

Special Report

Field Epidemiology and Laboratory Training Programs in West Africa as a model for sustainable partnerships in animal and human health

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The concept of animal and human health experts working together toward a healthier world has been endorsed, but challenges remain in identifying concrete actions to move this one health concept from vision to action. In 2008, as a result of avian influenza outbreaks in West Africa, international donor support led to a unique opportunity to invest in Field Epidemiology and Laboratory Training Programs (FELTPs) in the region that engaged the animal and human health sectors to strengthen the capacity for prevention and control of zoonotic diseases. The FELTPs mixed 25% to 35% classroom and 65% to 75% field-based training and service for cohorts of physicians, veterinarians, and laboratory scientists. They typically consisted of a 2-year course leading to a master's degree in field epidemiology and public health laboratory management for midlevel public health leaders and competency-based short courses for frontline public health surveillance workers. Trainees and graduates work in multidisciplinary teams to conduct surveillance, outbreak investigations, and epidemiological studies for disease control locally and across borders. Critical outcomes of these programs include development of a cadre of public health leaders with core skills in integrated disease surveillance, outbreak investigation, vaccination campaigns, laboratory diagnostic testing, and epidemiological studies that address priority public health problems. A key challenge exists in identifying ways to successfully scale up and transform this innovative donor-driven program into a sustainable multisectoral one health workforce capacity development model. (*J Am Vet Med Assoc* 2012;241:572–579)

It is a glorious feeling to discover the unity of a set of phenomena that seem at first to be completely separate.

Albert Einstein

Over the past several years, there has been growing recognition of the importance of strengthening collaboration between the animal and human health sectors. This has been driven largely by the rise of new and dangerous pathogens with the ability to cross the animal-human interface, including the SARS, Ebola,

ABBREVIATIONS

AFENET	African Field Epidemiology Network
FELTP	Field Epidemiology and Laboratory Training Program
IHR	International Health Regulations
SARS	Severe acute respiratory syndrome
WHO	World Health Organization

Marburg, and influenza viruses.¹ Furthermore, increasing evidence demonstrates the relationships between emerging infectious diseases, animal production practices, land and water use, climate change, population changes, and food consumption practices. For example, during drought or conflict, there will be a higher density of humans and animals competing for water to survive. If access to food is compromised, the harvesting of bush meat will increase, threatening wildlife and inviting the evolution of new disease threats.

Although the need for the animal and human health sectors to work together has recently gained attention, the idea is far from new. The concept and practice of animal and human health expertise being pooled to understand the treatment and prevention of diseases

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began thousands of years ago, when ancient healers were priests and cared for both animals and people.²

In France during the 18th century, Claude Bourgelat, (1712–1779) director of the Academy of Equitation in Lyon, became acquainted with controller general Henri Bertin and informed him of the need for a veterinary school to address livestock diseases, especially cattle plague (rinderpest) and equine health. Bertin obtained authorization for funding the effort from King Louis XV in 1761, and the first class began studies on January 1, 1762. Officials responsible for the school's founding recognized animal health as essential to society, with horses being the chief means for transportation and livestock serving as a primary food source for an expanding population. Because the veterinary profession was just beginning, Bourgelat had to draw upon physicians to launch the profession. This event attracted the attention of executive bodies that advised royalty throughout Europe and was followed by establishment of other schools in France and elsewhere.³

Rudolph Virchow, the founder of comparative medicine and cellular pathology, coined the term zoonoses and declared that “between animal and human medicine there are no dividing lines nor should there be—the object is different but the experience obtained constitutes the basics of all medicine.” Sir William Osler, the founder of modern human medicine and veterinary pathology, coined the term one medicine in the late 1800s.⁴

During the 19th century, pioneers in animal and human health discovered cellular pathology and microbiology, leading to enormous implications for disease prevention and control and increasing interest in the comparative aspects of veterinary and human medicine. In the 20th century, leaders in public health such as Calvin Schwabe, James Steele, Roger Mahr, and Ron Davis kept the one health concept alive by demonstrating the interconnectedness among global challenges such as hunger, poverty, climate change, human conflict, and emerging infectious diseases.

The earliest forms of healing for animals and people are still widely practiced in traditional pastoral societies, and some of the best examples of one health in practice can be found in African countries.⁵ In fact, Dr. Calvin Schwabe's revival of the term one medicine came about within an African context, while he was working with Dinka pastoralists, showing the added value of partnerships across disciplines, compared with more specialized disciplinary approaches. McCorkle⁶ has demonstrated that in developing countries, an intersectoral approach that facilitates joint delivery of basic health services for both livestock and humans would be more appropriate and feasible than imposing a dualistic Western-style structure on service delivery. For example, observations of higher vaccination coverage in cattle than in children among nomadic pastoralist populations in Chad have led to joint livestock and human vaccination campaigns through cooperation between veterinary services and childhood immunization programs.^{7,8}

After vaccination campaigns throughout the 19th and 20th centuries, the WHO certified in 1980 that smallpox, a disease that threatened humans throughout

the world, had been eradicated.⁹ Smallpox is 1 of only 2 infectious diseases to ever have been eradicated, the other being rinderpest, which in June 2010 was declared the first animal disease to be successfully eradicated.¹⁰ It is noteworthy that despite their different host targets, a similar disease control concept was used for rinderpest and smallpox, with an emphasis on disease surveillance to guide targeted vaccination programs. In addition, both disease eradication programs had support among donor countries, international organizations, national governments, and communities, with a consensus on strategies used to accomplish their shared goals.

Despite experiencing challenges in some human disease prevention and control programs, Nigeria conducts successful vaccination programs against animal diseases every year. In Nigeria, polio eradication campaigns and other childhood immunization programs gained credibility when linked with veterinary visits for livestock vaccination and other preventive health interventions. Communities that have boycotted polio and measles vaccination programs and experienced measles outbreaks have nonetheless vaccinated their cattle against major animal diseases.¹¹ The trust and confidence in animal healers might be transferable to doctors treating children if the animal and human medical sectors were perceived as working together toward improved health and well-being for the communities.

Throughout the world, the one health initiative needs practical examples in workforce development, training, and service delivery to institutionalize an integrated approach between veterinary and human medicine, including epidemiology, laboratory, and environmental disciplines. In the present report, we describe an example of such an initiative. Specifically, we discuss the implementation and lessons learned in the West African FELTP one health model, illustrating the multidisciplinary collaboration necessary to address the existing and emerging infectious disease threats to animal and human health, food security, and global health.

The FELTP One Health Model

The Field Epidemiology Training Program was designed by the CDC with a variety of partners, including the WHO, to help countries develop a public health workforce that could enhance their public health surveillance and response systems. The program was started in 1980 and was modeled after CDC's 61-year-old Epidemic Intelligence Service. Like the Epidemic Intelligence Service program, Field Epidemiology Training Programs were 2-year, in-service training programs in field epidemiology and public health practice. These programs were typically integrated within federal ministries of health, with trainees working on applied public health projects that address key health priorities of the country.¹²

In 2004, the Kenya Ministry of Health, CDC, and other partners implemented the first Field Epidemiology Training Program to which a laboratory component was added, forming the FELTP. This program was designed to train physicians and laboratory scientists jointly to develop a public health workforce that could simultaneously strengthen public health surveillance and response systems and public health laboratory networks.¹³

The primary goals of all FELTPs are to strengthen the capacity of national public health systems for disease surveillance and outbreak investigation and response. Additional goals are to enhance public health capacity by developing a cadre of health profession leaders with advanced skills in applied epidemiology so as to provide epidemiological services to the public health systems at the national and subnational levels. Until recently, FELTPs in Africa involved ministries of health, academic institutions, the CDC, and the WHO and offered training primarily to physicians and other human health professionals. Participation by veterinary institutions and enrollment of veterinarians was more of an exception than the rule. With the involvement of veterinarians, ministries of agriculture and veterinary schools began working with ministries of health and public health training institutions during all stages of planning, development, and implementation of new FELTPs. This allowed for a balanced curriculum and the inclusion of animal disease surveillance to enhance early disease detection and response systems.

In sub-Saharan Africa, countries that organize these competency-based training programs collaborate to share resources and best practices among FELTPs and similar programs through 2 nonprofit network organizations: the Training Programs in Epidemiology and Public Health Interventions Network and AFENET. Although the former represents all Field Epidemiology Training Programs, FELTPs, and similar programs throughout the world, AFENET is the first regional network ever developed. The AFENET provides an African institutional platform to ensure that the curriculum of the FELTPs and similar programs are adapted to those health-related subject matters most relevant and important to sub-Saharan African countries. The AFENET also provides direct service in terms of technical assistance, resource mobilization, and management support to member FELTPs. The AFENET and FELTPs in collaboration with other agencies provide countries with the additional human resources and technical support required to fully implement the IHRs, which were revised in 2005,¹⁴ by strengthening the early disease detection, reporting, and response capacities of the local animal and human health services.

FELTPs in West Africa—Currently, FELTPs exist in 3 West African countries (ie, Burkina Faso, Ghana, and Nigeria) and in 9 other African countries.⁷ The Ghana FELTP was established in 2007, with the University of Ghana School of Public Health and Ghana Health Service as the primary host institutions. As of 2011, 37 participants in 5 cohorts had been recruited into the program, which, given a population in Ghana of 24 million in 2010, represented 1.54 participants per million population. Each of the 37 participants received a master's degree in applied epidemiology and disease control upon fulfilling all the requirements of the program.

The Nigeria FELTP was established in 2008, with the Federal Ministry of Health and Federal Ministry of Agriculture and Rural Development, Ahmadu Bello University, and University of Ibadan as primary host institutions. By 2011, there were 65 participants in 3 cohorts in the program, which, given a popula-

tion in Nigeria of 158.3 million in 2010, represented 0.41 participants per million population. All 65 participants received master's degrees in public health, with 29 in a medical field epidemiology track, 21 in a veterinary epidemiology track, and 15 in a laboratory epidemiology track.

The Francophone West Africa FELTP (Burkina Faso, Mali, Niger, and Togo) was established in 2010, with the WHO Multidisease Center and University of Ouagadougou as primary host institutions. During 2011, there were 12 participants in a single cohort in the program, which, given a regional population of 54.1 million in 2010, represented 0.22 participants per million population. All 12 participants received master's degrees in public health, with 4 in a field epidemiology track, 4 in a veterinary epidemiology track, and 4 in a laboratory epidemiology track.

In May 2009, the US Agency for International Development supported AFENET in convening a workshop for West African FELTPs with an emphasis on establishing a standard curriculum and training program that would include inputs from animal and human health experts and institutes. The avian influenza outbreaks in West Africa created an opportunity, in that funding became available to strengthen coordination between the animal and human health sectors. During the workshop, the Accra Declaration was drafted to demonstrate consensus around the one health concept and a commitment for sustainable partnerships between animal and human health.¹⁵ This declaration represents an endorsement by the health and agricultural sectors in West Africa to increase working partnerships between animal and human health sectors so as to achieve effective zoonotic disease prevention and control.

The West African FELTPs demonstrate how animal and human health experts can train and work together to enhance disease surveillance and response, including zoonotic disease prevention and control. These 2-year competency-based in-service postgraduate programs are a mix of 25% to 35% classroom and 65% to 75% field-based training for cohorts of physicians, veterinarians, and laboratory scientists. During the field placements, the FELTP trainees conduct outbreak investigations and public health evaluations and implement public health programs under the supervision of senior ministry personnel at their field sites and resident advisors from the program. The resident advisors are experienced international field epidemiologists who provide technical advice for implementation of the FELTP by the host country's ministry of health, veterinary services directorate of the ministry of agriculture, and university faculty. Typically, FELTPs offer a 2-year course to equip future public health leaders with necessary skills and competencies in public health surveillance, outbreak investigation and response, epidemiological studies, public health laboratory management, economic and risk-based decision analysis, scientific communications, public health management, and leadership.

The programs' emphasis is on the acquisition of necessary expertise that will provide critical competencies required to support public health systems. The FELTP

not only ensures that trainees (residents) receive competency-based training to address issues of public health concern but also ensures that trainees learn the benefits of working as a multidisciplinary or one health team to coordinate public health surveillance, outbreak investigation and response, and other disease control efforts. Field Epidemiology and Laboratory Training Program residents work in multidisciplinary and sometimes multicountry teams for local and cross-border control of epidemics.

In addition to offering 2-year programs leading to the master's degree, the FELTPs also conduct a series of short courses for public health implementers or frontline workers at subnational levels. The short courses are focused on providing regional and district surveillance and disease control officers with necessary epidemiological skills to improve disease surveillance and outbreak investigation and response for important infectious diseases, especially zoonoses. The short courses usually also focus on strengthening the use of evidence-based decision making in public health. During each short course, participants receive a service-focused and competency-based project assignment that they perform under FELTP faculty and field-mentor supervision. They also disseminate their findings to relevant stakeholders for evidence-based decision making and action. Examples of short-term projects requiring collaboration between animal and human health sectors include epidemiological studies and investigations of rabies, Lassa fever, Rift Valley fever, influenza, brucellosis, cysticercosis, helminthiasis, and tuberculosis. These projects lead to recommendations for immedi-

ate control measures that can be implemented by the animal and human health authorities in the affected areas. Trainees are drawn from staffs of the ministries of health and agriculture who cannot enroll in a 2-year program. Graduates of the 2-year degree program and the short courses become mentors and leaders in various aspects and levels of the animal and human public health system.

Results

In general, the one health model of training and service adopted by the FELTPs in West Africa has led to strengthening of the public health workforce and systems capacity locally and internationally. Between 2007 and 2011, 43 individuals have completed 2-year FELTPs, including 7 physicians, 7 veterinarians, and 4 laboratory scientists in the Ghana FELTP; 6 physicians, 4 veterinarians, and 3 laboratory scientists in the Nigeria FELTP; and 4 physicians, 4 veterinarians, and 4 laboratory scientists in the Francophone West Africa FELTP. This has led to the development of in-country cadres of midlevel public health practitioners with core skills in integrated disease surveillance, outbreak investigation, and response for zoonotic and other communicable and noncommunicable diseases.

Residents from these 3 FELTPs led or supported 49 high-profile disease outbreak investigations and responses, including investigation of the first-ever reported outbreaks of monkey-associated herpes B viral encephalitis and pig rabies in Ghana during 2011 (Table 1), inves-

Table 1—Examples of public health event or disease outbreak investigations conducted by FELTPs in West Africa during 2011.

Start date	Disease or event	Location	Estimated No. of cases	Etiology	Impact or outcome of investigation
Jan 2011	Zoonotic herpes B viral encephalitis outbreak	4 districts in the monkey forest belt of Ghana (Brong-Ahafo and Ashanti regions)	16	Herpes B virus	Case definition developed and circulated to affected and adjoining districts. Acyclovir made available to affected districts. Awareness created for early detection.
Mar 2011	Yellow fever outbreak	Kundungu, Upper West Region, Ghana	4	Yellow fever virus	Vaccination program implemented in all affected communities and surrounding villages. District support provided by National Public Health Reference Laboratory.
Aug 2011	Outbreak of rabies in dogs	Adidome, Volta Region, Ghana	10	Rabies virus	Presentations given on rabies situation in Adidome and its management. Radio discussions were held to educate the public on what to do when bitten by a dog.
Sep 2011	Outbreak of rabies in multiple species, including pigs	Afalekpo, Volta Region, Ghana	3	Rabies virus	District Chief Executive organized stakeholder meetings. Findings presented during World Rabies Day Celebration in Accra. Radio discussions were held to educate the public.
Sep 2011	Outbreak of ulcers	Dormabin community, Krachi East District, Volta Region, Ghana.	11	<i>Mycobacterium ulcerans</i>	Active search for Buruli ulcer cases begun in the Volta region. Ulcer treatment started in the affected district.

tigation of a large lead poisoning outbreak in northern Nigeria, investigation of the H1N1 influenza virus pandemic in the West African subregion during 2010, and investigation of an avian influenza outbreak in Ghana and neighboring countries during 2008.

In addition, improved zoonotic disease prevention and management for animals and humans has been achieved. Field Epidemiology and Laboratory Training Program residents facilitated a cross-border rabies vaccination program involving Ghana and Burkina Faso following a rabies outbreak with a high human case fatality rate in 2009. Veterinary residents serving in various districts in Ghana, Burkina Faso, and Nigeria have applied their field epidemiology skills in early detection of rabies outbreaks and have organized prompt community education and postexposure prophylaxis programs, including vaccination of persons and animals suspected or confirmed to have been exposed to rabies, which has led to increased under-

standing of prevention measures and the avoidance of rabies deaths.

Integrated and multisectoral surveillance for early detection and control of zoonotic diseases and other infectious diseases of public health importance has been enhanced through the development of the FELTPs. Program residents have evaluated a total of 66 disease surveillance systems, including surveillance systems for zoonotic diseases such as anthrax, brucellosis, rabies, and trypanosomiasis and for other related diseases such as yellow fever (Table 2). The findings of these evaluations were shared as reports and seminars with ministries of health, ministries of agriculture, veterinary services, and other stakeholders at national and subnational levels, which led to improved case detection, reporting, and system response and better surveillance collaboration between the animal and human health sectors in Ghana and Nigeria. The 2009 class of FELTP residents was involved in active surveillance for

Table 2—Examples of surveillance activities (ie, evaluation of surveillance systems and analysis of surveillance data) conducted by FELTPs in West Africa during 2011.

Activity	Date completed	Key conclusion	Impact of activity
Evaluation of schistosomiasis surveillance system	Jan 2011	Surveillance report form did not collect data on intestinal schistosomiasis, although it occurs in some parts of the country. Data quality was poor, and there was no laboratory data at the regional or national level.	Intestinal schistosomiasis was added to the report form. Districts in the eastern region began to include laboratory data with the monthly surveillance reports.
Evaluation of yaws surveillance system	Jan 2011	Reporting of data to next level was not timely, and there was poor data quality.	Training on data collection and validation of data was conducted at the regional level.
Evaluation of leprosy surveillance system	Jan 2011	Data were manually processed at the district, regional, and national levels, giving the system poor stability.	Computer resources were obtained so that national level data could be stored and processed electronically.
Evaluation of Buruli ulcer surveillance system	Jan 2011	Data were representative of all 6 endemic regions, and there was 80% and 90% timeliness and completeness of forms, respectively.	Laboratory scientists in the western region were sensitized to obtain additional samples for PCR assay confirmation.
Evaluation of anthrax surveillance system	Jan 2011	There was a lack of collaboration between the Veterinary Services Department (VSD) and Ghana Health Service (GHS), along with poor data quality and lack of district level data analysis at the VSD.	Monthly reports on anthrax were shared by the VSD and GHS. Training for District Veterinary Officers on data management was conducted.
Evaluation of polio surveillance system	Jan 2011	The system was useful and met most of its objectives, but data were only partially analyzed at the district level.	District Health Officers were trained on software tools for analyzing data.
Evaluation of measles surveillance system	Jan 2011	Timeliness of feedback to the district was low. There was no collaboration between disease control officers and neighboring districts.	Districts were provided resources to train disease control officers on how to collaborate and work effectively with neighboring districts.
Evaluation of Guinea worm surveillance system	Jan 2011	The surveillance system was achieving most of its objectives, but had a low positive predictive value.	Periodic evaluations of the Ghana Guinea Worm Eradication Program were planned before the 2014 eradication target
Analysis of viral hepatitis data for Ghana, 2005–2010	Jul 2011	Contrary to findings of studies and surveillance data, health facilities data revealed that the Ashanti region had the highest number of viral hepatitis cases for the period.	The Disease Surveillance Department, the District Health Information Management System (DHIMS), and other sources of surveillance data have agreed to meet frequently to reconcile data.
Analysis of snake bite data for western region of Ghana, 2006–2010	Jul 2011	Of 7,275 individuals bitten by snakes, 12 (0.16%) died. The highest number of snake bite cases occurred in individuals 20 to 24 years old and the lowest in children < 1 year old.	The District Health Administration was advised to organize community education on snake bites. The Regional Health Information Office was also advised to double check all data from districts entered into the DHIMS.

H1N1 infection among persons returning from pilgrimage in Nigeria.

Integrated vaccination campaigns with improved coverage rates are another achievement of the FELTPs. For example, FELTP residents facilitated rabies and measles vaccination programs in response to outbreaks

in the Eastern and Volta regions of Ghana; a reactive yellow fever vaccination program in the upperwest region of Ghana; polio vaccination campaigns in Burkina Faso, Ghana, Niger, Nigeria, Mali, and Togo; and a synchronized meningitis vaccination campaign in Burkina Faso and Ghana. Three FELTP residents from Ghana

Table 3—Examples of epidemiological studies conducted by FELTPs in West Africa during 2011.

Study title	Date completed	Impact of study
Risk factors for severe malaria among children < 5 years of age in West Gonja District	Oct 2011	Children with a history of illness were more likely to develop severe malaria. Therefore, children with any illness are now given special attention, and health managers at the district level have strengthened the integrated management of childhood illnesses in health-care facilities.
Epidemiologic surveillance of hepatitis B genotype among patients reporting at Korle-Bu Teaching Hospital, Accra	Oct 2011	Hepatitis B genotype E was the predominate genotype, but genotypes A and E were responsible for most cases of hepatocellular carcinoma or cirrhosis with or without ascites. The Ministry of Health Ghana Health Service has included hepatitis B DNA detection and genotyping at the Central Laboratories in Korle-Bu Teaching Hospital in Accra.
Antimicrobial drug residues in poultry products in Ghana	Oct 2011	There was extensive use of antimicrobial drugs in poultry farming, sometimes in an extralabel manner. Antimicrobial residues were found in some products but less than the limits set by Codex Alimentarius. Educational and awareness programs for farmers on appropriate use of veterinary drugs with emphasis on emergence of possible drug resistance have been conducted.
Sensitivity of sputum smear microscopy, compared with culture, in diagnosing tuberculosis in HIV/AIDS and non-HIV/AIDS patients.	Oct 2011	Sensitivity of sputum smear microscopy was low in diagnosing tuberculosis in HIV/AIDS patients, leading to a high false-negative rate. Laboratory staff were provided training on sputum collection and smear preparation to improve outcome of microscopy results.
Prevalence of human taeniasis and human and porcine cysticercosis in Jirapa District, Upper West Region	Nov 2011	Pig and human populations in the district have been exposed to <i>Taenia solium</i> infection. Public health education has been conducted in all communities in the district, and deworming of people and pigs has been done.
Domestic ducks as potential reservoirs of avian influenza viruses in the highly pathogenic avian influenza H5N1 outbreak area, Sunyani Municipality	Nov 2011	Biosecurity adherence was poor in 89% of the sites; hence, there was a strong risk of reintroduction and spread of the highly pathogenic avian influenza virus. The regional Veterinary Services has therefore intensified biosecurity, poultry management, and sanitation awareness among farmers and the public.
Epidemiology of pneumococcal carriage in children < 5 years in Accra, Ghana	Nov 2011	Prevalence of pneumococcal carriage was 48.9%. Daycare attendance and runny nose were significantly associated with pneumococcal carriage. Health Promotion Unit of Ghana Health Service has started public education on the prudent use of antimicrobials in various media including television and radio.
Isolation and characterization of human enteroviruses in healthy children in the eastern region of Ghana; verification of polio eradication in Ghana	Nov 2011	Mothers interviewed had adequate knowledge of polio and acknowledged the importance of polio vaccination. District Health Management in collaboration with Environmental Health officers have conducted education on personal hygiene in densely populated areas.
Human and bovine brucellosis in North Tongu District, Volta Region, Ghana	Nov 2011	The number of human cases was the highest ever recorded in the history of Ghana. History of abortion, retained placenta, and herd size were significant risk factors for bovine brucellosis in the district. The Veterinary Directorate Service has instituted control and preventive measures in the affected district.
Predictors of preeclampsia: a hospital-based study in Accra, Ghana	Nov 2011	Variables could be used to predict preeclampsia before the 20th week of pregnancy and could be used to select pregnant women for focused surveillance for preeclampsia. The Obstetrics and Gynaecological Department of the Police Hospital now records height and weight of clients and the blood group of husbands, and the doctors and midwives fill in forms properly.
Applying spatial interpolation in a geographic information system as an alternative method for estimating and modelling HIV/AIDS morbidity rates in the greater Accra region of Ghana	Nov 2011	District prevalence rates could be predicted by interpolation. There was a slow steady decline in HIV prevalence in most regions of Ghana over the study period. Findings showed that there was a syphilis outbreak in the western part of Ghana. As a result, the National AIDS/STI Program has created awareness about the rapid spread of syphilis.
Porcine and human trypanosomiasis in the New Juaben Community	Dec 2011	Prevalence of trypanosomiasis was 56% in pigs, but infection was not detected in humans. Intervention activities supported by Pan African Tsetse and Trypanosomiasis Eradication Campaign such as traps to control flies have been started in the municipality.

and Nigeria have used their skills to lead international polio immunization campaigns in parts of Kenya, Nigeria, and Pakistan under the auspices of the CDC-led Stop Transmission of Polio Initiative. Francophone West Africa FELTP residents participated in the introduction of a new meningitis vaccine campaign in Burkina Faso, and Nigeria FELTP residents are involved in developing and implementing the Vaccine Adverse Event Reporting System.

The FELTPs have also increased the capacity for epidemiological studies that address priority public health problems, provide an evidentiary basis for public health action or strategy development, and influence public health policy (Table 3). As of December 2011, FELTP residents in the 3 West African programs have designed and conducted > 50 protocol-based epidemiological studies under supervision. The epidemiological skills acquired cut across the veterinary, medical, and biomedical fields. The findings of these studies have led to focused public health action, strategy review, and policy revision or development in various local settings. For instance, with less than half of the dog-bite victims receiving full postexposure prophylaxis owing to knowledge and health access gaps, specific strategies have been implemented to improve awareness and access to antirabies vaccines in Nigeria following a study by a resident. Also, recommendations from multiple rabies outbreak epidemiological investigations and surveillance system evaluations by FELTP residents led to the inclusion of rabies in the integrated disease surveillance and response routine reporting form and the enhanced sharing of dog-bite reports between human health and veterinary services in Ghana.

Another result of the FELTPs has been improved diagnostic and laboratory management skills, resulting in better field specimen and sample handling during outbreak investigations. Not only are FELTP residents able to apply their training in biomedical and clinical specimen collection during outbreaks or field research, they also have been able to train local staff in specimen collection and handling, thereby improving capacity at the subnational level. Laboratory-track residents have also conducted small-grant projects in which district-level laboratory personnel were trained in integrated disease surveillance with emphasis on field specimen collection, handling, transportation, and analysis and transmission of results to the surveillance or disease control unit of the Ministry of Health or Ministry of Agriculture Veterinary Service in Ghana and Nigeria.

Discussion

African countries often lack the necessary expertise, technology, infrastructure, and other logistic resources for effective public health surveillance systems that identify, investigate, and respond to outbreaks. In addition, there is an unmet need for field epidemiologists and public health laboratory professionals in Africa. The FELTP one health model helps fill these gaps through the joint training of physicians, veterinarians, and laboratory scientists in field epidemiology and public health laboratory management. This is complemented by the training of frontline public health workers such as surveillance officers, veterinary officers, dis-

ease control officers, environmental health officers, and laboratory technicians at the subnational level through the FELTP short courses. Although the critical mass of field epidemiologists required for optimal operation of zoonotic and multidisease surveillance systems in these West Africa countries has not yet been realized, the FELTP network has produced a foundational cadre of midlevel public health practitioners with core skills in integrated disease surveillance, outbreak investigation, and response for zoonotic and other communicable and noncommunicable diseases.

The revised IHRs are legally binding regulations that aim to encourage countries to investigate and report disease outbreaks and events that are considered to be public health events of international concern. These include outbreaks of highly pathogenic avian influenza, SARS, tuberculosis, brucellosis, and several other diseases, many of which are zoonotic. The IHRs exist as the primary legislative instrument to prevent the spread of infectious diseases and minimize disruptions to international traffic and trade. Key milestones for countries as they move toward IHR compliance include an assessment of their surveillance and response capacities and the development and implementation of plans of action to ensure that core public health capacities are functioning. The efforts of FELTP residents in the investigation, early detection, and reporting of the avian influenza outbreak during 2008; the response to multiple rabies outbreaks in various districts in Ghana during 2010 and 2011; the surveillance for the H1N1 pandemic and eventual detection of infected individuals in Ghana and Nigeria during 2009 and 2010; and the periodic evaluation of surveillance systems in these West African states provide concrete evidence to support the use of FELTPs as a template for IHR implementation in the African region.

Summary of lessons learned—Experience with the West African FELTPs illustrated that joint training of veterinarians, physicians, clinical health professionals, epidemiologists, environmental health officers, and laboratory or biomedical scientists is an effective way to address zoonotic diseases and other animal diseases impacting human well-being. Coordination between the animal and human health sectors was challenging but led to increased efficiency and success in addressing various aspects of disease prevention and control as well as creating sustainable linkages.

Creating opportunities for ministries of health and agriculture to work together during all phases of planning and implementation provided an environment for FELTP residents to offer service on current problems in their field placement sites. This facilitated institutionalization of the FELTP as an essential part of the national health system.

Zoonotic disease surveillance and response units could be developed through partnerships between the animal and human health sectors and, because most pandemic diseases are zoonotic, could provide career pathways for FELTP graduates that will further strengthen national and international efforts at mitigating emerging pandemic threats. Working with multiple universities and other animal and human health training institutions to run FELTPs requires considerable ef-

fort, including information sharing and adequate logistic coordination. However, this offers a wide range of benefits in expanding the scope of expertise for training, research, and service delivery. Also, the awarding of master's degrees to FELTP graduates is a great incentive for potential trainees and their sponsors, especially national governments, because it provides a template for career progression and, hence, program sustainability.

Field Epidemiology and Laboratory Training Programs can provide countries the human resources and technical support required to fully implement the revised IHRs through strengthening capacity for early disease detection, reporting, and response in the animal and human health sectors. In addition, FELTP training offers a unique opportunity to advance the one health—one medicine concept in the prevention and control of zoonoses by creating and strengthening partnerships between animal and human health experts. Strengthened intersectoral partnerships, improved coordination, and enhanced communication result in more complete answers and solutions to situations requiring animal and human health expertise. Efforts are being made through AFENET to extend the lessons learned from the West African FELTPs to other African subregions.

Action needed—In alignment with the increasing attention given to one health, there needs to be increasing and sustainable support for successful models such as the FELTPs in Africa and other regions. Donors who are investing in public health and food security in developing countries should consider building on existing programs such as the FELTPs as a platform for expanding human resource capacity while retaining the institutional memory required to carry forward into future generations. Countries that commit to hosting FELTPs must have mechanisms in place to ensure that FELTP graduates will have career opportunities that will allow them to address current and future public health problems while also training a cadre of future leaders. Furthermore, all regions should have a regional platform such as AFENET to ensure there is leadership

and coordination under a single unified strategic plan and should have an exit strategy for donors with mechanisms to ensure national ownership and commitment.

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