Incorporating appropriate technology into North American schools of public health

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The major discoveries in bacteriology during the last half of the 19th century and the promise of their application to sanitation and public health practice helped to stimulate the founding of the first generation of schools of public health in North America (1, 2). Sometimes referred to as the "West Points of Public Health," these schools at Johns Hopkins, Harvard, Columbia, Yale, Michigan, and Toronto shared an important mission: to apply new advances in laboratory sciences towards the development of new technologies for disease control (1, 2). The activities of these schools during the 20th century resulted in a number of landmark achievements, including the discovery of vitamins A and D, which led to the elimination of rickets and other pediatric diseases, a reliable formula for chlorinating water to make it safe to drink, tissue culture technology for the development of rubella and other vaccines, the isolation of human immunodeficiency viruses HIV-1 and HIV-2, cytomegalovirus and numerous arboviruses, and the clinical evaluation of inactivated polio vaccine (3, 4).

Over the last two decades, however, the schools of public health in the United States have increasingly moved away from technology, particularly as it relates to infectious disease control and prevention in developing countries. With the exception of the University at Albany (State University of New York), none of the U.S. schools of public health that have come into existence after 1980 have departments grounded in microbiology or related laboratory sciences (1, 5). Instead, these new schools of public health focus heavily on areas that interface with the social sciences, such as health services policy and management, health promotion, occupational health, communication sciences, and exercise sciences. Only eight of the 33 accredited schools of public health in the United States host departments of microbiology or infectious diseases, and all but six of these departments are housed in schools founded before 1950 (1, 5). Ironically, these reductions in microbiology training opportunities in public health schools coincided with the emergence or re-emergence of polio, severe acute respiratory syndrome (SARS), West Nile virus, and other infections.

ADVANCING APPROPRIATE TECHNOLOGY THROUGH PUBLIC-PRIVATE PARTNERSHIPS

Beyond these epidemiological reflections, the current trend in U.S. public health schools to move away from technology is even more surprising, given that some of the greatest success stories in modern public health resulted from the widespread and appropriate use of technology. These successes include the global eradication of smallpox, the Expanded Program on Immunization, the eradication of polio and measles in the Americas, and oral rehydration. Some estimates indicate that these technologies have saved more lives over the last 40 years than all of the lives lost during the 20th century (6). As the experience of the previous century has also shown, however, technologies are not effective in and of themselves. To be considered "appropriate technologies" they must be developed, produced, delivered and monitored within a comprehensive framework that takes into account the systems, the individuals, and the community. Some of our greatest global health disappointments resulted from inappropriate uses of technology. Examples include the re-emergence of malaria as a result of DDT and chloroquine resistance, the subsequent collapse of international malaria eradication campaigns during the 1960s, and the slow global uptake of low-cost treatment for tuberculosis (7, 8).

Despite its importance in alleviating health disparities, most of the innovation in the development of appropriate technology for infectious diseases does not currently take place in public health schools. In its place a new type of nonprofit entity, the product development public-private partnership (PD-PPP), emerged beginning in the 1990s. The major goal of PD-PPPs is to develop and distribute new health products including drugs, vaccines and diagnostics, with a primary emphasis on neglected tropical diseases in developing countries (9). Unlike the nongovernmental organizations that preceded them, the PD-PPPs use industrial practices and work with pharmaceutical companies, relying on private-sector approaches to attack public-sector research and development challenges (9).

The PD-PPPs are successfully developing new health products for leishmaniasis, malaria, African trypanosomiasis, hookworm, and Chagas' disease, for which there are no commercial markets (10, 11). Several PD-PPPs are developing global access plans for their products by partnering with manufacturers in middle-income countries, such as Brazil, China, Cuba, Egypt, India, and South Africa, which have achieved a degree of sophistication for developing health products, and yet which suffer from endemic tropical diseases (11). Together with the PD-PPPs, the activities of these so-called "innovative developing countries" represent the largest new investments in efforts to control and eliminate neglected tropical diseases (9, 11).

APPROPRIATE TECHNOLOGY RESEARCH AND TRAINING IN PUBLIC HEALTH SCHOOLS

Very few of the PD-PPPs have a university base. An exception is the Human Hookworm Vaccine Initiative, which has successfully transitioned a recombinant vaccine from the laboratory through current good manufacturing practices (cGMP) manufacture and phase-1 clinical testing (10). By hosting PD-PPPs in an academic setting, schools of public health could offer extraordinary opportunities for training a new generation of global health scientists (12). Therefore, an important new mission for public health schools could be to advance knowledge and provide training in appropriate technology for the control of diseases of poverty in developing countries. Such technologies could include ways to develop and evaluate new drugs, vaccines, and diagnostics for neglected tropical infectious diseases. Also needed are computer-based tools for functional genomics, disease surveillance, disease burden assessment, health resource allocation and cost effectiveness analysis, as well as for mathematical modeling of disease transmission dynamics and intervention strategies. Currently no U.S. public health school attempts to comprehensively apply these technologies to public health practice in developing countries. It is possible, however, that some of the new advances in these areas could stimulate a public health revolution similar to the one that followed the 1880–1915 revolution in bacteriology (1, 13).

Because appropriate technology has not been a priority for public health schools in the United States, most institutions do not have the cadre of trained faculty, nor do they traditionally provide the training needed to take a product (such as a human hookworm vaccine) through the entire development cycle. For instance, even though some public health schools have molecular biologists and protein chemists, they do not typically have experts in fermentation technology able to advise on ways

to maximize the yield of a recombinant protein secreted by bacteria or yeast. Yield optimization is critical, however, in order to produce biologicals at low cost for the "poorest-of-the-poor" in developing countries. Most public health schools do not have scale-up purification specialists who can isolate a recombinant product from 60 liters or more of fermentation broth, or formulation experts who know how to combine proteins with adjuvants. Also needed are experts with knowledge about batch production records to ensure successful technology transfer from the laboratory to a cGMP manufacturer. Hardly any schools provide training or expertise in quality control or quality assurance. However, these analyses are critical for ensuring the color, appearance, identity, purity, and potency of the product (10). These elements are part of the chemical, manufacturing and control section of an investigational new drug (IND) application to the FDA. Academic institutions generally do an inadequate job of writing IND applications, and their applications often fail. Most schools do not have regulatory experts who can guide investigators through the ethical and legal hurdles prior to FDA approval in the United States. They also lack experts in regulatory affairs or intellectual property law in innovative developing countries where vaccines might be developed and tested.

A FOCUS ON THE AMERICAS

Latin America offers particularly fertile ground for schools of public health to develop appropriate technology. This potential is based on considerations of geographic proximity as well as the dominant presence of older European schools of tropical medicine and hygiene elsewhere in the developing world (12). European health schools that are active on a global level, such as the London School of Hygiene and Tropical Medicine, the Liverpool School of Tropical Medicine, the Royal Institute of Tropical Medicine (Belgium), the Bernard Nocht Institute (Germany), and the Institut Pasteur network, work extensively in sub-Saharan Africa, Asia, and the Middle East, potentially leaving the Americas as an area lacking in significant collaboration.

However, establishing a Pan American focus for U.S. public health schools would be an ambitious undertaking. The Americas have an estimated population of approximately 840 million people (14 percent of the world's population), with 10 percent of the world's disability-adjusted life years from all diseases (14). Latin America, like other regions of the developing world, suffers from high rates of HIV-AIDS, tuberculosis, and malaria, as well as other important tropical infectious diseases such as Chagas' disease, leishmaniasis, schistosomiasis and hookworm (Table 1). Therefore an initial focus of efforts to develop appropriate technology could be on endemic tropical infections in the region, as well as emerging infectious agents. Several of these infections, especially Chagas' disease, leishmaniasis, cysticercosis, and dengue infections, have a high potential for emerging in the United States.

TABLE 1. Latin America's burden of tropical infectious diseases in 2001[a]

Condition	% disease burden in the Americas, based on disability-adjusted life years
HIV/AIDS	3.1
Diarrheal disease	4.3
Malaria	0.3
Tuberculosis	2.6
Measles	0.0
Sexually transmitted diseases	5.1
Lymphatic filariasis	0.2
Trachoma	0.0
Leishmaniasis	2.5
Hookworm infection	8.2
Schistosomiasis	10.4
Trichuriasis	17.7
African sleeping sickness	0.0
Ascariasis	14.6
Onchocerciasis	0.3
Japanese encephalitis	0.0
Poliomyelitis	0.0
Dengue	13.8
Chagas' disease	99.8
Leprosy	10.2

[a] Modified from Table 3 in Hotez PJ et al (14).

Public health schools could jump-start their nascent efforts to conduct appropriate technology research and provide training for the impoverished regions of the Americas by partnering with the Pan American Health Organization (PAHO). As the WHO representative in the Western Hemisphere, PAHO is one of the most effective public health agencies in the world. Among its accomplishments, PAHO is partly credited with the eradication of smallpox, the eradication of polio, and the eradication of measles from the Americas. Schools of public health could also link their appropriate technology efforts with selected Latin American research institutes and public health schools whose mission is focused on disease control. Major institutes include the Oswaldo Cruz Foundation (FIOCRUZ) in Brazil, the Instituto Conmemorativo Gorgas de Estudios de la Salud (ICGES) in Panama, the Institute for Advanced Studies in Mexico City, the Pedro Koury Institute in Havana, and the national public health schools in these nations.

NEW CORE COMPETENCIES: INTERDISCIPLINARY TRAINING IN GLOBAL HEALTH SCIENCES

Given how few public health schools retain microbiology departments, it is not surprising that schools of public health are becoming increasingly devoid of laboratory instruction for their Master of Public Health (MPH) degree students. Because the required training in this area is not provided, it is likely that the majority of MPH students never peer into a microscope during their training. For proper training in appropriate technology, students must have access to laboratory instructors who provide training in "the classics," i.e., bacteriology, virology, parasitology, and mycology, as well as the pathology of tropical and infectious diseases. Also needed is training in biotechnology, including fermentation technology, protein purification, formulation, quality control, and quality assurance. Students of appropriate technology should also obtain training in regulatory and legal aspects of product development, and should understand the economic and social implications of the disease burden. They should also learn the complexities of disease outbreak investigation and the control of endemic infections and should be trained to use computer databases to unravel the genome and proteome of tropical pathogens as well as their vectors and human hosts. A list of possible core competencies is shown in Table 2.

In addition to the need to build toolboxes to control neglected diseases, there is a need for better training in the management of demographic, epidemiologic, political and economic data to understand the nature of the disease burden in developing countries and to establish national priorities (14). Training in the operation of demographic surveillance systems and the International Network of Field Sites with Continuous Demographic Evaluation of Populations and Their Health in Developing Countries (INDEPTH) Network (www.indepth-network.net) would equip researchers to assess programs such as the Integrated Management of Childhood Illness (IMCI), programs for the intermittent chemoprophylaxis against malaria, the Direct Observed Treatment, Short Course program for tuberculosis (DOTS), and the Expanded Program on Immunization (EPI) (14).

TABLE 2. Examples of appropriate technological core competencies for different disciplines

Microbiology, Bacteriology, Parasitology, Virology and Entomology
Cultivation and maintenance in vitro or in vivo of major tropical disease pathogens
Ability to recognize the major pathogens with the aid of a microscope
Ability to perform common diagnostic tests for tropical disease pathogens
Understanding of disease pathogenesis (how tropical disease pathogens cause disease)
Recognition of the clinical manifestations of major tropical infectious diseases
Basic understanding of disease management and treatment
Basic understanding of the principles of vector biology
Epidemiology, Disease control, and Disease ecology
Core principles of the epidemiology of tropical infectious diseases
Mathematical principles essential to understanding transmission dynamics
Principles of sanitary engineering
Principles of outbreak investigation, disease control and quarantine
Understanding of how disability-adjusted life years and related metrics are derived
Principles of disease burden assessment in developing countries
Basics of clinical trial design
Training in current good clinical practices
Biotechnology
Use of genomic databases and bioinformatics to address scientific questions
Principles of proteomics, metabolomics and transcriptomics
Principles of molecular biology and cDNA cloning
Principles of drug discovery and vaccine antigen discovery
Fermentation technology and protein purification
Principles and implementation of quality control and quality assurance (QC/QA)
Development and evaluation of QC/QA assays
Understanding of the principles of current good manufacturing practices and good laboratory practices
Understanding of the regulatory requirements for biologicals of the US Food and Drug Administration and overseas regulators
Understanding of basic international patent law
Social Science and Biosecurity
Principles of cost-effectiveness analyses
Understanding the role of multilateral banks and public health agencies in health
The role of urbanization in disease emergence
Political science and macroeconomics of Latin America

FUNDING FOR APPROPRIATE TECHNOLOGY

Within the last five years considerable funds have been invested in the research and development of new vaccines and pharmaceuticals and in programs for neglected tropical diseases (12). Funding has come from private foundations such as the Bill and Melinda Gates Foundation, and from the US federal government through the proposed U.S. Leadership Against HIV/AIDS, Tuberculosis and Malaria Act, the National Institutes of Health's Global Health Research Plan for HIV/AIDS, Malaria, and Tuberculosis (which builds on the network of overseas laboratories of the International Centers

of Tropical Disease Research), and the Grand Challenges in Global Health Initiative (12). Internationally, the Global Fund to Fight AIDS, Tuberculosis, and Malaria has awarded more than US$ 2.1 billion, and the Commission on Macroeconomics and Health has called for the creation of a US$ 1.5 billion Global Health Research Fund (12).

Over the last five years the pharmaceutical industry has also made unprecedented commitments to solving neglected health problems for the poorest. For instance, Novartis and Pfizer have established new tropical disease research institutes in Singapore and Uganda, respectively (12), GlaxoSmithKline (GSK) has worked in partnership with the Malaria Vaccine Initiative and the Gates Foundation to develop a recombinant malaria vaccine (15), and Pfizer, Merck, and GSK have each made major donations of pharmaceuticals for the treatment of neglected diseases (16). The link between appropriate health initiatives and industry through public-private partnerships may become a regular feature of these collaborations. Because much of the nation's brain trust for the development, manufacture, and quality control of drugs, vaccines and diagnostics is within the confines of the pharmaceutical industry, establishing an industry link would provide badly-needed technical assistance for producing a new generation of tools for disease control and morbidity reduction in the developing world. Such links would also provide a way to seek new funds for appropriate technology initiatives in public health schools.

The entry of these organizations into the global health arena affords new opportunities for graduates trained in appropriate technology. Other participating organizations may include multilateral banks, international public health organizations, state and local health departments, NGOs, faith-based organizations, private foundations, vaccine and biologicals manufacturers, PD-PPPs, start-up biotechs, scientific equipment manufacturers, multinational corporations, contract research organizations, the U.S. Departments of State, Health and Human Services, Defense, and Agriculture, think tanks, academic health centers and schools of public health, and private research institutes.

Because of a unique convergence of forces at the international, national, and state policy levels, we now face a unique window of opportunity to add appropriate technology to the mission of public health schools. To do so requires a shift to a more integrated, practical approach that includes acquisition of "real-world" skills in terms of product development and use. By supporting a solid academic curriculum in schools of public health and fostering new, collaborative environments, we as public health practitioners can advance our efforts to address the health equity gap reflected in diseases of the poor.

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SINOPSIS

La incorporación de la tecnología adecuada en las escuelas de salud pública de América del Norte

El término tecnología adecuada *se refiere a la tecnología sanitaria que se crea, produce, ofrece y monitorea en un contexto general donde se toman en cuenta los sistemas, las personas y la comunidad. Esta tecnología abarca el diseño, desarrollo y adopción de productos sanitarios, entre ellos nuevos medicamentos, vacunas y métodos diagnósticos, y de medios computadorizados aplicables a la genómica funcional, vigilancia epidemiológica, evaluación de la carga de morbilidad, adjudicación de recursos sanitarios, creación de modelos matemáticos y análisis de efectividad en función del costo. En conjunto, estos medios son especialmente promisorios para el control y la eliminación de diversas enfermedades tropicales que han recibido escasa atención. Actualmente, buena parte de la investigación y el desarrollo en torno a tecnologías adecuadas está a cargo de alianzas formadas recientemente entre los sectores público y privado. No obstante, es preciso incrementar la investigación y el entrenamiento en este campo en las escuelas de salud pública de América del Norte en vista de los efectos sanitarios y económicos que se calcula que tendrá la tecnología adecuada en países en desarrollo.*

Palabras clave: biotecnología, educación en salud pública profesional, escuelas de salud pública, América Latina, medicina tropical, enfermedades transmisibles.

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Forum on Combating Disease and Promoting Health

Dates: 29 October – 2 November 2006
Location: Conrad Cairo Hotel
Cairo, Egypt

The Global Forum for Health Research, which is an independent international foundation promoting health research to combat the neglected diseases and conditions that are major sources of ill health in developing countries, will be holding its 10th annual Forum meeting in Cairo, Egypt, 29 October through 2 November. The theme of this year's meeting is "Combating Disease and Promoting Health."

The annual Forum meetings bring together policymakers, directors and users of research, and other health professionals to discuss critical gaps and to energize action to address the health needs of the poor and marginalized. The presentations at the meeting will focus on research that has implications for policy and practice.

The participation fee is US$ 250 for persons from low- and middle-income countries, and it is US$ 500 for individuals from high-income countries.

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