



## Revisiting academic health sciences systems a decade later: discovery to health to population to society

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Until recently, the mission of academic medicine has focused on providing care for complex medical problems, conducting research from discovery to translation, and educating the next generation of scientists and clinicians.

This mission has traditionally been undertaken in teaching hospitals and medical schools separately, or organised under institutions of academic medicine. Over the past decade, these institutions have evolved into academic health science centres or systems by “bringing together [and aligning or integrating] health and academic partners to focus on world-class research, teaching and patient care”, to take new discoveries and promote their application, and whenever possible under one organisational structure to fulfill this mission.<sup>1</sup> In this Viewpoint, we will refer to these institutions as academic health sciences systems (AHSS).<sup>2</sup>

To date, academic medicine has been very successful, resulting in countless advances and seminal discoveries, including better treatments for heart disease, stroke, and diabetes; new techniques including organ, bone, and stem-cell transplants and minimally invasive surgery; and novel discoveries, cancer treatments, and therapeutics. As a result, millions of lives have been saved.

However, in the past decade, academic medicine has been continuously challenged by changing environments and faces an uncertain future. In our previous viewpoints<sup>2,3</sup> we called for academic medicine to develop the concept and approach of a discovery to care continuum (bench to bedside to population), which will enable seamless integration of research and translation, and importantly deliver quality health care to communities locally and globally. Since our publication in *The Lancet* in 2010,<sup>2</sup> we have witnessed the passage of the Affordable Care Act in the USA, the designation of academic health sciences centres and the development of academic health sciences networks in the UK, the development of academic collaborative centres for health promotion and public health in the Netherlands, the widespread adoption of electronic health records, increasing practice of accountable care, the recognition of long-standing societal problems such as inequity and structural racism, and the COVID-19 pandemic.

As we enter a new decade marked by rapid changes in science and technology, increased stresses in working environments, changing societal needs, and expectations and lessons from the COVID-19 pandemic, there is a compelling need to revisit the current model of academic medicine, to assess the functions of AHSS, and to redefine their futures.

We are living in a time of unparalleled and inspirational advances in science and medicine. Most recently,

effective SARS-CoV2 vaccines were developed and administered with unprecedented speed. In a century, life expectancy nearly doubled due in part to impressive advances in science and technology. Cardiovascular deaths have been reduced by half over the past 50 years, and many conditions such as cancer and some infectious diseases that were once death sentences have become manageable or curable. Developments in genomics are leading to new diagnostics and therapies that we could barely imagine a generation ago. Big data and artificial intelligence are rapidly reshaping the promise of how care will be delivered and diseases diagnosed. Unprecedented amounts of information are yielding new insights into health and disease. Taken together, these scientific developments hold the promise of transformation for health and medicine.

At the same time, we are living in a time of significant challenges in the health-care environment and increasing societal expectations for academic medicine. The rise of non-communicable diseases along with population ageing are contributing to an increased demand for health care. Too often, health care is fragmented, and persistent challenges in access, cost, and equity abound. In just the past decade the major changes in health-care delivery, technology, and society have created new challenges. Electronic health records have become pervasive and created a vast amount of data, which has turned some clinicians into data gatherers and moved them away from direct patient contact. Advances in science and technology (such as genome editing or artificial intelligence) have transformative power yet raise new questions for academic medicine as they pertain to unintended risks to society. Health systems face constrained funding and resources. In addition, political forces created public uncertainties and put pressure on health-care systems and the research enterprise—eg, Brexit in the UK, uncertainty around health-care reform in the USA, and changes in governments that have changed the environments for AHSS. Over the past several years, we have seen growing mistrust in science and the rise of misinformation. A prime example is vaccine hesitancy in the midst of the COVID-19 pandemic. Importantly, the COVID-19 pandemic disrupted clinical care, research, and education for which AHSS were generally unprepared and which required urgent adaptation and resilience of the institutions. Finally, clinicians are increasingly stressed and burnt out, thereby putting the entire system in a vulnerable situation.

Our 2010 publication proposed the expansion of traditional academic medicine from the Oslerian model of bench to bedside to a model of discovery to care continuum: bench to bedside to population.<sup>2</sup> The model

we proposed was a seamless integration of discovery and translation research, translation of knowledge to clinical care, and its application within the community and across the globe. In 2013, we discussed the growing challenges to the clinical, research, and education missions and the need for AHSS to counter these challenges by engaging in enterprise-wide integrated planning and seeking out non-traditional research and clinical partnerships.<sup>3</sup>

In the new decade of the 2020s, we need to rethink academic medicine's future in the context of new challenges and expectations and the role of AHSS in addressing them. AHSS must continue to lead in discovery science, translation of research, and delivery of high-quality care. But, importantly, they must extend their mission to improve health beyond health care, and contribute to issues such as social determinants, ethics, and equity that are critical to the wellbeing of all people and for the good of society locally and globally.

In this context, in this Viewpoint we address two central issues: redefining the mission of academic medicine, and implementing the new paradigm by changes in the strategy and practice of AHSS.

10 years ago, our original paper focused on health and health care as we proposed the discovery to care continuum concept. In this paper, we further revise this concept to a discovery to health to society concept or bench to bedside to population to society, in which we move beyond health care to health and wellbeing of people and society (figure).

To accomplish this paradigm shift, academic medicine must fundamentally adopt new approaches and practices including systems thinking, convergence science, molecules to population, data and quantitative sciences, and social responsibility. While some premier institutions are already adopting most of these approaches, the purpose of this paper is to underscore their importance and emphasise the need to strategically adopt and systemically integrate them into the practice of all academic medicine. Furthermore, we propose that the principles and practice of academic medicine should extend beyond health and health care to contribute to societal good.

Shifting from a reductionist to a systems approach requires bringing together all elements that affect health in an integrated fashion. To accomplish the systems approach, it is necessary that academic medicine moves from individual to team science with interdisciplinary and multidisciplinary collaborations. But we need to go beyond the current approach of team science to that of convergence science, which is defined as a means of solving vexing research problems, in particular, complex social issues by integrating knowledge, methods, and expertise from different disciplines and forming novel frameworks to catalyse scientific discovery and innovation.<sup>4,5</sup> The National Science Foundation identifies convergence research as having two primary characteristics: it is driven by a specific and compelling problem and it features deep integration

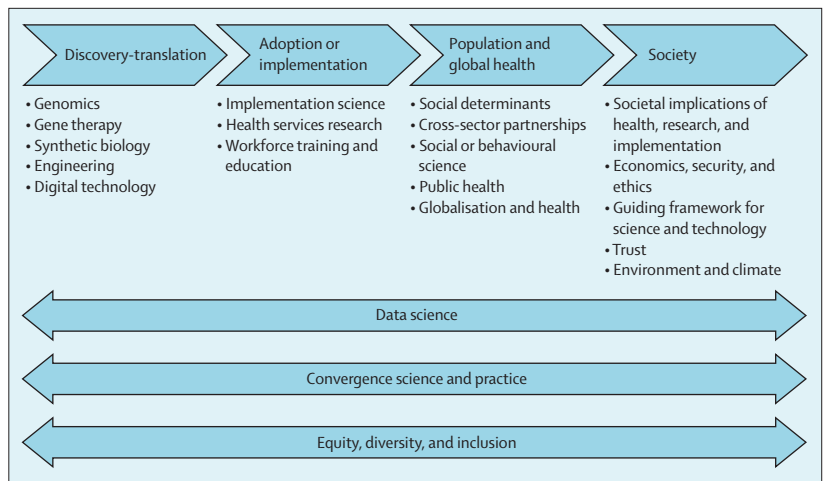


Figure: Discovery to health to population to society framework

across disciplines.<sup>6</sup> In this way, convergence science is distinctive from the current approach of team and multidisciplinary science. A convergence approach would consider health through vantage points outside of medical disciplines and sectors, incorporating physical and engineering sciences, mathematics, and computer science, and engaging sectors such as housing, jobs, education, transportation and urban planning, and more.<sup>7</sup>

Radical collaborations outside of traditional research and funding opportunities are needed to develop new models of collaborative research to scale that leverage innovative investment approaches from the private and public sector and financial institutions. Funding agencies that have been traditionally organised around siloed organ systems or diseases will need to change to incentivise convergence research. Creative relationships can be developed between academic medicine and the private sector, leveraging respective strengths and advantages. For example, in the precompetitive area, partnership or collaboration between academic medicine and private industry can lead to joint agreements on funding, sharing of patient samples and information, platforms, or discoveries in specific health or disease areas. This collaboration can be between individual or multiple academic systems and companies. Another innovative model is in the establishment of private-public joint investment funds.

Academic medicine must cover the spectrum of molecules to population. Scientific advances must be applied with the goal of improving the health outcomes of the population. The shift from precision medicine to precision public health exemplifies such an approach. Genomics and other omics must be applied with the goal of improving health outcomes in individuals and across the population. Public health strategies and interventions using molecular tools must be implemented in a more precise manner, tailored to the right population at the right time.

Success in academic medicine will depend on the systematic collection and analysis of big data, and therefore the development of expertise and capacity in quantitative and data sciences. The past decade has ushered in an influx of data through the pervasive adoption of electronic health records, increase in emerging science and technology related to genomic and sequencing technologies, and the collection and understanding of the importance of socioeconomic data. Data can be used to develop hypotheses, generate evidence, drive decision support, and through machine learning or artificial intelligence provide algorithms that can problem solve, automate, and transform the future of medicine.

Although academic medicine strives to improve health through scientific advances, transformative scientific breakthroughs may carry risks and have important implications for society, with particular concerns related to the speed of adoption, the ability to control cost of care, the potential to aggravate inequity, the ability to challenge social norms and ethics, and more. Examples include human germline genome editing, synthetic biology, neuro-technology, data and digital technology, artificial intelligence, and others. The successful development and adoption of these new scientific tools and technologies, while mitigating societal risks, will depend on an effective and enlightened governance ecosystem, in which academic medicine plays a critical role.

Academic medicine's responsibility does not stop there. It must commit to advancing social good by seeking solutions to societal challenges by working across sectors, orchestrating stronger community relationships, and developing new partnerships. Academic medicine must embrace diversity, equity, and inclusion, and address structural racism within itself and across society. An important social responsibility is climate change and human health. Academic medicine must treat climate change as a public health crisis and must work actively to communicate, educate, investigate, innovate, and develop solutions.

Finally, COVID-19 highlights the need for AHSS to work effectively with public health and communities to plan and implement strategic and coordinated responses and serve as a resource for clinical care, testing and sequencing, data collection and coordination, vaccine allocation, administration, and communication. Importantly, AHSS must work with the communities to address the challenge of inequity.

To achieve the framework of discovery to health to population to society outlined in the figure, AHSS must extend its traditional disciplines of health and medicine to include quantitative sciences, social sciences, behavioural economics, law, ethics, and engineering, among others. AHSS should leverage existing opportunities and expertise in other schools in their universities and partner with them to develop convergent programmes. Furthermore, AHSS must develop its own

internal capabilities and expertise in several areas such as population health, data science, and behavioural and social sciences in addressing socioeconomic determinants, social inequity and injustice, and racism. To that end, the integration of these disciplines with clinical care, research, and education can accelerate the transformation of health and medicine.

10 years ago, the importance of population health was not as widely recognised as it is today. The term was beginning to be used in the public health community but not in AHSS. Since then, the health-care system has expanded from community health to a more expansive view of population health. It is understood that such population health outcomes are the product of multiple determinants of health, including medical care, public health, behaviours, social factors, and environmental factors.<sup>8</sup> In the past several years, AHSS, especially in the USA, have developed accountable care organisations (ACOs) and many have been conflated as population health. In fact, ACOs are integrated value-based care models that focus on health care, using networks of providers from primary care to specialty care. Although some ACOs are beginning to address the upstream determinants of health, this is not widespread. To achieve population health outcomes, convergence of quantitative sciences, public policy, law, ethics, and social sciences is needed to address the myriad of factors that influence health. Universities and AHSS must take action to bring relevant sectors together with the necessary changes in structures and incentives for faculty, administration, research, teaching, and funding.<sup>5,7</sup>

As discussed earlier, it is critical for AHSS to collect big data and invest in quantitative science. A prerequisite to accomplishing this aim includes creating data warehouses to hold discrete data to allow the application of quantitative sciences to advance knowledge through research and facilitate optimal clinical care workflows. Therefore, AHSS must commit to data sharing and health information exchange with other provider institutions, ancillary care partners, claims data, and forms of data that have not been historically captured in discrete mechanisms, such as socioeconomic data and genomic information. This comes not only in creating the data infrastructure to appropriately capture, normalise, and harmonise the data, but also partnering with industry and others to find the most effective way to work together to incentivise and facilitate data sharing. This tenet is critically important because many institutions or partners may view data as a valuable resource and do not wish to give it away.

AHSS should continue to lead and be at the forefront of innovation in science and technology. Indeed, AHSS should be advancing knowledge, making new discoveries, and translating science to improve human health. They should leverage their networks and partner with the private sector to advance emerging science, technology, and innovation and enable its translation to clinical care. However, they must also recognise that new advances in

science and technology carry risks and have important implications for society, such as access, affordability, equity, ethics, privacy, security, and more. Notably, there is concern that these technologies may be expensive and create an equity divide. It is important that they are affordable and accessible to all.

Researchers have long engaged in self-governance through norms and standards of conduct. Importantly, AHSS must proactively assess and mitigate potential risks and unintended consequences raised by new technologies, and participate along with other sectors and sciences in the development of a multisectoral governance framework and policy at every stage of the product life cycle, from conception and planning, to funding, research conduct, publication and dissemination of results, translation and product development, and commercialisation.

Importantly, AHSS have a social responsibility beyond health care. Their roles must expand, to work with community organisations and sectors to address social issues and do greater good. These issues include housing, job creation, food security, education, career development, and more. AHSS must leverage their role as anchor institutions—ie, as a major employer and economic driver within their communities—to do social good by investing in community development and equity. Examples include preferential business relationships with community-owned businesses, minority-owned businesses, and companies that have a commitment to diversity and community.

AHSS must play a key role in preparedness and response to health and societal emergencies. AHSS must learn from their COVID-19 pandemic experiences and prepare themselves to respond effectively and avoid disruptions in research, education, and clinical care. AHSS must work closely and strategically with public health and communities serving as an important resource for care, testing and sequencing, data collecting and coordination, vaccine allocation, distribution, and communication. AHSS must effectively use digital technology to develop new models of care and education. AHSS should advance research in basic discoveries, vaccinology, digital health, novel methods in testing, genomic epidemiology, host factors and immunity, social sciences, data collection, information management, and artificial intelligence.

AHSS should play a leadership role in addressing climate change and human health through convergent research, education, communication, changing care delivery, and bringing together the entire health sector (including hospitals, clinical care, supply chain, industry, and infrastructure) to work collectively to respond, adapt, mitigate, and take action against the harmful effects of climate change. In the UK, the NHS has launched a new initiative, For a Greener NHS, to tackle the climate health emergency, making it the world's first national health system to commit to become carbon net zero. In the USA, the National Academy of Medicine is

launching a grand challenge on climate change and human health to bring public-private partners to mobilise action.

AHSS across the world must come together to address global societal issues and advance the greater good. It is increasingly clear that many of the greatest existential threats facing society, such as climate change or infectious disease outbreaks, do not respect national borders. AHSS in different parts of the world should come together to form a global network that can learn from each other and draw on their collective strengths and expertise to advance innovative solutions to these threats. By doing so, there is an opportunity to strengthen existing relationships or build bridges across different nations that may not have strong ties. Furthermore, advanced AHSS can lend their expertise to countries that have nascent or no AHSS and provide guidance in developing them.

The above capabilities are foundational for AHSS for the 2020s. While there is great diversity in governance structures of AHSS globally, what matters is how the principles of our model are adopted, integrated, and put into practice regardless of differences in governance structure, geography, or national frameworks. In addition, each institution can and should establish its own distinction in specific areas by creating centres of convergence in emerging opportunities such as medicine and engineering (as seen by the Carle Illinois College of Medicine at the University of Illinois at Urbana-Champaign in the USA, which is the first engineering-based medical school), medicine and computer science, medicine and public policy, and others.

For AHSS to successfully implement the aforementioned approaches and concepts, there must be a re-evaluation of health education, which may require changes in curricula and additional competencies. We must train a new type of clinician and protect the ones we currently have. AHSS must lead in creating new curricula that encourage team science and interprofessional education. The 2010 *Lancet* Commission on the health professional education framework emphasised the integration of training with clinical delivery and defined a set of competencies.<sup>9</sup> In our model, these competencies should be extended to include social determinants and quantitative science. Finally, ongoing training for clinicians already in practice is important to ensure uptake of new developments.

Education must ensure that all students understand social inequities and the ethics of medicine to be on the front lines of not only solving the clinical needs but also understanding and caring about the societal needs of patients. In our opinion, all trainees should have early exposure and direct experience in community and social issues in the preclinical years, even before direct clinical training.

Given the importance of data in the ever-increasing digital world, trainees should be faceted with quantitative sciences; they should have an understanding of the use

For more on the Greener NHS initiative see <https://www.england.nhs.uk/greenernhs/>

of data given that the information it can generate is essential for the practice of medicine in the future. To train the right kind of health-care professionals, we need an education system that is well aligned with health needs. Knowledge, skills, and values should improve the health of patients and populations.

Finally, AHSS must recognise its fundamental duty to develop a supportive work culture and environment. The systems and culture must support the health and wellbeing of the workforce. In the past several years, there has been a significant increase in clinician burnout, depression, and suicide. As was stated in the National Academy of Medicine clinician burnout consensus study, “emotional exhaustion, depersonalization, and loss of sense of professional efficacy—the three dimensions of burnout—are detrimental to the clinicians and the quality of care.”<sup>10</sup> Clinician burnout is also costly for organisations experiencing workforce shortages and difficulty retaining high-quality clinicians.<sup>11</sup> It is imperative at this critical time in health care that AHSS create, implement, and evaluate their own programmes and initiatives by using a systems-based approach, using rigorous methods of evaluating burnout and burnout risk, sharing lessons learned with other health-care organisations, and acting collectively to scale sustainable approaches.<sup>12</sup>

The COVID-19 pandemic underscores the need for AHSS to be prepared for future health crises. The pandemic created challenges across the tripartite mission for AHSS, from shutting down clinics, cancelling and delaying elective procedures and surgery, disrupting routine and preventive care, and disrupting education and research. Despite this pressure, AHSS rose to the challenge and provided an indispensable service caring for patients; advanced basic and translational science, and launched clinical trials and other studies focused on disease expression, treatments, and vaccines; and rapidly adapted medical education to ensure safety, including a shift to remote learning and implementing innovations in teaching and licensing.

AHSS should build on the experience during the COVID-19 pandemic to better prepare for future pandemics. Implementing the aforementioned framework would be an important step. AHSS must leverage their unique strengths and work with partners to advance pandemic preparedness and response for the good of society. In particular, they must leverage their resources and capacities to support and align with the strategy of the government and public health. AHSS should act together as a national network to coordinate care and planning; support public health, testing, and sequencing; and drive the systematic collection of data to inform preparedness and response. AHSS should act as anchor institutions in their communities by providing resources, support, and engagement, and attending to vulnerable populations.

The past decade has seen major changes in health and medicine, and AHSS have responded by developing more integrated systems that advance science from discovery to translation to care. In this new decade, AHSS must continue to evolve by expanding its mission to discovery to health to population to society. To continue leading the transformation of health, in the next decade AHSS must move from a reductionist to a systems approach, integrate molecular sciences and population health, enable big data to provide information, develop convergence science, work closely with public health and communities, become anchor institutions that take social stands to better the health of all citizens, and focus on the wellbeing of the workforce. Although not all aspects of this model can be achieved by all academic health systems everywhere, these principles should be contextualised to ensure that this model of bench to bedside to population to society forms the foundation of AHSS going forwards.

#### Contributors

VJD conceptualised the article, edited the manuscript, and responded to reviewer comments. CAB and WFE researched and drafted the manuscript.

#### Declaration of interests

We declare no competing interests.

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