

2 A Global View of Structures and Trends in Medical Education

Bridget C. O'Brien¹, Kirsty Forrest², Marjo Wijnen-Meijer³, and Olle ten Cate^{1,4}

¹Department of Medicine, Center for Faculty Educators, University of California, San Francisco, CA, USA

²Faculty of Health Sciences and Medicine, Bond University, Gold Coast, QLD, Australia

³TUM Medical Education Center, Technical University of Munich, Munich, Germany

⁴Center for Research and Development of Education, University Medical Center, Utrecht University, Utrecht, The Netherlands



KEY MESSAGES

- The educational pathway from secondary school to unrestricted medical practice shows roughly six structural routes worldwide.
- All pathways will likely be affected by educational system innovations, globalisation, health care systems, social and cultural values, and technology.
- Each of these forces pushes and pulls medical education in different directions, which results in disparate views and uncertainty about the purpose of medical education.
- Change is one constant feature of medical education that we can anticipate. The speed of developments in health care and education will require programmes, learners, and educators to adapt throughout the continuum of training and practice, as a core quality.

Introduction

This book, the third edition of *Understanding Medical Education*, aims to provide a more global perspective on medical education. This chapter provides context for subsequent chapters. In the first section we describe six structural models of medical education around the world. In the second section, we consider the purpose of medical education and the complexity of defining and working toward a shared sense of social accountability in an increasingly globalised world. In the third section, we discuss current trends in medical education, identified by thought leaders in the field. We speculate where these trends may take us in the next 10 years, and then conclude with some overarching reflections on the themes presented in the chapter and questions for further consideration.

Medical Education Pathways Worldwide

The training of medical doctors is well established in virtually every country around the globe; to the public, physicians are physicians, no matter where they train. Yet when we look in detail, the pathways students must follow to become licensed appear to vary considerably. In many industrialised societies, the current structure of medical training was established between 100 and 150 years ago, when university studies in medicine were combined with the guild-like models of barber-surgeon training. A theoretical training

phase followed by a phase of practical apprenticeships became a dominant model in the first half of the twentieth century. After World War II a large expansion of postgraduate medical specialty training emerged, and in parallel newer educational models of undergraduate education were introduced. Several solutions to transition problems, from theory to practice, from undergraduate to postgraduate, and from training to unrestricted practice were created. As these innovations in the medical education pathway did not occur at the same time in all countries, international and even regional differences within countries became apparent, with possible differences in outcomes [1, 2].

Additionally, countries and international regions have their own views on how best to educate doctors to serve the needs of their populations. Influential models arose from: the British model, influencing predominantly the Commonwealth countries; the North American model, influencing several emerging countries; and the continental European model. In Europe, all European Union (EU) countries must comply with EU rules regulating the internal market, including the mutual recognition of professional diplomas, based on rules that prescribe some features of medical training [3].

Despite increasing international communications about medical education through dedicated medical education journals, conferences, associations, a World Federation for Medical Education (WFME) [4], and organisations and initiatives devoted to or impacting international development of education such as FAIMER [5–7], the pathways to

medical practice remain distinctly different among countries. Information about these differences is important because of the growing mobility of students and graduates and the corresponding need to understand what level of performance and experience diplomas and qualifications signify [8–10].

To supply this much needed information, Wijnen-Meijer and colleagues carried out a qualitative questionnaire study among well-informed medical educators in several countries. This led to an overview of structures and terminologies in 40 countries, published in 2013 [11]. This chapter adds 10 more countries to the 2013 data set, for a total of 50 countries. Most questionnaire responses were collected by e-mail and supplemented with information obtained at international conferences. Well-informed respondents answered questions about the different stages of medical education in their country, the length of these stages, the point at which unrestricted practice is allowed, and any additional requirements such as exams.

Wijnen-Meijer and colleagues found six dominant pathways through medical education that they called ‘routes’ (see Figure 2.1). In most countries students enter medical school directly after finishing secondary school (Routes I through IV). Routes V and VI describe pathways for which a bachelor’s degree is required. In many countries graduates can enter residency directly after finishing medical school (Route I and V), while in other countries graduates must first finish an internship or mandatory social service or both. Of note, the six pathways contain much variation within their general structures and within countries multiple routes may exist. For example, as shown in Figure 2.2, the length of postgraduate (residency) training varies

among specialties within one country as well as within the same specialty across countries. Also, the requirements for unrestricted practice can range from attainment of the MD degree to one year of specialty training to completion of specialty training and fellowship.

Similar to structure, terminology differs from country to country and can pose challenges for translation of educational levels across borders or comparison of curricula, instruction, and outcomes internationally. Box 2.1 describes some of the commonly used terminology in medical education worldwide. These terms are used variably throughout the book, reflecting the international perspective of individual chapter authors. Box 2.2 identifies the degrees awarded in medical education.

Though appealing on many levels, attempts to harmonise medical education across countries have had limited success. For example, in 1999, the governments of all EU countries and some surrounding countries agreed to harmonise all of higher education in three phases: bachelor, master, and doctorate [12]. This Bologna Process was well accepted by all of higher education in 48 countries with the exception of medical education in all but 7 countries. Those seven countries now organise ‘undergraduate’ medical education in two phases (bachelor and master), while all of the others in the agreement do not. The attempt created more disparity than harmony [13, 14]. The WFME takes a different approach. Rather than attempting to harmonise the structure of medical education, the WFME provides a consensus-based set of 106 basic standards and 90 standards for quality improvement that provide ‘a template for medical schools and other providers of medical education, and the agencies which accredit them to define institutional, national and regional standards,

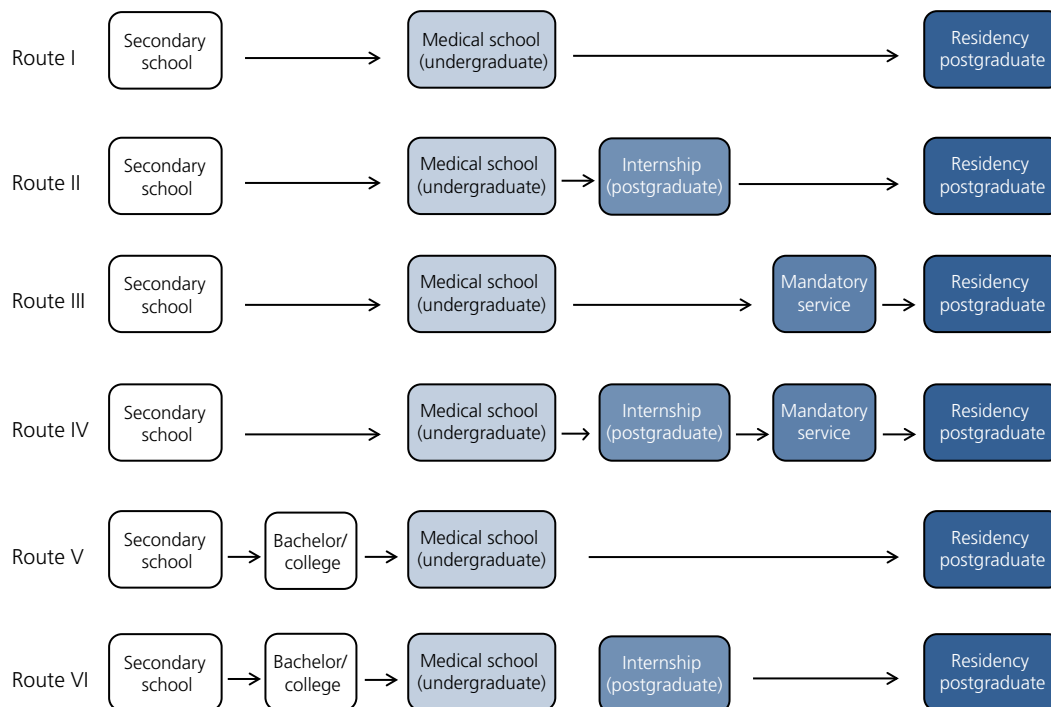
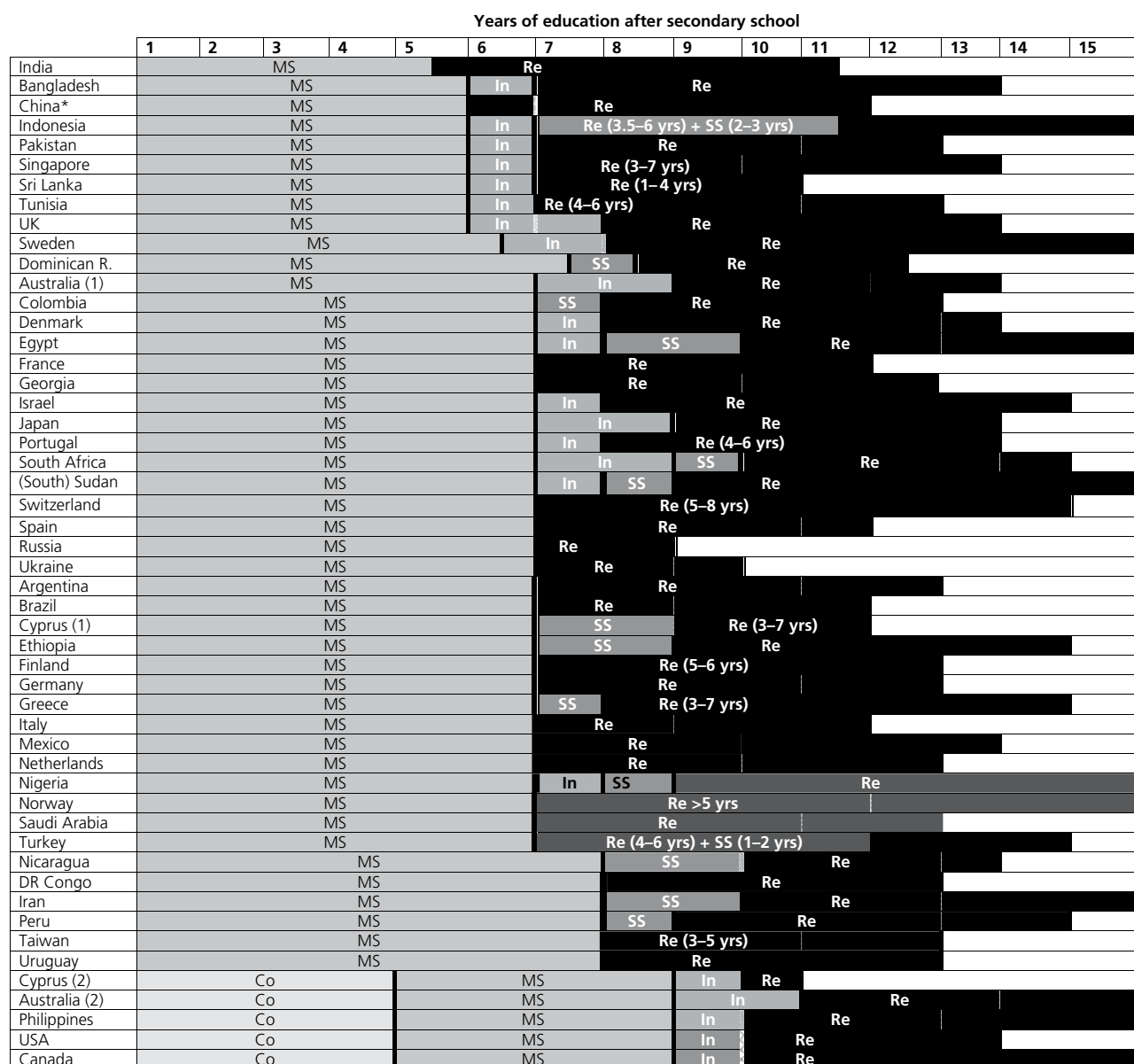


Figure 2.1 Six routes to unrestricted practice.



*after 1 year of residency and completion of the National Medical Examination, residents are allowed unrestricted practice

Lines

-----	Minimum number of years (for example for residency period)
————	End of phase (for example medical school or residency)
=====	End of phase and trainee is allowed unrestricted practice of medicine at this point
=====	Trainee is allowed unrestricted practice after finishing this phase, +/- additional requirements (for example exam)
~~~~~	Trainee is allowed unrestricted practice of medicine at this point (other moment than end of phase)

Abbreviations

Co:	College
MS:	Medical school
In:	Internship, also called 'Foundation programme', 'Medical officer', 'House officer training period' or 'Housemanship'
SS:	Social Service, also called 'National Service', 'Service in rural areas' or 'Mandatory service'
Re:	Residency

Figure 2.2 Medical education comparisons by country: phases and duration.

and to act as a lever for quality improvement' [15]. This approach aims to enable, or even foster, diversity so educational programmes across the continuum of medical education can accommodate economic, political, social, and cultural contexts while having an internationally recognised

framework to guide curriculum development, learner assessment, faculty development, and programme evaluation.

There may not be a compelling reason or any chance of success in forcing countries to adopt similar structures or terminologies, if only because it cannot be determined


**BOX 2.1 FOCUS ON: Common terminologies in medical education**

Term	Description
Basic medical education	The portion of medical education that occurs in medical school; also called undergraduate medical education.
Chief resident	A selected senior resident with administrative and teaching responsibilities toward junior medical trainees.
Clerk	A medical student on a clinical rotation or in clerkship phase.
Clerkship	A period of one or more weeks of (clinical) experience in a medical specialty during medical school.
Consultant	Senior hospital-based physician who has completed residency.
Fellowship	A training period in a medical sub-specialty that occurs one or more years after completion of general specialty training.
Foundation doctor	A trainee in a Foundation Programme (UK).
Foundation programme	A two-year, clinical training programme after medical school and before postgraduate medical training in the UK.
Graduate medical education	Used in North America. Synonymous with postgraduate medical education.
House officer	Period of practice between medical school and full registration in several countries. Also called: medical officer or housemanship or a postgraduate medical trainee.
Intern	A trainee in a clinical training period directly after medical school, usually identical to the first year of residency training.
Medical bachelor	The first three years of medical school in countries that have signed the EU Bologna agreement and have included medical education in this structure.
Medical master	The second three years of medical school in countries that have signed the EU Bologna agreement and have included medical education in this structure.
Medical school	The institutional organisation that offers an undergraduate medical education programme, usually overlapping with the medical faculty of a university; sometimes used as undergraduate medical education phase.
Medical student	A person enrolled in an undergraduate medical education programme.
Physician	A graduate from a medical school who is formally licensed to practice medicine.
Placement	Synonymous with rotation.
Postgraduate medical education	Usually synonymous with residency training, but in Australia and New Zealand the phase after initial higher education.
Registrar	A medical trainee in a postgraduate education programme after registration as MBBS or MBChB.
Residency	A postgraduate training programme to become a medical specialist.
Resident	A medical trainee in a postgraduate education programme.
Rotation	A period or one or more weeks of experience with a medical specialty during medical school or residency.
Senior house officer	A year (or two) after house officer prior to specialist training.
Social service	A period of mandatory clinical service after medical school, usually as part of an agreement with the school or funding body, in a region in need of medical service (also called national service).
Specialist	Physician who has finished residency in a specific specialty of medicine.
Trainee	An individual who is in a formal educational or training programme at any level of medical education; often a term confined to the clinical phases of education.
Undergraduate education	Either initial higher education at bachelor level preceding undergraduate medical education, or medical school education.

which are better than others. But, as will become clear in the section on globalisation below, international interactions about medical education are naturally becoming much more intense. Schools and countries learn through publications, conferences, and student and faculty exchanges, and it may be expected that through natural processes of curriculum development, informed by what other countries do, that medical education will gradually converge to more similar models.

### Purposes and Priorities in Medical Education

The pathways and terminologies described in the previous section reflect educational systems designed to meet societal needs for health care. These systems are steeped in cultural, historical, political, and economic contexts that have changed substantially since many of these systems were first established. Yet the basic systems of medical education



## BOX 2.2 FOCUS ON: Degrees in medical education

### Degrees

BSc	Bachelor of Science in Medicine
MSc	Master of Science in Medicine, usually equal to MBBS/MBChB or MD
MD	Medical Doctor, the degree awarded after medical school; in Commonwealth countries MD is optional and requires additional doctoral training
MBBS	Medical Bachelor and Bachelor of Surgery, leading to a licence to practise (Commonwealth countries)
MBChB	Medical Bachelor and Surgical (chirurgia) Bachelor, leading to a licence to practise (Commonwealth countries)

remain largely the same, despite numerous local and national reform efforts [16]. Some would argue these systems are no longer ‘fit-for-purpose’ [6].

According to the mandate of social accountability, societal needs and priorities should drive medical education [17–19]. But this seemingly simple mandate is actually quite complex, as evidenced in a 2011 theme issue of *Medical Teacher*. Societal needs vary from the local communities served by the medical school and affiliated health care systems to national and international communities. Historically, local needs have taken priority, but in an increasingly international world we need to reconsider which of these takes priority and how an optimal balance among all three might be achieved [20]. Additionally, it takes students at least six years to complete medical training and enter practice. This lengthy process creates a lag between demand and supply that is difficult to correct midcourse. Curriculum planning faces a similar conundrum as content and processes try to keep pace with new discoveries, technologies, and epidemiological patterns. Can existing educational systems become more flexible and adaptable or do we need a major redesign that integrates multiple health professions? Furthermore, society consists of multiple stakeholders (e.g. patients, health professionals, government officials), each of whom may define societal needs and priorities differently. How are these to be reconciled?

Several national and international groups have attempted to establish a collective vision of the purpose of medical education [6, 21–25]. This vision can, in theory, provide the essential basis for accreditation standards, workforce and education policies, curriculum development, and required competencies for licensure or unsupervised practice. In practice, operationalising a global, collective vision of the purpose of medical education and enacting necessary structural and curricular reforms might be characterised as a ‘wicked problem’, one that lacks ‘definitional clarity because multiple stakeholders in shifting social contexts have different interpretations and seek different outcomes’ [26, p. 339, 27]. In the section that follows, we gain some insight into the issues that thought-leaders in medical education see as priorities in the sense that they are likely to impact the future of medical education over the next 10 years.

### Glimpses of the Future

*‘In the long run, we will neither need nor want professionals to work in the way that they did in the twentieth century and before’* (Susskind and Susskind) [28, p. 1].

To prepare a chapter discussing the future of medical education, we (the authors of this chapter) sought assistance from experts around the globe. In June 2017 we asked authors of chapters in this book, its editorial board members, and a group of thought-leaders from diverse geographic, disciplinary, and institutional perspectives to *‘Identify at least 3 factors you think will impact the future of medical education in the next 10 years and describe why each of these factors will be so influential’*.

We contacted 91 individuals and 51 shared their ideas, from 18 countries across 6 continents (see Box 2.3). Respondents identified more than 150 factors likely to impact the future of medical education. We clustered these factors into five overarching themes. On balance, the responses might be characterised as ‘cautiously optimistic’, though as one respondent astutely noted, ‘the answer depends on whether one takes an optimistic or pessimistic view of the future’.

Admittedly, predictions of social phenomena are often erroneous [29], but clairvoyance was not the goal of this endeavour. Rather, the point was a global snapshot to capture the current focus of attention as, perhaps, an important way of contextualising the content in the chapters that follow. We suggest readers consider the themes as commentary on the current state of affairs in health professions education and an opportunity for reflection as well as anticipation.

In writing up the themes from the responses, we attempted to capture the many thoughtful and insightful responses we received. That said, we acknowledge that the resulting picture cannot fully capture an accurate representation of the surveyed population. We integrated some of our own perspectives with those of respondents to the survey (noted in quotes) and referenced literature where we identified relevant connections. We realise that re-reading the chapter five years after its appearance may strike us with embarrassment [30], but if this chapter inspires readers to ponder a *possible* future, and guides readers in current educational and curricular decisions, then its purpose is fulfilled.

**BOX 2.3 Location and number of respondents**

Continent	Country (Number of respondents)
Africa	Ethiopia (1), Tanzania (1), South Africa (2)
Asia	Japan (1), Taiwan (1), Singapore (2)
Australia/New Zealand	Australia (4), New Zealand (1)
Europe	Denmark (1), Germany (1), The Netherlands (2), Spain (1), Sweden (1), United Kingdom (12)
North America	Canada (9), United States (7)
South America	Argentina (1), Venezuela (1)

We grouped the responses into five primary themes, each with several sub-themes:

- Educational system factors that highlight developments in curricula across the continuum such as competency-based time-variable programmes, simulation, faculty development, and market aspects such as finances and selection procedures.
- Globalisation, including attention to migration, sharing of educational tools and concepts, increasing international collaborations, and development of international standards.
- Health care system factors, including greater attention to preventative medicine, the need for team-based approaches to care, and workforce shortages.
- Cultural and societal factors, including further elaboration and clarification of core principles of professionalism, changing values and expectations among and toward patients, and changing values and expectations among and toward learners.
- Technological factors, including technology-supported clinical reasoning, changing relationships with patients, information access and the role of knowledge acquisition, and methods of instruction in medical education.

### Educational System Factors

An old saying, attributed to Harvard's past president Derek Bok, is that it is more difficult to change an undergraduate curriculum than to move a graveyard. Medical curricula, however, have changed over time, and national initiatives, such as the Flexner investigations a century ago [31], have significantly contributed. Yet, medical curricula do not change easily, given the considerable numbers of students, faculty members, departments, and external regulations and requirements [32]. Few higher education programmes train professionals with such clear societal and internationally agreed status as medical schools and residencies, despite the international disparities highlighted in the beginning of this chapter. Changes are therefore limited within the boundaries of societal expectations of what doctors and medical specialists are and should be. Yet, the

second half of the twentieth century has shown significant innovations, well summarised in 1984 in the SPICES acronym [33]: Student-centred approaches, Problem-based methods, Community-based content, Electives, and Systematic clinical education; many of which still reflect the changes medical curricula undergo at the present day. However, the twenty-first century started showing renewed calls for reform [6, 34] and competency-based medical education dominated the renewal of postgraduate education, despite debates in the medical education community [35, 36]. Competency-based models have drawn attention to communication, collaboration, professionalism, advocacy, scholarship, and leadership as important attributes of doctors and objectives for training, but the definition of what a medical doctor is or should be has not become clearer [37]. Nevertheless, the rate of change in medical school curricula and postgraduate training programmes seems to have increased and few would now compare changing these programmes to moving a graveyard. Rather, medical school curricula in Western countries now seem to have a half-life of a decade. The desire for change is strong, as reflected in one survey respondent's remarks, 'If we had to design the education system from scratch we would never have designed it with the system we currently have inherited'. In fact, change and adaptability of educational programmes may become the constant in medical education, rather than an exception or rarity.

Respondents to our survey massively addressed educational systems changes that they foresee in the coming decade. We categorised these into five sub-themes.

### Competency-based, Time-variable, Individualised Pathways across the Continuum

Fixed standards and flexible pathways, a recommendation from the 2010 Carnegie Report [24] aligns with the promises of competency-based education, in which not time but acquired competence should determine the licence to practise in health care [38]. Several respondents considered transparency and accountability key to competency-based education. While time-variable training poses substantial logistical challenges [39], several respondents predicted that future medical education models will focus more heavily on outcomes and will apply milestones and entrustable professional activities (EPAs) in a time-variable fashion [40]. A focus on EPAs, as units of professional practice – the things medical practitioners must be trusted to do – may ease the way to more individualised trajectories for learners. An individual, dynamic portfolio of EPAs, rather than a static general diploma, may define learners' licence to practise. Core EPAs may constitute a traditional specialty, while EPAs that are not practised may drop from the list of privileges and other, elective, EPAs may be added during or even after a formal training period. This approach would constitute true competency-based medical practice, but may be highly visionary. Narrowing the core and widening the elective components of curricula, as one respondent suggested, would lead to more individualised, contextualised, and diversified education that could be highly tailored to local needs. Another respondent envisioned 'a

continuum of education with no longer separate stages of undergraduate, postgraduate and continuing education working in silos’.

### Simulation

Simulation in medical education, first proposed by Barrows in 1964 [41], has slowly but very steadily matured and has now reached a level of sophistication that allows for standardising not only patients but technical procedures and even real-life clinical scenarios [42–44]. Several respondents suggested this would increase the quality of preparation for workplace-based training and improve patient safety. Meanwhile, others stressed the importance of reviving bedside teaching, not so much to deny the usefulness of simulation and the need for quality in sophisticated diagnostic procedures, but to focus on the core of patient-centred education [45–47] and restore the *raison d’être* of the physician [48].

### Faculty Development and Education Careers

One respondent expressed worries that essential basic science education is at risk, as anatomy, physiology, and pharmacology do not offer attractive career prospects, which may subsequently threaten the teaching in these domains. Several respondents emphasised that academic careers for faculty members must include education as a core pathway for promotion if high-quality education is to be sustained. Translational scholarship should not only apply to the hard sciences, but also to educational science, another respondent suggested.

### Funding of Education and Selection of Students and Residents

In countries with market-driven health care systems, the funding of medical education has become so problematic that changes seem inevitable. Exorbitant tuition fees, exorbitant debts after training, and exorbitant physician salaries seem to hold each other captive, at the cost of meritocratic admission of students and diversity in the health care workforce. Some respondents felt current systems of admission – for those who can afford medical school – with a strong focus on knowledge and academic achievement were inadequate, ‘If we want reflective, considerate doctors who are good at team working, etc. then maybe we need to turn selection completely on its head, and select for personal attributes as the first hurdle’. Likewise, Aagaard and Abaza suggest that for residency in the US, the matching and selection process has become a source of frustration as it now consumes the energy of most of the final curricular year, and needs to change [49].

### Curricular Content

Predicting which basic and clinical science topics and procedural skills will be most relevant to clinical practice of the future seems futile given rapid advances in knowledge, shifting epidemiological trends, and easy access to information. Instead, several respondents suggested curricula need to devote more attention to reflection, humanism, self-regulated and adaptive learning, communication, team working (especially across professions), ethical

decision-making, effective and efficient use of technology, and leadership. Despite significant advances in the sciences (genetics, genomics, pharmacology, stem-cell therapies, personalised cancer care, and others), remarkably few respondents stressed these as impacting the future of medical education. There were several comments recognising the need for governance structures and ‘mechanisms for enabling change of the curriculum when needed’. One other respondent noted ‘curricula will need to be quickly responsive to global changes and not be expected to last 10years!’, which advocates for adaptive expertise not only in learners but also in educators and curriculum developers.

### Globalisation

There is no doubt that globalisation will affect the future of health professions education. Our respondents discerned a number of specific topics that warrant special attention.

#### Migration Effects

Socio-economic differences between countries, population density differences, warfare, climate change, differences in workforce demands, and the ease of travel all stimulate migration. The significance for health professions education is that all doctors must be prepared to face the increasingly international population mix, both as patients and as colleagues. Learners must also be prepared to work with a growing number of foreign peers in medical schools and residency or postgraduate programmes. Humans have a natural tendency to develop and create a better life for themselves. This is no different for medical students and physicians than any other human being. In countries of lower socio-economic conditions, this may have a devastating effect, because the scarce resources used to educate doctors to serve the local health care needs often lead to graduates seeking a better life in a more developed country [50]. One of our respondents noted, ‘in the Least Developed Countries like Tanzania in sub-Saharan Africa, one doctor serves 20000 to 30000 persons in the population, compared to one doctor for a few hundred persons in the developed world’. In the decade ahead, we must face the challenge to retain doctors where service is most needed. The FAIMER Institute, created to stimulate the improvement of local education and stop this brain drain, offers one example of an initiative [5].

#### Sharing Education Concepts Globally

One respondent eloquently wrote, ‘No individual, community, nation or even continent can boast of good health when its neighbor’s is wanting. That is truer now than ever in a world that has become a “global village”. There is thus a need for the world to adopt a more global outlook towards medical education in the interest of health worldwide’.

Since the beginning of this century, stimulated by a rapid globalisation of information through the Internet, health professions education has become more globally oriented. Health professions educational ideas are shared

in a large number of journals, increasingly open access, and as the number of international conferences increases, so does the number of participants and the opportunities to expand thoughts, approaches, and techniques beyond local or national borders. Concepts developed in one country are quickly adopted in other countries; examples include problem-based learning, curricular integration, competency-based education, simulation, and the objective structured clinical examination (OSCE) [33, 51–53]. Some respondents reminded us, however, of the costs involved in such adoptions for low-resourced countries.

Teaching methods constitute another area of exchange. Portable educational techniques using technology may help to support the training in countries with few faculty or patients. ‘The training of large numbers of students stands face to face with the (relative) shortage of patients in poorly equipped hospitals. The deployment of clinical skills laboratories is one way of coping with this challenge. While this has budgetary implications, it is a very necessary area for development if acceptable standards of training are to be achieved and maintained.’ Another respondent explained, ‘We tend to think of health professional education as more of the same but better [suggesting identical development across countries]; however, this education is also taking place in less stable areas than our own and curricula need to adapt to local circumstances as well as global ones’.

### **International Collaborations Between Institutions**

International courses and collaborations to develop medical education and its research are quickly expanding [54, 55]. ‘I was impressed, for example, by students in Dundee learning about the cardiovascular system using a programme to which 14 medical schools had contributed. Some students were facilitated online by a cardiologist from Florida rather than a local cardiologist in Dundee.’

One example of a truly global enterprise to shape the future of medical education is the Initiative by Dr Hilliard Jason to establish a trust foundation to support medical education in developing countries through an ‘adaptive medical education’ model, guided from a school in London, UK, to be built in the coming years, serving educators and institutions worldwide. The adaptive education model aims to serve individual learner needs [56].

### **Towards International Standards with Local Applications**

Objectives of education can lead to worldwide standards to globalise education, but some respondents voiced a nuanced view. ‘We are now at the globalisation side, but there are some voices (including mine) beginning to speak in favour of going back to the local priority.’ Why? ‘There are the added difficulties of communication, professionalism and ethics – all of which differ fundamentally across different cultural groups.’ ‘[There is] clearly a different view on what constitutes good medical education in the Asian countries and competitive Western countries.’ This reflects a debate that is not new [57, 58]

but that will become even more relevant with the upcoming economies that have cultures quite different from Western societies.

## **Health Care System Factors**

Many of our respondents highlighted factors within the health care system that will impact its sustainability. These factors included rising health care costs, increasingly specialised/technical and siloed approaches to care, and the ageing population with multiple morbidities. The challenge moving forward is to find ways in which medical education can play a role in helping to mitigate these factors.

Solutions discussed, which are not new, included developing better interprofessional working relationships, increasing community-based care, and improving workforce planning. These can be categorised broadly as changing the context of medical education (from disease-based to preventative health care education), matching the context of training to that of care (away from hospital tertiary institutions toward community-based care models), and changing the ways physicians work with one another and across professions (workforce development, new roles in teams, and better interdisciplinary processes of care).

The blessing and curse of clinical education is that much of the learning occurs in practice, through delivery of care in existing systems. Correspondingly, physicians are well trained to ‘provide medicine now and not in 10 years’. The challenge of preparing learners for an uncertain and rapidly changing practice environment is well recognised, but how best to do this remains unclear.

### **From Disease-based Education to Preventative Health Care Education**

The growing proportion of the ageing population with co-morbidities has resulted in higher health care costs due to the demand for increasingly technical and complex care. Given this context, respondents were of the view that available health care resources (money/people/infrastructure) cannot keep pace. Accordingly, ‘... preventative medicine will be a cost-driven necessity. Doctors will be pressed to reduce the costs of infectious diseases, cardiovascular disease, smoking, obesity, drugs and mental disorders ...’ and ‘Public health and Primary Care should be the curriculum drivers’.

At present, medical education focuses mainly on disease models, with limited attention given to public health and behavioural/psychosocial effects on health. This lack is exacerbated when graduates progress to postgraduate training in hospital-based systems. Some argue that shifting health care toward a preventive model will not save money unless over-testing and over-treatment are also addressed. Indeed, some medical school and postgraduate curricula are beginning to attend to these topics [59]. Whichever viewpoint one takes, achieving a cost-effective system that delivers quality care will require significant changes on multiple fronts, but, as one respondent noted, maintaining the status quo is not an option: ‘Any future



vision in which medical education does not embrace disease prevention and health promotion is doomed to be unsustainable and to produce doctors who are not fit for practice.'

### **From Hospital to Community-based Education**

There is now quite wide consensus that health care needs to be organised into networks of care, with services integrated around the patient and based in the community as much as possible. This model of care requires physicians and other health professionals to partner with patients over the long term rather than providing single, unconnected 'episodes' of care [60]. Medical education will need to prepare physicians to coordinate and collaborate across these networks. As one respondent explained: 'We need to rethink our curriculum and offer greater balance in terms of the contexts in which training happens (hospital based training still dominates) ... too often we train in disciplinary silos expecting our graduates to work in ways that are interdisciplinary.'

Longitudinal clerkships provide learners with continuity of patients and educators, and the opportunity to become identified members of the team [61]. Evidence suggests that learners who partake in these clerkships gain a better understanding of the impact of health and illness on the patient and the communities and develop a compassionate and caring approach.

As care shifts away from the hospital to outpatient and community-based settings, patients will need to be supported in self-care and self-management. One respondent speculated on the need to redefine the role of the doctor and how '...we educate our students to manage these issues in the face of change...'

### **Team-based Care**

There was a large consensus in responses that the increasingly technical and complex health care needs of the population require a team approach to care. Growing awareness that breakdowns in communication and poor teamwork are major contributors to many medical errors further bolsters the calls for effective team working and therefore interprofessional education (IPE) [62, 63].

For interprofessional team-based care to be effective there is a need for more training and experience working in IP teams; however, 'it seems we are still looking for effective ways in which professions can "learn from, about, and with each other"'. While many curricula include IP education, evidence of lasting impact on behaviour and communication among professionals in practice is sparse [64].

An aspect of teamworking in education that needs further exploration is that of the 'collective' competence. Above, we described patient care as a network; this network is of individuals working together in teams, in a complex system. However, we still generally educate and assess on individual competencies and not on how the individual affects the team. A body of work is building around 'team' performance and its translation into the undergraduate and postgraduate education of health care professionals is yet to be addressed [65].

Although practitioners already work in teams, most are not IP teams. Although such 'tribes' are good for moral and professional support they can have deleterious effects on patient care when 'tribes' defend their 'patch' [66, 67]. One physician respondent wondered, admittedly cynically, if 'the medical profession's defence of its own turf will become harder to sustain in the face of other professions rightly insisting they have as much actual or potential expertise as doctors, as the imperative for increasing team-working will make doctors aware how many advanced skills their non-medical colleagues have, and make it apparent to other professions that there may be nothing special about the ones that physicians have.' Another respondent explained: 'As the technical opportunities for up-to-date medical care for patients will grow in numbers and complexity, there will be a more diversified team of professionals in health care.' These new 'team members' will add extra imperative to be able to work together effectively for patient care.

### **The Changing Workforce**

'Without radical change to health care education we will not be preparing students for the future but delivering them to the past. Are we producing a flexible enough workforce prepared for the challenges of the future?'

The global economy is projected to create around 40 million new health sector jobs by 2030, mostly in middle- and high-income countries. Despite this growth, there will be a projected shortage of 18 million health workers needed to achieve the UN Sustainable Development Goals in low- and lower-middle-income countries [68]. As mentioned in the globalisation section of this chapter, the crisis in recruitment of health professionals means that countries all around the world will be 'fishing from the same [small] workforce pool'.

Many countries, particularly in the developing world, are looking at addressing projected workforce shortages by introducing new roles (such as physician's assistants – PA) or by role substitution (such as advanced clinical practitioners). The fundamental premise is that the training time and cost is less than for a doctor, and that graduate salaries are lower. This development has caused much angst, with some physicians calling PAs a 'poor man's' doctor and suggesting that these roles were ill thought out 'quick fixes'. However, the role of PAs (and others) seems likely to stay, probably with increasing scope of practice over the coming years [69, 70].

There was consensus among our respondents that the doctor of the future should be flexible and able to work in interprofessional teams to provide quality health care. Also, that the education of future doctors has to change, although the direction of that change is not as clear. Some declared that doctors should become broader based in their approach and community focused, others suggested that doctors should be even more sub-specialised, as other professionals could fulfil the community roles. The following two quotes illustrate these dichotomous views:

'We need more generalists rather than specialists, and health professionals who can work collaboratively rather than hierarchically.'

'Much of routine medicine can be carried out by health care professionals like Physician Associates, Specialist Nurses, Midwives, etc. Maybe medical education should prepare students for more specialised and complex medicine.'

Currently, a primary medical education qualification 'produces' an intern or resident who is a generalist, but with the least experience in the health care team. This intern, over many years of postgraduate training, focuses their skills to a specialism and often a sub-specialism. This process inherently puts forward the value proposition that being a 'generalist' is not worth as much as being a 'specialist', especially given that physicians are rewarded financially the more specialised they become. As a radical alternative, future medical school education may be envisioned to switch to producing narrow specialists with a competency-based model and postgraduate training could then prepare generalists. This would require a major paradigm shift in medical education.

Respondents also highlighted the need for alignment between training choices and workforce needs, which could result in more 'engineering' of career pathways [71]. This approach would reduce trainees' freedom to choose their specialty and location. One respondent suggested medical education leadership had to show the way: 'Over the next 10 years, medical education has to take a leadership role in producing graduates who take an ethical and responsible approach to health resource stewardship.'

## Cultural and Societal Factors

Culture and society are part of the ubiquitous, multifaceted context in which medical education is situated [72, 73]. Both health care and medical education interact with broader social, cultural, political, legal, and economic forces – sometimes accommodating these forces, other times reacting against them. The social contract metaphor is often used to characterise the complex relationship between physicians (or the medical profession as a whole) and society [74]. The basis for this social contract rests in the power of physicians, as members of the medical profession, to self-regulate (to set and maintain standards for education and practice) in exchange for the provision of medical care that serves the needs of patients and society [73, 75]. Yet, increasing heterogeneity within the medical profession and throughout society has prompted important questions about the terms of this contract. In 2002 the American Board of Internal Medicine, the American College of Physicians Foundation, and the European Federation of Internal Medicine published the 'Physician Charter' in an effort to make the principles and professional responsibilities of physicians explicit. Altruism, honesty, respect, and trust were associated with three principles of professionalism, namely 'primacy of patient welfare, patient autonomy, and social justice'. These principles are presumed to provide ethical guidance to physicians in times when patients, organisations, governments, and markets place new, often competing, demands on physicians [74]. These new and competing demands may challenge the personal values held by individual or sub-groups of physicians, thus

raising questions about the medical profession as a collective entity attempting to uphold a contract in a dynamic context with changing expectations [76–78].

Responses to our survey revealed many thoughts about how changes in cultural values and expectations among patients and health care systems might impact the future of medical practice and, correspondingly, medical education. Responses also highlighted changing values and expectation among learners in medicine [79], from those entering the profession to those engaging in continuing professional development and lifelong learning. Many suggested that physicians and educators will need to respond to and accommodate these changes.

## Core Principles of Professionalism

As noted above, one of the core principles in the Physician Charter is 'the primacy of patient welfare' [74]. In line with this principle, one respondent wrote: 'The best doctors have an underpinning altruism. This finds expression in their attitudes towards their patients, the community, and the medical profession.' The respondent then identified several aspects of current medical training that may undermine altruism and emphasised the need for training experiences that reinforce altruism, such as working in teams over time and developing longitudinal clinical relationships. Other respondents anticipated a change in the social contract, with growing demand for 'more balanced lives' and 'less sense of self-sacrifice' among physicians which may require new ways of operationalising altruism [80].

Respondents also mentioned patients' need to trust physicians to provide safe, competent care, anticipating shifts toward greater social accountability and external regulation of competence and further reduction of professional self-regulation. Growing attention to physicians' roles in teams and systems and notions of competence as a group- or system-level construct as well as an individual-level construct appeared in few responses. One respondent noted: 'Future patients are going to ask for person-centered care, and must be able to trust that the team around the patient can deliver that – with safety.' Physicians of the future were expected to be more involved in systems improvement and to have a stronger orientation toward public health and holistic interventions.

## Changing Values and Expectations Among Patients

Several respondents described patients as 'empowered', 'engaged', and increasingly 'involved in self-care' – largely made possible through technology and increasing access to information. They anticipated growing demand for not only person-centred care, but personalised medicine and immediate access. Respondents also noted that patients will interact with physicians and health care teams in new ways, perhaps with less personal contact and 'less satisfying relationships'. Others suggested that these changing relationships might require more empathic physicians and development of 'novel communication skills that both embrace this evolution of the doctor-patient relationship while still promoting a long-term relationship'.

### **Changing Values and Expectations Among Learners**

Perhaps signifying overarching cultural changes, several respondents described parallels between patient and learner expectations. 'We are rapidly evolving from a provider-centered health care delivery and teacher-centered model of educational delivery to patient-centered and learner-centered models.' Another respondent suggested: 'We have personalised medicine – we should have personalised education.' Ideas about how this might emerge included online, mobile, self-paced learning modalities replacing in-person, campus-based instruction; growing use of simulation; new sources of motivation for learning (driven by perceived needs and interests rather than proscribed curriculum); increasing use of international collaboration; and new forms of assessment.

Respondents also described the 'democratisation' of education as relationships between teachers and learners become less formal and less hierarchical compared to just a few decades ago. As discussed in the next section, ever-increasing access to information and rapidly changing practices are likely to contribute to this trend as less and less knowledge becomes exclusive property of expert clinical teachers. Instead, teachers may be increasingly learning alongside, or just barely ahead of, the learners they are teaching.

### **Addressing Strenuous Work Environments and Enhancing Student Resilience**

Learners' desire for 'work-life balance and supportive, well-functioning working and learning environments' was mentioned by several respondents. One respondent emphasised 'we need to pay a lot more attention to the nature of the working and learning environment if we do not want to lose a generation'. Given the alarming figures on the prevalence of burnout and depression among medical students, residents, and physicians [81, 82], education, coupled with systems changes, can address the ways learners are prepared for a difficult working environment. One respondent suggested that physicians will need 'coping and resilience skills to thrive in this new practice'.

Comments about learners' desire for a work-life balance echo conversations about professionalism in the context of duty hours regulations for physicians. Many feared the degradation of altruism and prioritisation of patient welfare with the rise of a 'shift work' mindset while others saw an opportunity to redesign health care systems that honour the need for self-care without compromising the primacy of patient welfare and overly relying on individual altruism [83]. A fact is that resident restrictions in duty hours in Europe differ vastly from those in North America, while there are no reports of differences in professionalism. There is no doubt, however, that these topics of physicians' psychological distress, burnout, and well-being [84–87] will continue to be important for many years to come in countries across the world.

### **Technological Factors**

Throughout history, people have pointed to technology as a primary source of change in society. The rise and rapid

development of computers and robots has prompted many to think about the implications for the way people will work in the future and the educational requirements for such work [88]. Medicine and health professions education are no exception [28, 89, 90], with articles on the use of computers as consultants appearing in the late 1960s and early 1970s [91]. This exciting prospect inspired decades of research by cognitive scientists, physicians, and computer scientists that aimed to understand clinical reasoning and expert decision-making processes so they could be replicated in computer programs [92]. While some might argue that these efforts have shown limited success based on practical application and use, recent improvements in data processing capacity, coupled with exponential increases in the volume of data available through the digitisation of health care systems and records, are rapidly changing the rate of implementation and uptake in clinical practice. As these changes occur, medical education must keep pace and incorporate technology into competency domains, learning objectives, and pedagogical techniques.

The core of discussions of technology, both in the literature and among our respondents, seems to be about information and how technology is used to collect, analyse, synthesise, and ultimately transform information into an 'intelligent' judgement, action, or solution of value to people. Terms such as 'artificial intelligence' and 'machine learning', all made possible by access to 'big data', came up repeatedly. Artificial intelligence generally refers to machines capable of performing complex cognitive activities at or beyond the level of a knowledgeable and skilled (i.e. 'smart') human. Machine learning denotes the ability of these machines to access and process data in ways that allow them to improve their performance – essentially to learn or get smarter [93]. Big data refers to the huge volume of information available digitally through databases, photos, videos, audio recordings, text, and biometrics. Machine learning employs analytics technology to search for patterns among all these information sources and, ideally, provide insights and predictions that prove valuable, or intelligent [93]. Technology also relies on information to support the development of tools that automate functional or physical tasks (e.g. robots that dispense medications) and that supports human access to information used to make decisions (e.g. smartphones and apps).

We identified four general themes among the responses citing technology as a key factor impacting the future of health professions education. Two themes focus on changes in the practice of medicine, with implications for the content of clinical training and two focus directly on changes in education, with implications for educational processes. Several respondents also emphasised significant disparities in the impact of technology. They predicted further exacerbation of disparities between patients, populations, communities, and countries with limited access to technological and other resources and those that are well resourced.

### **Changing Clinical Reasoning**

Many respondents described changes in how physicians make diagnostic and management decisions. They wrote about the growing capacity for artificial intelligence (AI), or

machine learning coupled with big data, to identify patterns and algorithms. While this would not necessarily eliminate the need for physicians to engage in clinical reasoning, such technologies were expected to provide decision support systems to aid and enhance physicians' decision-making. One respondent wrote: 'Physicians will need to rely less on their own memory to recall information and use expert systems to avoid treatment biases.' Some expected that AI would, in fact, eventually 'provide an alternative to diagnosis and treatment' which would satisfy the growing demand and expectation for instant advice and treatment. Others expected automation of routine tasks and replacement of procedural skills with robotic instruments. With these technologies in place, some respondents predicted that physicians' role would become that of an interpreter or translator of patients' descriptions and critical appraiser of information and evidence. One respondent described this as 'the rise of the coach, the routinisation of the technician'. This change suggests a shift in required competencies, with less emphasis on 'technical competencies' reliant on medical knowledge for diagnostic and treatment purposes and more on innovation and 'humane competencies' such as patient education and advocacy. Indeed, some have already described these trends in fields such as radiology and pathology [94]. While the capacity for expert systems and AI to outperform human experts was established in the 1970s (e.g. MYCIN) [95], such systems never became part of routine medical practice because they required manual data entry, took considerable time to produce solutions, and generated fear and mistrust among users concerned about being outperformed by a machine [96]. Today, these systems can be integrated into existing health information systems and information can be processed almost instantaneously. While concerns about technological displacement still exist, such systems have been recast as 'decision support systems' and guidelines that enhance performance of human experts rather than competing with it [97].

One respondent offered a prediction, summarising many of these ideas: 'Without a doubt, the implementation of artificial intelligence systems as part of the practice of medicine will have a major impact on what it means "to be a doctor" and what competencies we will expect of future physicians ... The greater use of technologies will free physicians to focus on treating patients and innovating with more automated tasks being relegated to engines that accomplish the latter with a much higher level of precision.'

### **Changing Relationships with Patients**

Respondents highlighted technology's role in providing new ways for patients and physicians to communicate, including telehealth, email, and social media. Some predicted face-to-face visits would become obsolete or at least significantly less common. Correspondingly, they saw a need for medical education to prepare physicians to interact with patients through various new technologies and to use technology as a tool to engage, monitor, treat, and educate patients.

Respondents also noted technology's role in providing patients access to information that previously belonged almost exclusively to physicians and was more or less

inaccessible to non-physicians. This includes both information about one's own health (from digital records as well as from genomic testing) and information about diseases, diagnostics, and treatment available (through websites of variable repute). While some respondents saw this as a beneficial way of empowering patients and promoting preventative measures that might reduce reliance on physicians, others anticipated an even more significant role for physicians to 'interface between patient concerns and technology' as interpreters of patients' concerns and evaluators of the quality of evidence or soundness of reasoning guiding patients' decisions.

### **Changing the Focus and Content of Medical Education**

Responses suggested two primary ways in which technology will impact the core curriculum in medical education. First, given rapidly changing and growing knowledge bases that learners can instantly access in real time, respondents anticipated significantly less need to teach for knowledge retention and much greater need to teach for finding, critically appraising, synthesising, and integrating information. This view raises intriguing questions about the relationship between knowledge and reasoning, many of which are not new [98, 99] but perhaps are relevant in new ways as we consider what types of knowledge and conceptual understanding physicians will need to evaluate the quality of decisions recommended by a 'smart machine' and/or of the information returned from a query. Yet, these views assume ubiquitous access to credible information with no barriers. For resource-limited countries, this will require open access to reputable journals for hospitals and educational institutions.

These shifts have implications for assessment, as one respondent noted: 'Every medical educator knows that it is impossible for practising clinicians to hold in their heads all of the knowledge that must be incorporated into their clinical reasoning and decision making. And yet we continue to assess our students on what factoids they can recall, rather than what they can find out. Assessments over the next 10 years will need to become much smarter not only at measuring what students understand about concepts, but how they go about finding the information they need to apply that understanding.'

Second, the analytic processes used to support and enhance AI in health care systems can feed information to educators and educational systems to align curricula better with practice. As one example of how this might work, Baker and colleagues described opportunities to use data from the US National Center for Health Statistics to guide the design and contextualisation of cases in a case-based learning curriculum. The authors described ways of using summary data about the most common diagnoses, tests, procedures, and medications associated with patients presenting to the emergency department with fever in a given geographic region [100]. Access to such information also raises questions about how to design current educational systems to support future practice that might look quite different. Should the focus be on common diagnoses or on challenging or uncommon diagnoses that are often missed?

## Changing the Methods of Instruction and Assessment

The response, 'new technologies are changing not only our lifestyle but also our relation with students and the learning/teaching paradigm' captures the essence of themes about technology's impact on the methods of instruction and assessment in medical education. Several respondents anticipate changes in teachers' roles as technology increasingly mediates their interactions with learners. The current rise in online courses, many of which are freely available worldwide (provided you speak the language and have sufficient bandwidth and equipment), creates what one respondent called 'borderless education'. Teachers are also interacting with learners in virtual 'classrooms' or learning spaces, often asynchronously. In clinical settings, respondents expected the role of the teacher to change too, with teachers no longer functioning as the primary source of medical knowledge, but instead communicating and modelling expertise in clinical skills, attitudes, values, and professionalism. With growing technological resources available to enhance teaching and learning, educators will need to be more flexible and 'able to respond with innovative ways of matching learners' information technology skills with teaching methods' and 'channeling in a positive way' learners' willingness to challenge the status quo. Educators and learners alike will need to vigilantly monitor their use of technology to ensure that it enhances, rather than detracts from, learning [101–103].

Multiple respondents identified ways in which the combination of 'big data' with learning analytics and AI will change assessment processes and create opportunities for truly learner-centred, individualised approaches to learning. For example, they foresee these technologies allowing us to 'analyze student behavior', 'use digital traces of teacher and learner activities to generate feedback', 'rapidly and effectively screen assessment data to identify learners at risk or excelling', and improve selection processes by 'creating profiles on potential trainees ... including not just formal educational performance (hand-offs on entrustment activities of students) but also information gathered through longitudinal portfolios and the Internet in general (e.g. social media, LinkedIn, videos or podcasts)'. Information and learning technologies were often mentioned in relation to programmatic assessment and competency-based medical education, topics discussed in greater depth under educational system factors. At present, few examples of these systems exist on a large scale, but design and development are underway [104, 105]. There are, of course, costs and risks associated with managing, securing, interpreting, and sharing this information. Respondents raised concerns about data security, privacy, and ethical use of information in the digital age.

## Discussion

Opportunities to envision the future appeal to our human imagination. Perhaps we are drawn by the desire to plan better, avoid surprise, prove our hypotheses, or reflect on and learn from the past. Perhaps we hope to improve the

future through such musings. Whatever the case may be, the respondents to our survey each had important messages to convey. And, while each drew on different contexts and structural models of medical education to formulate their visions for the next 10 years, we found considerable overlap in their perspectives. Some responses were truly forward looking, others reflected anxiety about current circumstances and urged recognition of 'festering problems for which a solution *must* be found'. Some predictions, particularly around technology development, resemble ones that could have been made 40 years ago when AI, diagnostic support systems, and computer-based education started to catch medical educators' attention.

The training of health professionals is the preparation for services that populations need or desire to improve their health, but cannot provide for themselves. Health and disease have been mysteries for many ages and remain so to some extent. The world has changed, however, and most educators would agree that in the twenty-first century these population demands have evolved. Many of the mysteries of disease have been solved, patients obtain information through many sources other than health professionals, many health care decisions are shared among health professionals and patients. All of these suggest less dependency in populations. On the other hand, many more health conditions can be improved than in the past, life expectancies have increased in many parts of the world, and chronic diseases are more prevalent. Just extrapolating these developments may shift the need for decision makers and curers to being supporters of patients in their navigation through complex health care systems and myriads of options. Education must prepare learners for these shifting roles. Akin to the loss of rote memory skills for long texts after the invention of print (think of Homer's *Iliad* and *Odyssey*), doctors in training may be better not spending most of their time on rote memorisation of facts and detailed physical examination skills, as these may be replaced by much more accurate diagnostic procedures. This is not merely a shift to different curricular content, but a change that may affect the identity of health professionals and their relationship to society.

This review illuminates the opportunities and concerns most salient to the leaders, educators, and researchers who responded to our inquiry. Their responses depict promising opportunities for education customised to individual capability and learning needs; integration of technologies that enhance precision, efficiency, and safety of patient care; redesign of working and learning environments to be more satisfying and sustainable for clinicians, learners, and patients; and international collaboration on and sharing of educational materials and resources (e.g. curricula, instructional techniques, assessment tools, and procedures). They also portray dark clouds on the horizon with the issues such as workforce shortages, resource disparities, inequities in access to education and patient care, growing demands on educators with insufficient support and recognition for their efforts, and challenging work environments. Clearly, many of these concerns will limit the array of opportunities if not addressed. For example, creating and implementing individualised learning pathways requires

educators who are trained and invested in this approach. In environments where educators already feel stretched thin, support will be critically important as will open conversations about how such efforts will benefit (and change) their role as educators rather than replace it.

So now what to do with these glimpses of the potential future of medical education? The people who provided the responses are also the leaders in the delivery and development of medical education. These responses indicate the directions of their plans, and prompt a follow up question that asks what they are doing to address these issues because if they don't, then who will? The first section of this chapter shows us how medical education has previously responded to evolution in medical education by adapting or changing into different pathways/routes. Instead of convergence of the pathways, we may see more divergent models and individualised pathways as an adaption to new factors and drivers.

Rather than ending this chapter with recommendations for the future, we prefer to end with questions that educators and leaders can keep in mind when creating or revising curricula and educational programmes, advocating for educational policies, building partnerships within and across institutions, and drafting five or ten year plans.

- 1 What do we need to do now to prepare learners for future careers as physicians, where the work of physicians may be quite different from what it is now?
- 2 What is the unique value of a doctor to the health care workforce and what are the implications for education and training?
- 3 How does medical education and training reconcile individual aspiration with the social purpose of schools and programmes?
- 4 How do we create more satisfying and sustainable work and learning environments?
- 5 How do we move toward a more equitable distribution of health care resources around the world, both within countries and globally?

## Acknowledgements

The authors would like to acknowledge the contributions of all who shared their insights about factors likely to impact the future of medical education: William Burdick, Angel Centeno, Fremen Chou, Jen Cleland, Debra Cohen, Richard Cruess, Sylvia Cruess, Andre de Champlain, Erik Driessen, Rachel Ellaway, Kevin Eva, Martin Fischer, Shiv Gaglani, Deborah Gill, Marja Govaerts, Janet Grant, Larry Gruppen, Ronald Harden, Ken Harris, Brian Jolly, Robert K. Kamei, Manuel Kassaye Sebhatu, David Kaufmann, Athol Kent, John Launer, Peter McCrorie, Judy McKimm, Charles Mkony, Lynn Monrouxe, Clare Morris, John Norcini, Hirotaka Onishi, José Peinado, Sari Ponzer, Pablo Pulida, Bill Reid, Richard Reznick, Charlotte Ringsted, Trudie Roberts, Dujeepa Samarasekera, Lambert Schuwirth, Jonathan Sherbino, Tim Swanwick, George Thibault, Jill Thistlethwaite, Alik Thomas, Steve Trumble, Sebastian Uijtdehaage, Tim Wilkinson, Zareen Zaidi, and Gert van Zyl.

## References

- 1 Jonker, G., Manders, L.A., Marty, A.P. et al. (2017). Variations in assessment and certification in postgraduate anaesthesia training: a European survey. *British Journal of Anaesthesia* 119 (5): 1009–1014.
- 2 Weller, J.M., Sullivan, M., and Boland, J. (2017). Does variable training lead to variable care? *British Journal of Anaesthesia* 119 (5): 866–869.
- 3 European Parliament (2013). Directive 2013/55/EU of the European Parliament and of the Council of 20 November 2013 amending Directive 2005/36/EC on the Recognition of Professional Qualifications and Regulations. Available from: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:354:0132:0170:en:PDF> (accessed 9 December 2017).
- 4 Karle, H. (2006). Global standards and accreditation in medical education: a view from the WFME. *Academic Medicine* 81 (12 Suppl): S43–S48.
- 5 Burdick, W.P., Morahan, P.S., and Norcini, J.J. (2006). Slowing the brain drain: FAIMER education programs. *Medical Teacher* 28 (7): 631–634.
- 6 Frenk, J., Chen, L., Bhutta, Z. et al. (2010). Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. *Lancet* 376 (9756): 1923–1958.
- 7 Frank, J.R., Snell, L.S., and Sherbino, J.D. ed. (2015). *CanMEDS 2015 Physician Competency Framework*. Ottawa, Ontario, Canada: Royal College of Physicians and Surgeons of Canada.
- 8 Boulet, J.R., Norcini, J.J., Whelan, G.P. et al. (2006). The international medical graduate pipeline; recent trends in certification and residency training. *Health Affairs* 25: 469–477.
- 9 Hallock, J.A., McKinley, D.W., and Boulet, J.R. (2007). Migration of doctors for undergraduate medical education. *Medical Teacher* 29: 98–105.
- 10 Teichler, U. (2003). Mutual recognition and credit transfer in Europe: experiences and problems. *Journal of Studies in International Education* 7: 312.
- 11 Wijnen-Meijer, M., Burdick, W., Alofs, L. et al. (2013). Stages and transitions in medical education around the world: clarifying structures and terminology. *Medical Teacher* 35 (4): 301–307.
- 12 Bologna Working Group on Qualifications Frameworks (2005). Available from: [http://ecahe.eu/w/images/7/76/A_Framework_for_Qualifications_for_the_European_Higher_Education_Area.pdf](http://ecahe.eu/w/images/7/76/A_Framework_for_Qualifications_for_the_European_Higher_Education_Area.pdf). *A Framework for Qualifications of the European Higher Education Area [Internet]*. Copenhagen, Denmark: Bologna Working Group on Qualifications Frameworks (accessed 9 December 2017).
- 13 Patrício, M., den Engelsen, C., Tseng, D., and Ten Cate, O. (2008). Implementation of the Bologna two-cycle system in medical education: where do we stand in 2007? – results of an AMEE-MEDINE survey. *Medical Teacher* 30(6):597–605.
- 14 Patrício, M., de Burbure, C., Costa, M.J. et al. (2012). Bologna in Medicine Anno 2012: experiences of European medical schools that implemented a Bologna two-cycle curriculum – an AMEE-MEDINE2 survey. *Medical Teacher* 34 (10): 821–832.
- 15 World Federation for Medical Education (WFME). <http://wfme.org/standards/bme> (accessed 9 December 2017).
- 16 Whitehead, C.R., Hodges, B.D., and Austin, Z. (2013). Captive on a carousel: discourses of ‘new’ in medical education 1910–2010. *Advances in Health Sciences Education* 18: 755–768.
- 17 Green-Thompson, L.P., McInerney, P., and Woollard, B. (2017). The social accountability of doctors: a relationship based framework for understanding emergent community concepts of caring. *BMC Health Services Research* 17: 269.
- 18 Lindgren, S. and Karle, H. (2011). Social accountability of medical education: aspects on global accreditation. *Medical Teacher* 33: 667–672.
- 19 World Health Organization (WHO) (1995). *Defining and Measuring the Social Accountability of Medical Schools*. Geneva: World Health Organization.
- 20 McKimm, J. and McLean, M. (2011). Developing a global health practitioner: time to act? *Medical Teacher* 33 (8): 626–631.

- 21 Global Consensus for Social Accountability of Medical Schools 2011. Available at [www.healthsocialaccountability.org](http://www.healthsocialaccountability.org) (accessed 3 December 2017).
- 22 Larkins, S.L., Preston, R., Matte, M.C., Lindemann, I.C., Samson, R., Tandinco, F.D., Buso, D., Ross, S.J., Pálsdóttir, B., Neusy, A.J. on behalf of the Training for Health Equity Network (THEnet). Measuring social accountability in health professional education: development and international pilot testing of an evaluation framework. *Medical Teacher* 2013;35(1): 32–45.
- 23 THEnet. Training for Health Equity Network. <https://thenetcommunity.org/our-work> (accessed 9 December 2017).
- 24 Cooke, M., Irby, D.M., and O'Brien, B.C. (2010). *Educating Physicians: A Call for Reform of Medical School and Residency*. San Francisco: Jossey-Bass.
- 25 Association of Faculties of Medicine in Canada (AFMC) (2010). The Future of Medical Education in Canada (FMEC): A Collective Vision for MD Education, Final project report. <https://afmc.ca/future-of-medical-education-in-canada/medical-doctor-project/index.php> (accessed 9 December 2017).
- 26 Hawick, L., Cleland, J., and Kitto, S. (2017). Getting off the carousel: exploring the wicked problem of curriculum reform. *Perspectives on Medical Education* 6: 337–343.
- 27 Carter, L. (2011). Gathering threads in the insensible global world: the wicked problem of globalization and science education. *Cultural Studies of Science Education* 6: 1–12.
- 28 Susskind, R. and Susskind, D. (2015). *The Future of the Professions: How Technology Will Transform the Work of Human Experts*. Oxford, UK: Oxford University Press.
- 29 Tetlock, P.E. and Gardner, D. (2015). *Superforecasting: The Art and Science of Prediction*. New York: Crown Publishers.
- 30 Eva, K. (2008). Covering up the crystal ball. *Medical Education* 42: 330–332.
- 31 Flexner, A. (1910). Medical Education in the United States and Canada. A Report to the Carnegie Foundation for the Advancement of Teaching.
- 32 Gale, R. and Grant, J. (1997). AMEE medical education guide no. 10: managing change in a medical context: guidelines for action. *Medical Teacher* 19 (4): 239–249.
- 33 Harden, R.M., Sowden, S., and Dunn, W. (1984). Educational strategies in curriculum development: the SPICES model. *Medical Education* 18: 284–297.
- 34 Irby, D.M., Cooke, M., and O'Brien, B.C. (2010). Calls for reform of medical education by The Carnegie Foundation for the Advancement of Teaching: 1910 and 2010. *Acad. Med.* 85: 220–227.
- 35 ten Cate, O. (2017). Competency-based medical education and its competency frameworks. In: *Competence-Based Vocational and Professional Education: Bridging the Worlds of Work and Education* (ed. M. Mulder), 903–929. Dordrecht, the Netherlands: Springer International Publishing Switzerland.
- 36 ten Cate, O., Hart, D., Ankel, F. et al. (2016). Entrustment decision making in clinical training. *Academic Medicine* 91 (2): 191–198.
- 37 ten Cate, O. (2014). What is a 21st-century doctor? Rethinking the significance of the medical degree. *Academic Medicine* 89 (7): 966–969.
- 38 Carraccio, C., Englander, R., Van Melle, E., ten Cate, O., Lockyer, J., Chan, M.-K. et al. Advancing competency-based medical education: a charter for clinician-educators. *Academic Medicine* 2016;91(5):645–9.
- 39 Kogan, J.R., Whelan, A.J., Gruppen, L.D. et al. (2018). What regulatory requirements and existing infrastructures must change if competency based time-variable training is introduced in the continuum of medical education in the United States? *Academic Medicine* 93 (35): S27–S31.
- 40 Carraccio, C., Englander, R., Gilhooly, J. et al. (2017). Building a framework of entrustable professional activities, supported by competencies and milestones, to bridge the educational continuum. *Academic Medicine* 92 (3): 324–330.
- 41 Barrows, H. and Abrahamson, S. (1964). The programmed patient: a technique for appraising student performance in clinical neurology. *Journal of Medical Education* 39: 802–805.
- 42 Motola, I., Devine, L.A., Chung, H.S. et al. (2013). Simulation in healthcare education: a best evidence practical guide. AMEE Guide No. 82. *Medical Teacher* 35 (10): e1511–e1530.
- 43 Wijnen-Meijer, M., Van der Schaaf, M., Booij, M., Harendza, S., Boscardin, C., Wijngaarden, V. et al. An argument-based approach to the validation of UHTRUST: can we measure how recent graduates can be trusted with unfamiliar tasks? *Advances in Health Sciences Education* 2013; 18(5):1009–27.
- 44 Kalet, A., Zabar, S., Szyld, D. et al. (2017). A simulated “Night-on-Call” to assess and address the readiness-for-internship of transitioning medical students. *Advances in Simulation* 2 (13): 1–9.
- 45 Peters, M. and ten Cate, O. (2014). Bedside teaching in medical education: a literature review. *Perspectives on Medical Education* 3 (3): 76–88.
- 46 Elder, A., Chi, J., Ozdalga, E. et al. (2013). The road back to the bedside. *Journal of the American Medical Association* 310 (8): 799–800.
- 47 Frenkel, J., Chen, H.C., and ten Cate, O. (2016). Patient-centered teaching in a technology-dominated era. *Southern Medical Journal* 109 (12): 743–746.
- 48 Rosenthal, D. and Verghese, A. (2016). Meaning and the nature of physician’s work. *New England Journal of Medicine* 375 (19): 1813–1820.
- 49 Aagaard, E.M. and Abaza, M. (2016). The residency application process – burden and consequences. *New England Journal of Medicine* 374 (4): 301–303.
- 50 Burch, V.C. (2007). *Medical Education in South Africa – Assessment Practices in a Developing Country [doctoral dissertation]*, 1–266. Rotterdam: Erasmus University.
- 51 Barrows, H.S. (1983). Problem-based, self-directed learning. *Journal of the American Medical Association* 250 (22): 3077.
- 52 Harden, R. and Gleeson, F. (1979). Assessment of clinical competence using an objective structured clinical examination. *Medical Education* 13 (1): 41–54.
- 53 Frank, J.R., Snell, L.S., ten Cate, O. et al. (2010). Competency-based medical education: theory to practice. *BMC Health Serv. Res.* 32 (8): 638–645.
- 54 Armstrong, E.G., Doyle, J., and Bennett, N.L. (2003). Transformative professional development of physicians as educators: assessment of a model. *Academic Medicine* 78 (7): 702–708.
- 55 ten Cate, O., Mann, K., McCrorie, P. et al. (2014). Faculty development through international exchange: the IMEX initiative. *Medical Teacher* 36 (7): 591–595.
- 56 iMedtrust: a global solution for population health. <http://imedtrust.org> (accessed 9 December 2017).
- 57 ten Cate, O. (2002). Global standards in medical education – what are the objectives? *Medical Education* 36 (7): 602–604.
- 58 Karle, H. (2002). Global standards in medical education – an instrument in quality improvement. *Medical Education* 36 (7): 604–605.
- 59 Stammen, L.A., Stalmeijer, R.E., Paternotte, E. et al. (2015). Training physicians to provide high-value, cost-conscious care: a systematic review. *Journal of the American Medical Association* 314 (22): 2384–2400.
- 60 National Health Service (NHS) (2014). Five Year Forward View. <https://www.england.nhs.uk/wp-content/uploads/2014/10/5yfv-web.pdf> (accessed 9 December 2017).
- 61 Thistlethwaite, J.E., Bartle, E., Chong, A.A. et al. (2013). A review of longitudinal community and hospital placements in medical education: BEME Guide No. 26. *Medical Teacher* 35 (8): e1340–e1364.
- 62 Salas, E. and Rosen, M.A. (2013). Building high reliability teams: progress and some reflections on teamwork training. *BMJ Quality and Safety* 22 (5): 369–373.
- 63 Epstein, N.E. (2014). Multidisciplinary in-hospital teams improve patient outcomes: a review. *Surgical Neurology International* 5 (Suppl 7): S295–S303.
- 64 Reeves, S., Palaganas, J., and Zierler, B. (2017). An updated synthesis of review evidence of interprofessional education. *Journal of Allied Health* 46 (1): 56–61.

- 65 Lingard, L. (2012). Rethinking competence in the context of teamwork. In: *The Question of Competence: Reconsidering Medical Education in the Twenty-First Century* (ed. B.D. Hodges and L. Leingard), 42–70. Ithaca, NY: Cornell University Press.
- 66 Weller, J. (2012). Shedding new light on tribalism in health care. *Medical Education* 46: 134–136.
- 67 Weller, J., Boyd, M., and Cumin, D. (2014). Teams, tribes and patient safety: overcoming barriers to effective teamwork in healthcare. *Postgraduate Medical Journal* 90: 149–154.
- 68 World Health Organization (2016). Final Report of the Expert Group to the High-Level Commission on Health Employment and Economic Growth. Geneva: WHO. <http://apps.who.int/iris/bitstream/10665/250040/1/9789241511285-eng.pdf?ua=1> (accessed 9 December 2017).
- 69 Ostler, J., Vassilas, C., and Parle, J. (2012). Physician Assistants: Friends or Foes to Doctors? *BMJ Careers*, 18 July 2012. <http://careers.bmj.com/careers/advice/view-article.html?id=20008022> (accessed 9 December 2017).
- 70 de Graff, M. (2017). Britain is offering US physician assistants cash and long vacations in Europe if they relocate to fill desperate staff shortage. *Daily Mail*, 18 Sept 2017. [www.dailymail.co.uk/health/article-4896782/Britain-begging-qualified-doctors-staff.html](http://www.dailymail.co.uk/health/article-4896782/Britain-begging-qualified-doctors-staff.html) (accessed 9 December 2017).
- 71 Addicott, R., Maguire, D., Honeyman, M., and Jabbal, J. (2015). Available at: [www.kingsfund.org.uk/sites/default/files/field/field_publication_file/Workforce-planning-NHS-Kings-Fund-Apr-15.pdf](http://www.kingsfund.org.uk/sites/default/files/field/field_publication_file/Workforce-planning-NHS-Kings-Fund-Apr-15.pdf). *Workforce planning in the NHS*. London: The King's Fund (accessed 9 December 2017).
- 72 Bates, J. and Ellaway, R.H. (2016). Mapping the dark matter of context: a conceptual scoping review. *Medical Education Annals of Internal Medicine* 50: 807–816.
- 73 Cruess, S.R., Cruess, R.L., and Steinert, Y. (2010). Linking the teaching of professionalism to the social contract: a call for cultural humility. *Medical Teacher* 32 (5): 357–359.
- 74 ABIM Foundation 2002. Medical Professionalism in the New Millennium: A Physician Charter. <http://abimfoundation.org/what-we-do/physician-charter> (accessed 9 December 2017).
- 75 Cruess, S.R. and Cruess, R.L. (2004). Professionalism and medicine's social contract with society. *AMA Virtual Mentor* 6 (4): 1–4.
- 76 Hafferty, F.W. and Castellani, B. (2010). The increasing complexities of professionalism. *Academic Medicine* 85 (2): 288–301.
- 77 Hafferty, F.W. and Tilburt, J.C. (2015). Fear, regulations, and the fragile exoskeleton of medical professionalism. *Journal of Graduate Medical Education* 7 (3): 344–348.
- 78 Harris, J.M. (2017). It is time to cancel medicine's social contract metaphor. *Academic Medicine* 92: 1236–1240.
- 79 Twenge, J.M. (2009). Generational changes and their impact in the classroom: teaching generation me. *Medical Education* 43: 398–405.
- 80 Cruess, S.R., Cruess, R.L., and Steinert, Y. (2016). Entitlement in medical education: an ongoing discourse. *Canadian Medical Education Journal* 7 (2): e142–e143.
- 81 Mata, D.A., Ramos, M.A., Bansai, N. et al. (2015). Prevalence of depression and depressive symptoms among resident physicians: systematic review and meta-analysis. *Journal of the American Medical Association* 2115 (22): 2373–2383.
- 82 Rotenstein, L.S., Ramos, M.A., Torre, M. et al. (2016). Prevalence of depression, depressive symptoms, and suicidal ideation among medical students: a systematic review and meta-analysis. *Journal of the American Medical Association* 2115 (21): 2214–2236.
- 83 Coverdill, J.E., Alseidi, A., Borgstrom, D.C. et al. (2016). Professionalism in the twilight zone: a multicenter, mixed-methods study of shift transition dynamics in surgical residencies. *Academic Medicine* 91 (11): S31–S36.
- 84 Dyrbye, L.N., Trockel, M., Frank, E. et al. (2017). Development of an agenda to identify evidence-based strategies to improve physician wellness and reduce burnout. *Annals of Internal Medicine* 166 (10): 743–744.
- 85 Hayes, B., Prihodova, L., Walsh, G. et al. (2017). What's up doc? A national study of psychological wellbeing of hospital doctors in Ireland. *BMJ Open* 7 (10): e018023.
- 86 Salyers, M.P., Bonfils, K.A., Luther, L. et al. (2017). The relationship between professional burnout and quality and safety in healthcare: a meta-analysis. *Journal of General Internal Medicine* 32 (4): 475–482.
- 87 Shanafelt, T.D., Hasan, O., Dyrbye, L.N. et al. (2015). Changes in burnout and satisfaction with work-life balance in physicians and the general US working population between 2011 and 2014. *Clinic Proceedings* 90 (12): 1600–1613.
- 88 Zuboff, S. (1988). *In the Age of the Smart Machine: The Future of Work and Power*. New York, NY: Basic Books, Inc.
- 89 Hodges, B.D. (2018 (ePub ahead of print)). Learning from Dorothy Vaughan: artificial intelligence and the health professions. *Medical Education* doi: 10.1111/medu.13350.
- 90 Wachter, R. (2015). *The Digital Doctor: Hope, Hype and Harm at the Dawn of Medicine's Computer Age*. New York: McGraw Hill.
- 91 Schwartz, W.B. (1970). Medicine and the computer: the promise and problems of change. *New England Journal of Medicine* 283: 1257–1264.
- 92 Szolovits, P., Patil, R.S., and Schwartz, W.B. (1988). Artificial intelligence in medical diagnosis. *Annals of Internal Medicine* 108: 80–87.
- 93 Marr, B. (2016). What is the Difference Between Artificial Intelligence and Machine Learning. *Forbes*, December 6 2016. <https://www.forbes.com/sites/bernardmarr/2016/12/06/what-is-the-difference-between-artificial-intelligence-and-machine-learning/#2129859c2742> (accessed 9 December 2017).
- 94 Jha, S. and Topol, E.J. (2016). Adapting to artificial intelligence: radiologists and pathologists as information specialists. *Journal of the American Medical Association* 316 (22): 2353–2354.
- 95 Shortliffe, E.H. (1976). *Computer-Based Medical Consultation: MYCIN*. New York, NY: American Elsevier.
- 96 Lillehaug, S.I. and Lajoie, S.P. (1998). AI in medical education – another grand challenge for medical informatics. *Artificial Intelligence in Medicine* 12: 197–225.
- 97 Mukherjee, S. (2017). AI versus MD: What Happens when Diagnosis is Automated. *The New Yorker*, April 3 2017. <https://www.newyorker.com/magazine/2017/04/03/ai-versus-md?currentPage=all> (accessed 9 December 2017).
- 98 Woods, N.N. (2007). Science is fundamental: the role of biomedical knowledge in clinical reasoning. *Medical Education* 41 (12): 1173–1177.
- 99 Woods, N.N., Brooks, L.R., and Norman, G.R. (2007). The role of biomedical knowledge in diagnosis of difficult clinical cases. *Advances in Health Sciences Education: Theory and Practice* 12 (4): 417–426.
- 100 Baker, A.J., Raymond, M.R., Haist, S.A., and Boulet, J. (2017). Using national health care databases and problem-based practice analysis to inform integrated curriculum development. *Academic Medicine* 92: 448–454.
- 101 Ellaway, R.H., Pusic, M., Yavner, S., and Kalet, A. (2014). Context matters: emergent variability in an effectiveness trial of online teaching modules. *Medical Education* 48 (4): 386–396.
- 102 Cook, D.A. and Triola, M.M. (2014). What is the role of e-learning? Looking past the hype. *Medical Education* 48 (9): 930–937.
- 103 Woodham, L.A., Ellaway, R.H., Round, J. et al. (2015). Medical student and tutor perceptions of video versus text in an interactive online virtual patient for problem-based learning: a pilot study. *Journal of Medical Internet Research* 17 (6): e151.
- 104 Chan, T. and Sherbino, J. (2015). The McMaster Modular Assessment Program (McMAP): a theoretically grounded work-based assessment system for an emergency medicine residency program. *Academic Medicine* 90: 900–905.
- 105 Schuwirth, L., van der Vleuten, C., and Durning, S.J. (2017). What programmatic assessment in medical education can learn from healthcare. *Perspectives in Medical Education* 6: 211–215.