The role of academic health science systems in the transformation of medicine

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The challenges facing the health of communities around the world are unprecedented, and the data are all too familiar. For 5 billion people living in developing countries, environmental factors and inadequacies in hygiene, economic development, and health-care access are the main causes of shortened life expectancies. Improvements in health status, including reductions in infant mortality and declining incidence of infectious diseases, are being met by the new epidemics of obesity, diabetes mellitus, and cardiovascular disease.[1]

Developed countries are beset by disparities in access to care and health outcomes,[2,3] unreliable quality, and high costs.[4] Increased demand for services, ageing populations, inadequate evidence to guide practice, and a misdirected emphasis on research and treatment in late-stage disease contribute to the high cost of health care.[5] In many countries, these difficulties are exacerbated by fragmented health-care delivery systems, resulting in inadequate continuity of care across community, primary-care, and tertiary-care settings. The creation of novel treatments remains protracted and expensive,[6] new discoveries are not delivered swiftly to patients,[7–9] and population-wide strategies using cheap, simple, and efficient interventions are not effectively implemented.[10]

Many countries, including the USA, the UK, Singapore, the Netherlands, and Canada, have focused on the promise of academic health science centres (AHSCs) to improve health locally and globally while also supporting economic development. In this Viewpoint, we draw attention to the potential of these organisations in leading the transformation of medicine through the development of a discovery-care continuum—a network to disseminate knowledge and innovations globally—and describe a few activities that are underway with the aim to make the potential a reality.

To resolve the difficulties described above, AHSCs should create not only novel drugs, devices, and other technologies, but also new ways of deploying broad, inexpensive preventive and treatment strategies among populations. An amalgamation of broad public health and individualised care might seem contradictory, but a vision of transformation supported by a radical reorganisation of AHSCs can initiate a creative synthesis in which technological innovations, effective treatments, and delivery of care combine to formulate common solutions that can be applied to individuals and large populations. The discovery-care continuum (figure 1A) represents such a pathway, in which innovative ideas can be put into practice to improve patient care, irrespective of where on the continuum they arise.

In order to achieve transformation, two distinct translational blocks or gaps in the discovery-care continuum must be overcome.[11,12] The first is the gap between a scientific discovery and its clinical translation (ie, from bench to bedside); the second is the gap between expert acceptance of the application and its broad adoption in practice by local and global communities (ie, from bedside to population). AHSCs traditionally give their discoveries to industry at the first gap and to practising physicians at the second gap, thereby creating barriers and inefficiencies. We believe that AHSCs are ideally poised to become system integrators that are capable of bridging these translational gaps, thereby greatly reducing delays and inefficiencies between discovery and global adoption. These system integrators do not replace industry or non-academic providers, rather, they improve the capacity to develop and deliver new treatments by filling the spaces between academic discovery, science, industry, and the general health-care delivery system. In the USA, the Roadmap Initiative of the National Institutes of Health (Bethesda, MD),[13–15] and resulting Clinical and Translational Science Awards[16] have shown this perspective. Examples of US institutions that have begun to develop models of integrated translational research and care-delivery systems include the University of Pennsylvania (Philadelphia, PA), Johns Hopkins University (Baltimore, MD), and Harvard University-Partners Healthcare (Boston, MA). At Duke, we have developed an AHSC (Duke Medicine) that includes the Duke University Schools of Medicine and Nursing, the Duke University Health System, and related organisations. The UK is also creating AHSCs through the integration of academic (eg, education and research) and care-delivery systems, enabled by partnerships between universities and the National Health Service Trusts, such as Imperial College's Academic Health Science Centre in London.[17]

To transform health care, we believe that AHSCs should evolve further into academic health science systems (AHSSs). The term AHSC connotes a specific location where patients receive care (eg, a medical campus), whereas AHSSs are thought of as integrated health-care delivery systems that not only include the traditional medical centre but also a network of community hospitals and practices. Ideally, each AHSS has missions, resources, and standards that are shared by the system to improve the way in which it helps patients and communities. To catalyse the needed transformation, we believe that AHSSs should focus on organisational structures, external partnerships, research translation, models of care delivery, new

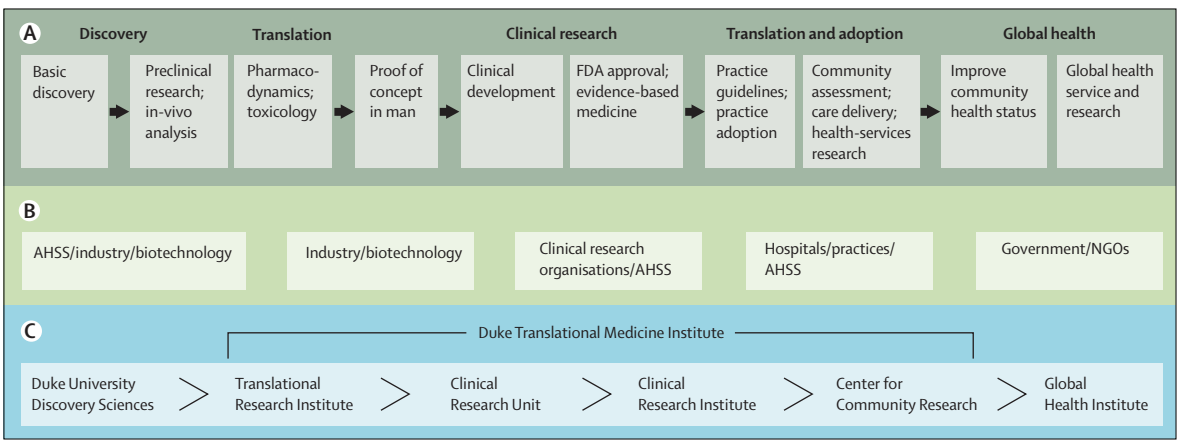

Figure 1: **Academic health science systems as integrators**
(A) The discovery-care continuum, including discovery science, preclinical and clinical research, adoption in practice, and global uptake; (B) current fragmented organisational structure of the clinical research enterprise; (C) Duke Medicine model: a continuous, intercommunicated discovery-care model. FDA=US Food and Drug Administration. AHSS=Academic health science systems. NGOs=non-governmental organisations.

educational models, and information technology. Further, tactics of AHSSs should include push (eg, targeted grant support) and pull (eg, creation of common resources) approaches, and active management and leadership. We address below each of the strategies and briefly describe efforts underway at our institution (Duke Medicine) and at others.

Many AHSSs are fragmented, both internally and among their external partners. The private biomedical and health-care industries (eg, clinical research organisations, hospitals, community practices, and research institutions) are made up of specialised sectors that for structural and historical reasons—including disconnected reimbursement systems, regulation, and business models—are housed in separate organisations or institutions (figure 1B). Each institution has its own incentives, which are often not aligned, resulting in inefficient systems of research, health-care delivery, and finance. Reform of national health-care systems to overcome these barriers is beyond the purview of AHSSs alone, but AHSSs are the only organisations that interact with all points along the continuum. Therefore, we believe they can become models of horizontal integration of discovery and care delivery through reorganisation of their key structures and encouragement of cultural change that emphasises effective interfaces among academic departments, research organisations, and delivery systems, and by extending these interfaces to participate in more effective public–private partnerships.

To create infrastructure in which innovations are moved quickly along the discovery-care continuum, AHSSs should create horizontal, functionally integrated organisations that transcend academic departmental structures and promote interdisciplinary collaboration and efficient use of common resources. By using a matrix organisational structure,[18] AHSSs can manage novel associations among traditional departments and new centres and institutes. The roles and responsibilities of the constituents of the matrices need to be clearly defined,[19] and will vary according to the strengths, cultures, and priorities of the different AHSSs. For example, in the UK, King's Health Partners is establishing interdisciplinary groups in targeted disease areas to help achieve clinical and academic integration.[20] There is no single perfect organisational model; indeed, institutions should be encouraged to experiment, candidly disclosing successes and failures so that best practices can be shared. Principles such as strong leadership, committed partnerships, shared vision, mutual trust, and clarity in governance and decision rights will enable the success of AHSSs.

An experiment in organisational transformation is in progress at Duke Medicine, which has aligned research and care delivery by developing a matrix organisation and establishing inter-related institutes, including the Duke Translational Medicine Institute and the Duke Global Health Institute (figure 1C). These institutes, which are system-wide and integrate traditional organisational structures, are agnostic about the organ-system orientation of biomedical specialties (eg, haematology, cardiology), and the academic specialties within clinical departments (eg, medicine, surgery, psychiatry), basic science departments (eg, biochemistry, pharmacology), and related specialties (eg, environmental science, public health, business). Instead, these flexible systems bridge translational gaps and encourage propagation of several types of knowledge along the discovery-care continuum.

The Duke Translational Medicine Institute, which receives substantive institutional commitments and also support from a clinical and translational science award, provides leadership and resources for clinical and translational research, medicine, nursing, and related disciplines, and assesses approaches to these investigations. The Duke Translational Medicine Institute consists of four organisations. The Duke Translational Research Institute focuses on translating early discoveries

into clinical applications. The Duke Clinical Research Unit undertakes biological proof-of-concept studies with advanced genomic and imaging technologies. The longstanding Duke Clinical Research Institute undertakes many clinical trials and registries, policy and health services research projects, and educational programmes in related research methods. The Duke Center for Community Research develops best practices for community-based research, and the development and assessment of new models of care delivery. Furthermore, the Duke Translational Medicine Institute provides each component organisation with essential integrative functions such as informatics support, information technology, regulatory consulting, biostatistics, ethics, nursing, and specialised facilities and personnel for specific types of research.

As AHSSs develop, effective communication and collaboration with external stakeholders increases in importance. AHSSs should engage in flexible arrangements, including public–private partnerships (eg, the Clinical Trials Transformation Initiative partnership between the US Food and Drug Administration, Duke Medicine, and other academic and industry partners that is dedicated to modernising clinical research[21]) and the strategic cultivation of external resources. Partnerships should focus on filling specific gaps (eg, institutional shortfalls in technical expertise or internal capacity) and should cross geographic and functional boundaries.

In partnerships that are targeted towards turning research into innovative products, US universities can retain intellectual property rights to the results of federally funded research.[22] However, the route to commercialisation is increasingly unclear. As concern over individual and institutional conflicts of interest grows,[23] so do the challenges of working with external commercial partners, and new models should be explored.[24] An example is provided by Imperial College London, which created the first technology transfer company owned mostly by a university that was offered publicly on the UK stock market (Imperial Innovations, London). In fiscal year 2007 alone, Imperial Innovations created 11 companies and disclosed 354 new inventions.[25] In another model, the University of Toronto (Toronto, ON, Canada) created physical and virtual space (the MaRS Centre) to promote "innovation by uniting the disparate worlds of science and technology with industry and capital."[26] Similarly, the Duke Translational Medicine Institute has created Duke Ventures and is developing systems-based approaches and project management methods to help work with external partners, such as industry, government, non-governmental organisations, and other academic institutions.

In addition to supporting traditional, discovery-oriented investigation, AHSSs should support new priorities to lead development of cheap, fast, readily adoptable technologies and care models. For example, resources should be devoted to advancing medicine that is preventive, predictive, pre-emptive, personalised, and prospective—eg, customised prevention or treatment modalities, with an emphasis on novel, effective prevention strategies, community health programmes, and care-delivery models.

Care delivery at AHSSs should be vertically integrated (figure 2) to develop a continuum from community care to tertiary care, helped by effective clinical information systems. At the moment, there are many barriers to the creation and implementation of effective integrated care models. For example, reimbursement schemes in many countries do not reward innovations that support care coordination.[27,28] Furthermore, human capital constraints (eg, shortages of community health workers) are additional challenges. AHSSs will need to work with communities to support programme development, implementation, assessment, and dissemination to overcome such barriers.

Despite these challenges, promising examples of innovative care models exist. Through partnerships with the state of North Carolina and various community groups, Duke Medicine currently participates in a primary-care case management programme (Community Care of North Carolina) that resulted in substantial Medicaid savings for the state of North Carolina and the Federal government (about US$300 million in fiscal year 2006),[29] and has created a home-based care programme for at-risk elderly people, reducing inpatient expenses for participants by 68% while improving health outcomes.[30] Through successful experimentation, AHSSs can develop approaches that improve access, outcomes, and cost efficiency and effectiveness, thereby justifying appropriate reimbursement. Ideally, such vertically integrated AHSSs could evolve into accountable care organisations that are financially responsible for the health of the populations they serve.[31]

The sustainability of these efforts across the discovery-care continuum depends on the quality, commitment,

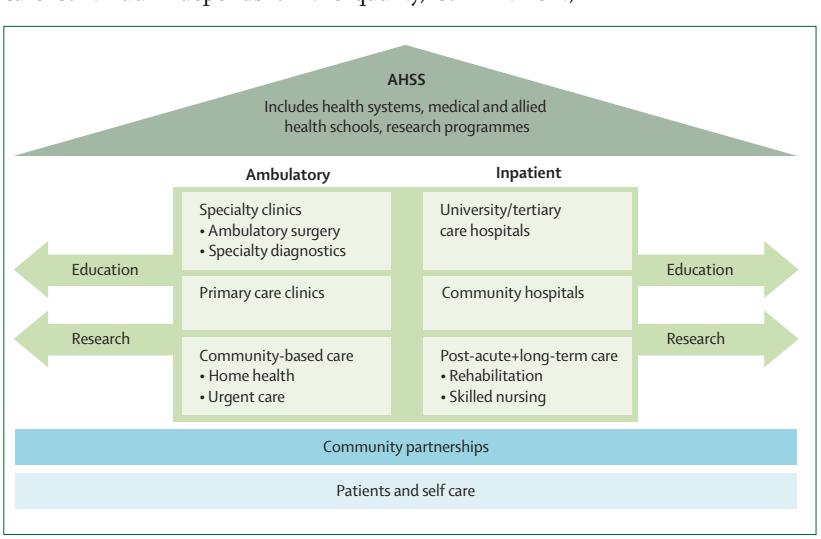

Figure 2: **Academic health sciences system (AHSS) as a vertically integrated care-delivery system**

and availability of future care providers, researchers, and leaders, and in turn requires a transformative educational model. Future researchers and providers will need new methods of knowledge acquisition, problem solving, teamwork, and multidisciplinary investigation and care delivery. This model should include students not just in research and medicine, but also in nursing, pharmacy, social work, and other allied health professions. To be most effective, trainees should also be exposed to complex social problems, health economics, business, and policy—topics that are not included in most curricula. AHSSs should provide education in leadership and management skills for the essential development of future leaders.

One effort in novel curricular development currently underway is a public–private partnership between Duke Medicine and the government of Singapore—ie, the Duke-National University of Singapore Graduate Medical School. While this collaboration is working to strengthen many elements of the discovery-care continuum within and between Singapore and Duke Medicine, early efforts have focused on the training of clinician scientists.[32] Duke-National University of Singapore delivers novel learning aids, including lectures and supporting material that is continuously available online to its students, with classroom time devoted to team-based education and lifelong learning and skills development.

Investment in information technology and informatics expertise are crucial for an effective discovery-care continuum, which requires the distillation of knowledge from rapidly increasing amounts of raw data. The challenges are many and include insufficient data standards and a lack of professional acceptance. However, if properly developed, health-care information technology can improve efficiency and reduce costs,[33] not only by supporting clinical care directly, but also by enabling the creation of integrated meta-datasets and real-time analyses of interventions that allow AHSSs to assess their efforts. Indeed, many institutions, such as Duke Medicine, Cleveland Clinic (Cleveland, OH, USA), and Vanderbilt University (Nashville, TN, USA), are now working to aggregate their disparate data systems to support research and inform operational and clinical decision making.[34] These investments will help support a true "learning healthcare system"[35] in which data are used in real time to improve health-system performance.

AHSSs need to transcend traditional academic and geographic borders and engage in global public–private partnerships, not only to fill gaps in research domains, but also to build the final essential component of the discovery-care continuum.

Innovations that succeed locally can be adapted for global application, and global discoveries can be imported and applied locally. For example, partnerships enable AHSSs to engage in service-learning projects within different populations, cultures, or geographic locations, bringing resources to populations that are not adequately served. Through bidirectional service learning, investigators and their partners can refine discoveries and spread findings globally, addressing unmet needs, and supporting additional discovery.

One example is the dramatic increase in the rates of HIV testing recorded just 1 year after initiation of an opt-out programme in Botswana,[36] which subsequently led to high coverage rates for patients with HIV who needed antiretroviral drugs. This experience subsequently stimulated many other countries, irrespective of their national income level, to implement opt-out testing programmes.

In this spirit, Duke Medicine established the Duke Global Health Institute to complete its own discovery-care continuum. This institute studies not only diseases, but also the political, economic, social, and environmental factors that contribute to health inequalities, as well as approaches for improving prevention and treatment services for susceptible populations worldwide. In fact, as of early 2009, 41 universities in North America had an interdisciplinary centre dedicated to global health.[37] Such institutes and their partners can help to achieve the greatest global health benefits of innovations, whether simple or highly technological.

Assessment of whether the benefits of establishing a functional discovery-care continuum are worth the incremental costs is important because of budget constraints in countries at all levels of economic development. Although it is too early to assess most efforts, we recognise the importance of assessing their ultimate success or failure. The evaluation metrics include a range of different types of costs (eg, human *vs* financial costs) and benefits (eg, efficiency, economic growth, global competitiveness). Ultimately, human health is the most important outcome, and AHSSs should be held accountable for the health of the populations they serve, both locally and globally.

There is substantial interest in the role that AHSCs and AHSSs can have in promoting health and economic development. We believe that AHSSs have the capability and the collective responsibility to transform medicine, improve health, and reduce health-care disparities locally and globally. Achievement of these goals necessitates the development of a continuum that spans discovery and translation sciences to provide integrated care delivery and improved global health. New organisational structures, external partnerships, research priorities, models of education, care delivery, and investments in institutional information systems can make the achievement of this goal possible and ultimately allow AHSSs, with their vast potential, to enable health transformation globally.

Contributors

DCA participated in research and data gathering, and figure design. DCA, RMC, PSW, RSW, MHM, KRK, and VJD participated in writing and editing of the Viewpoint. PSW did the literature search. RCT, RSW, and MHM contributed to project design. VJD contributed to the conceptualisation of the Viewpoint and research.

Conflicts of interest

We all work for an academic health science system and declare that we have no other conflicts of interest regarding the content of this Viewpoint.

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