In reality people use their private phones to take images and send it via the phone network. IT systems available at [the hospital] lags [*sic*] behind available capabilities so it feels like needless red tape.*

Table 5

Key Themes From Students' Opinions About Learning Health Informatics During Their Primary Medical Degree

Theme	Illustrative Quotations
Medical digital native	Student 1: "Kind of like, with the system the GPs use, I can't remember what it's called. Student 2: "MedTech"[1]. Student 1: "I'd never seen it before, but within, like, a couple of days it was quite easy to use. (all laugh) But you can use it, you know?" "I guess I just feel like, again, we're pretty tech savvy. We've had lectures on appraising the reliability of studies, but that's widely applicable to, like, also things like, that, you can kind of see that things like holisticnaturalhealth.com isn't gonna be a very reputable medical information site compared to something that's like, produced by Starship[2]. You know, you can kinda gauge that, and I think that … " "I remember, in, it was either second or third year, they did have a lecture about this kind of thing. And it was more around inappropriate patient relationships and inappropriate posts on Facebook and stuff, and I personally sat there and thought, 'Oh my God, how stupid do they think we are?' Like, our generation is pretty savvy, and we know that you shouldn't post stupid stuff on Facebook, and maybe there are people where that's a more new thing for them to need that kind of information, but our generation just goes, 'Oh God, are you serious?'" "So I think that overall, our generation is quite good at using technology." "Yeah, I mean, technology came up when we were still young. and our brains were still very plastic, so we know how to learn technology."
Experiential clinically situated learning	"I don't think you really need formal teaching on that because when you're working, you will be at a different place from where you learn. It's something that you need to learn from your job" "And I feel like it's certainly not something, like, knowing how to get that information is certainly not something you're ever, like, formally taught. It's just like, oh, you know, the house officer is asked to do it, and you're there and they're kind of like, this is how you would do it. So it's not, definitely not something I've ever been sat down and showed how to do. But it's also not something that I think would be too difficult to work out." "But I think it's just best learned just before you're about to use it. I don't feel like a tutorial would actually be that helpful."

Experiential clinically situated learning *(continued)*	"I think as well, if we got taught how to actually use MedTech, say in fourth year, you'd go: This is so stupid, not relevant, what a waste of time, blah blah blah. Yeah. So you wouldn't actually get much out of it, whereas hindsight, when you're actually working and using it, you'd be like, yep, could have been useful to do that in our degree but you know, our brains at that point in time aren't ready for that, and they don't think it's useful so I wouldn't actually benefit that much from it."
Risk of disconnect and tension	"I personally feel very confused by this. I don't actually know what [hospital name] 's policy is [regarding patient consent to share information] … I wouldn't know what to do in a WhatsApp group, but everyone just seems to text patient information pretty openly." "We had a WhatsApp group … so we were constantly sending our registrar and consultant pictures of ulcers! And cos I'm not very savvy, they were auto-downloading onto my phone … and then I lost my phone for 4 days. That's really dangerous … But it's what we had to do, because the registrar would be off doing whatever, and the boss would be at private [practice]." "Yeah. Cos I feel like the teaching would be advice for a perfect system which we don't really have so we just have to deal with what we've got, and it probably isn't ideal, but I guess, yeah, getting – cos, certainly, from the teaching that I had in medical school, it was: don't take photos, really, but that's not practical." "But the consultants use their phones a lot, and like, I, yeah, they would often, like, hand me their phone or get me to pick up their phone in theatre and then take a photo of what they're doing for, like, their records of, 'this is an interesting surgical case' or something." "I guess you do it the most practical way possible and try to anonymise the photo, have the photo of the ulcer which could be anyone's ulcer. And then try and send it off in a … I mean, if you're going through WhatsApp, you know, it's technically not in private or anything else like that, yeah … unless we all get our fantastic mystical DHB phones and everything else like that. I feel, I mean, you need to have the resources to be able to follow the teaching that they might be teaching us because otherwise it's just pointless being taught about something that you aren't going to do anyway."

[1] Electronic medical record commonly used by GP practices in New Zealand

[2] Starship Children's Hospital, a public children's hospital in Auckland, New Zealand

Discussion

In our case study, we found that our MB ChB declared curriculum covers many, but not all, of the key skills and knowledge in an ideal HI curriculum. While many students were self-assured in their technology abilities, many students also reported low confidence in some areas of HI. Our participants tacitly approved HI skills as essential to their future work but also noted student learning did not align with their experiences of digital healthcare in clinical settings. They emphasised their agency in learning and expressed a preference for clinically relevant, up-to-date HI teaching and reiterated the importance of a curriculum content that is authentic and clinically situated. Given the importance of online resources for patient information (Honey et al., 2018), emphasis on participatory health and use of apps (Qudah & Luetsch, 2019) and the recent widespread adoption of telehealth (Monaghesh & Hajizadeh, 2020; Qudah & Luetsch, 2019), the omission of some learning outcomes in our declared curriculum needs addressing. This, and the comments from our participants, highlights that HI is an evolving field, so any learning outcomes need to be sufficiently generic to remain future-proofed. Future HI curriculum should have explicit clinical relevance and address gaps between theory and practice.

Many of our participants' responses indicated they identified as digital natives (Prensky, 2001). These students were confident that they could become proficient with unfamiliar HI concepts without difficulty due to their familiarity with technology in general. However, some digital natives have only a superficial understanding of technological developments and applications (Cummings et al., 2017). Indeed, some scholars debunk the notion that a generation might have greater digital skills simply because they have never known a world without technology (Kirschner & De Bruyckere, 2017). Others maintain that the apparent digital proficiency among the "Google generation" does not translate to effective technology use due to lack of critical and analytical skills (Rowlands et al., 2008). Researchers from the University of Sydney found that health sciences students' skills and confidence in technology gained from personal contexts does not directly translate into professional HI contexts, which creates a need for specific training and scaffolding (Lam et al., 2016). Therefore, future curriculum development should be cognisant of the potential for disconnect between learners' perceived abilities and actual abilities.

Our findings suggest educators should be encouraged to consider pedagogies that enhance learner agency and avoid a potentially troublesome focus on current skill levels (Bennett et al., 2008). This could also address the perceived, or actual, outdated skills of educators. For an HI curriculum, an emphasis on student-centered learning and contemporary professional competencies seems particularly desirable (de Wet & Yelland, 2015). This might involve co-creation with students and teaching focused more on the bigger-picture HI concepts rather than ICT systems with which students already have confidence. For example, any current digital technology teaching should emphasise application of principles such as data security, confidentiality and accuracy and managing online presence as agnostic to the actual technology and always model professional digital behaviour (Ellaway et al., 2015).

Given students perceived that many relevant principles underpinning HI concepts were already included in their curriculum, ensuring this teaching reflected current ICT practices is also critical. Our case study identified that some of the taught curriculum may not be able to be applied within existing ICT in clinical settings. Widespread use of WhatsApp in clinical settings created tension for our participants, as this contradicted formal teaching in digital professionalism. The use of WhatsApp in hospitals is unsurprising given its simplicity, cost effectiveness and lack of regulation or guidelines (Mars et al., 2019). This example highlights how clinical settings that lack appropriate systems for work can lead to inappropriate role modelling that erodes learning. Students will also be hampered in developing digital skills and professionalism in clinical settings if they are not given access to the digital tools used in the workplace. Clinical placement providers should be encouraged to confirm their workplaces provide appropriate digital tools for contemporary work and make those available to health professional students.

Our participants supported integration of clinically relevant HI content within their medical degree. As well as accounting for variation in student skills and confidence and addressing potential cognitive bias from digital natives, this curriculum will need to address future areas in technology. A contemporary HI curriculum needs to cover participatory health (Qudah & Luetsch, 2019), machine learning (Williams & Grainger, 2020) and genomic medicine (Topol, 2019) and be flexible enough to include new technologies as they emerge.

A strength of this study is the inclusion of both final-year medical students and recent graduates, who have sufficient clinical exposure and retrospect to determine what HI learning is relevant. Another strength was that the data collection was conducted by a peer student. We also highlight our novel use of authentic vignettes that provided additional face validity for participants. The study also has limitations. The response rate to the survey was very low. While snowball sampling does not have a definite denominator, our survey has an estimated response rate of under 5%. This is a considerable shortcoming, as the participants that did respond may have bias toward HI and may hold non-representative views. These data should therefore be considered exploratory only. The HI domains we used as a basis for our study are somewhat dated. At the time of the study, this was the most recent Australasian HI curriculum proposal for health professions. To date, there is not yet a widely endorsed HI curriculum for primary medical degrees nationally or internationally. Finally, we only interrogated the declared curriculum, not the taught curriculum, as the declared curriculum is readily available in our curriculum management tool but the taught curriculum is not.

Conclusion

In our setting, medical students understand HI skills are required for contemporary medical practice and value education in this domain. Students prefer relevant, experiential, clinically situated learning, and education providers need to be prepared for disillusionment over tensions that may emerge around the disparities between the teaching and clinical environments. Future studies should aim to identify how HI can be effectively integrated into the current curriculum in a manner that is authentic to practice so that students graduate as part of the digitally capable health workforce. Seeking views from more students, educators, relevant clinicians and sector leaders in digital health capabilities for our workforce would extend our exploratory study.

Conflicts of interest and funding

Tim Wilkinson and Rebecca Grainger are associate editors for *Focus on Health Professional Education*. The authors are not aware of any other potential conflicts of interest for this work that are not already explained in the body of the manuscript. Funding for Amy O'Neill and Hermaleigh Townsley to be employed as research assistants on this project was obtained from a University of Otago Committee for Advancement of Learning and Teaching (CALT) grant.

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Appendix 1

Clinical Vignettes

The six areas of health informatics

1. Managing data and information

- Use of electronic health records
- Accessing data from different health services, e.g., private/GP/public
- Patient portals
- Email and texting

Vignette: You are a surgical house officer admitting a patient with an acute abdomen who has had previous abdominal surgery performed at a different hospital. The patient mentions some complications following the operation, but they are unsure of all the details. Your registrar asks you to access the operation note from the hospital in question.

Vignette: You are a surgical house officer whose new team communicates via a group WhatsApp conversation. You will need to understand the limits of patient details that can be communicated via this forum.

2. Knowledge engineering and decision support

- Finding and using appropriate decision support tools

Vignette: You are a house officer working in the emergency department. You are seeing a patient who you think may have a DVT and want to calculate their Wells score to help assess their risk and guide your next investigations. You have recently downloaded an app that you've seen other doctors using to calculate various clinical scores, so you decide to

use this to calculate a Wells score. You will need to be able to assess the reliability of the app and determine how appropriate its calculations are for our XX population.

3. Data security and confidentiality

- Storing data
- Sending/communicating data, e.g., via email

Vignette: You are a medical house officer looking after a patient who has developed a diabetic ulcer. Your consultant is off-site and asks you via text to take a photo of the wound to show them. You need to share this photo with them securely and confidentially. If you are going to show the consultant later in person, you will need to safely store the image somewhere to protect patient confidentiality.

4. Evaluating software and systems

- Evaluating resources for patient use
- Using new systems, e.g., e-prescribing

Vignette: A patient with Type II diabetes on the ward asks you, their house officer, about apps they can use to monitor their glucose levels and symptoms. You want to recommend them an app that provides safe medical information and is secure. You also wonder whether there are any apps that have been shown in studies to improve clinical outcomes in diabetes. You will need to find and appraise apps to advise the patient about.

Vignette: Your hospital is de-commissioning its paging system as the paging towers are being turned off. You are asked to be the house officer on the committee advising IT about likely clinical impact of introducing a new smartphone-based communication system. You will need to identify some challenges and possible implications of switching to a new system.

5. Searching online information sources and databases

- Formulating appropriate questions
- Developing a search query from a question to maximise search
- Determining where to search for information
- Critically evaluating online sources for clinical and patient use

Vignette: You are a house officer looking after a patient with multiple comorbidities and chronic pain. One of the members of your team mentions a new medication they have heard of that may be helpful for chronic pain and asks you to look at the evidence for this. You will need to devise a search strategy and evaluate the available evidence to help your team make a decision.

6. Communication and the internet

- Medical blogging
- Social media for disseminating health information/education, e.g., hospital FB pages
- Texting/email with patients
- Social media interaction with patients
- Telemedicine

Vignette: You are a house officer working in the emergency department in XXXXX Hospital, seeing a patient who is being evaluated for a stroke. You and your supervising consultant are going to use the XXXXX telestroke service, where a neurologist will provide advice about whether to initiate thrombolysis. You will need to use a telemedicine approach, including performing an examination for the off-site neurologist and communicating the situation to allow them to make treatment decisions.

Vignette: You are a house officer working on a medical ward, looking after a patient who has pneumonia. You get on well with the patient and the family members who have been visiting. One family member finds you on Facebook and sends you a message asking about the case. You will need to respond to the situation appropriately and ethically.

Appendix 2

Focus Group Interview Schedule

1. How well do you feel your MB ChB has prepared you to use these skills in clinical practice?
   - *Could expand on how they learned as per survey*
2. Which topics do you think should be included in the curriculum?
   - *Could ask to rank the sections in order of importance*
3. How important do you think these topics are compared to other areas of medicine taught in the MB ChB?
4. How would you like to be taught about these topics?
   - *Ask about if it would be useful in light of actual practice in the hospital*

Note: Questions to be repeated for each area of health informatics