PAYING FOR OUTCOMES

Protecting Human and Animal Health in Sub-Saharan Africa

Financial Innovations Lab™ Report

Milken Institute

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Financial Innovations Lab™ Report

Financial Innovations Labs™ bring together researchers, policymakers, and business, financial, and professional practitioners to create market-based solutions to business and public policy challenges. Using real and simulated case studies, participants consider and design alternative capital structures and then apply appropriate financial technologies to them.

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The greatest appeal of pull mechanisms is that donors are not just funding good intentions: They know that their contributions are achieving their desired goals.

Introduction to Pull Mechanisms

A wave of innovation has swept through the world of philanthropy in recent years; foundations and NGOs alike have been implementing new models, approaches, and technologies. But *pull mechanisms*—financial incentives that trigger donor payments when specific outcomes are achieved—remain surprisingly underutilized. Unlike grants (or *push mechanisms*), they are paid out after results are realized, allowing donors to reward the entities that actually produce the desired outcome.

Both grants and incentives can be effective if deployed in the right circumstances. But donors should consider expanding their use of pull mechanisms where possible.

Pull mechanisms are an attractive option for several reasons. They do not require donors to pick winning strategies in advance, decreasing the risk that subjectivity will influence award selection. Moreover, donors only pay when results are achieved. If no solution or intervention proves to be effective, donors keep their money. And the greatest appeal of pull mechanisms is that donors are not just funding good intentions: They know they are eliciting the desired outcomes for which they are paying.

Table 1 outlines the differences between pull and push mechanisms, situations in which they are best utilized, and examples of specific tools.

TABLE 1 — *Overview of pull and push mechanisms*

Tool	Description	Situations in which it works best	Examples
Pull mechanism	▪ Donors provide funding only when pre-defined outcomes are achieved ▪ Pay for results ▪ Ex-post payment	▪ When there are information asymmetries (e.g., between donors and researchers, or between researchers and consumers) ▪ When it is difficult to identify the best path to achieve a desired outcome	▪ Output-based aid; results-based financing ▪ Prize ▪ Price guarantee ▪ Purchase guarantee
Push mechanism	▪ Donors provide funding to increase the supply of a socially beneficial product or service ▪ Pay before results ▪ Ex-ante payment	▪ To fund basic research that will inform specific applications ▪ When milestones are clear and specific	▪ Grant

Sources: Kimberly Ann Elliott, "Pulling Agricultural Innovation and the Market Together," Center for Global Development (June 2010); Milken Institute.

In sub-Saharan Africa, where hunger is endemic, crop diseases represent a particularly urgent threat. Aflatoxin can poison crops such as groundnuts and maize, causing severe health consequences such as liver disease and reduced immune function when it is ingested.

Pull mechanisms have been around for centuries as a means of financial incentive—in fact, a prize to discover a method of measuring longitude at sea was offered as early as the 1500s.[1] But they have garnered more attention only recently with the pilot of a pull mechanism for health: the Advance Market Commitment (AMC) for pneumococcal vaccines.

In 2009, the GAVI Alliance partners (the World Bank, the World Health Organization, and UNICEF), five national governments (Italy, the United Kingdom, Canada, Russia, and Norway), and the Bill & Melinda Gates Foundation launched the AMC. Their goal was to incentivize private-sector investment in late-stage R&D to adapt existing pneumococcal vaccines for use in developing countries and manufacturing the vaccines once they are available. The donors guaranteed the price of the vaccines, so that companies could invest in R&D and expand manufacturing capacity with greater certainty of recovering their investment. In return, the companies must commit to selling the vaccine at an agreed-upon affordable price after donors' funds are depleted.[2]

With the early success of the AMC for pneumococcal vaccines serving as inspiration, the Milken Institute, in conjunction with the Bill & Melinda Gates Foundation, held two half-day Financial Innovations Labs to explore the use of pull mechanisms in the context of agriculture. The Labs, which took place in October 2010 and were held in London, convened authorities from development finance institutions, philanthropy, academia, government, and NGOs, as well as scientists, vaccine manufacturers, and peanut traders. (See Appendixes 1 and 2 for full lists of Lab participants.)

The Labs focused on sub-Saharan Africa, where agriculture employs two-thirds of the population and contributes one-third of GDP.[3] The region is marked by high poverty rates and low agricultural productivity: Almost three-quarters of the population lives on less than $2 a day,[4] and cereal yields are about one-fifth of those in the U.S.[5] The Labs concentrated on solving two specific agricultural issues that have a significant impact on food security and poverty, both of which might lend themselves to use of pull mechanisms:

- **Development of an improved vaccine for a livestock disease.** The current vaccines for contagious bovine pleuropneumonia (CBPP), a respiratory disease affecting cattle, are inadequate. They confer less than full immunity, can cause side effects in vaccinated animals, and require frequent boosters.
- **Commercialization of an aflatoxin biocontrol product.** Aflatoxin, a toxic chemical produced naturally by fungi, poses a real health risk. It contaminates maize, groundnuts, and other crops, causing trade losses in Africa of almost a half-billion dollars per year. An effective biocontrol product called aflasafe™ has been developed in Nigeria, but early indicators suggest that getting smallholder farmers, who stand to benefit most from the product, to purchase it will be a challenge.

Controlling CBPP and aflatoxin has the potential to substantially increase agricultural and livestock-sector productivity and raise economic growth in sub-Saharan Africa.[6]

CBPP is often described as the most significant cattle disease in Africa. More than 24 million people in at least 17 sub-Saharan African countries are estimated to be at risk from its effects.

Aflatoxin is a pervasive problem across the African continent, imposing large, detrimental impacts on health and trade. And the problem is not just limited to Africa. The United Nations Food and Agriculture Organization (FAO) estimates that up to 25 percent of crops around the world are affected by aflatoxin-causing fungi and similar toxic substances,[7] while the U.S. Centers for Disease Control and Prevention (CDC) approximates that 4.5 billion people are chronically exposed to dangerous levels of aflatoxin through their diet.[8]

The asset and income shocks from deterioration in animal health and crop quality caused by CBPP and aflatoxin impact some of the poorest individuals in sub-Saharan Africa in the short term. In the longer term, they can also limit investments in health, nutrition, and education across generations.[9] Smoothing these shocks would enable farmers and pastoralists to generate higher, less volatile incomes; maintain valuable assets; and heighten their productivity, decreasing poverty and advancing their countries' economic growth.

Case I: Eliminating Africa's Most Pressing Cattle Disease

THE SCOPE OF THE PROBLEM

Caused by the bacteria *Mycoplasma mycoides* subspecies *mycoides*, contagious bovine pleuropneumonia (CBPP) is a contagious respiratory disease, spread mainly through the inhalation of droplets from infected coughing cattle. Although a number of countries around the world have successfully eradicated the disease (see table 2), it remains a persistent threat to livestock owners in at least 17 African countries (see figure 1).[10] Even countries without recent CBPP cases are still at risk, because CBPP is a transboundary disease that spreads across borders through animal movement.

CBPP was first reported in South Africa in the 1850s. Since then it has spread widely, devastating livestock herds throughout the continent. Its impact differs depending on whether herds have been previously exposed to the disease. In epidemic (or epizootic) areas, where the disease is new, the morbidity and mortality rates can be dramatic: Up to 50 percent of cattle can die and almost the entire herds may suffer from the disease. Where CBPP has become endemic (or enzootic), many fewer cattle are affected (perhaps as few as 8 percent).

Even if CBPP does not prove deadly, it weakens animals, hampering their ability to provide draft power on farms. It can also contribute to scarcity of cattle products (beef and milk) and decreased fertility. The disease can even impact trade, although CBPP is unlikely to be transmitted through cattle products.[11]

TABLE 2 ***Selected countries that have eradicated CBPP***

Country	Year of Eradication
Sub-Saharan Africa	
Zimbabwe	1904
South Africa	1924
Botswana	1939, 1997
Other countires	
Canada	1876
USA	1892
Australia	1967
China	1996
India	2006

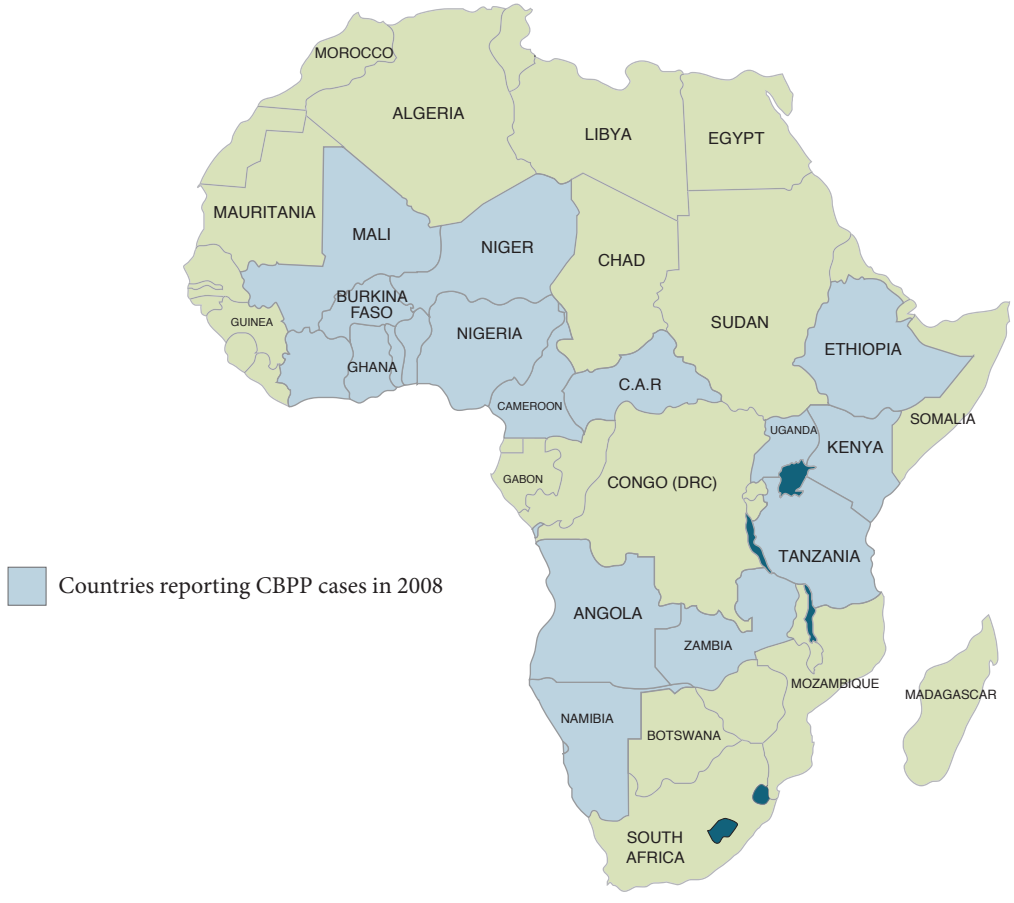
Source: William Amanfu, formerly of the U.N.'s Food and Agriculture Organization.

In general, CBPP in infected animals takes two forms:

- **Acute, clinical form.** In the acute form of CBPP, cattle exhibit signs of the disease, including coughing, labored breathing, and fever. The disease can last between six and ten weeks. Exacerbating the spread of the disease, CBPP has a long incubation period before clinical signs appear. Estimates vary on the length of the incubation period, but it may last anywhere from four weeks to more than three months. During this period, infected cattle are contagious, but it is not yet evident that they have the disease, and diagnostic tests cannot reliably detect it during this phase.[12]
- **Chronic form.** Animals that have recovered from the disease can become chronic carriers of CBPP. Thomson (2005) likened both chronic carriers and cattle in the incubation stage to Trojan horses. Although they do not exhibit any clinical signs of the disease, chronic carriers can continue to infect other animals for up to two years. Diagnostics currently cannot accurately detect the chronic form of CBPP, making the disease especially insidious and difficult to eradicate.[13]

FIGURE 1

African countries where CBPP was reported in 2008



Source: African Union-Interafrican Bureau for Animal Resources, "Pan African Animal Health Yearbook: 2008" (2009).

Prevalence and Impact

Now that rinderpest has been eradicated (see sidebar on p. 10), CBPP is often characterized as the most significant cattle disease in Africa. Thomson (2005) estimates that about 24.4 million people in sub-Saharan Africa who depend on livestock for their livelihood are at risk from the effects of the disease. Livestock are an important asset for many poor households, and the loss of an animal can have a long-term negative impact on wealth. Moreover, CBPP is a transboundary disease—and in animal health, transboundary diseases require special attention, because they can spread across borders and wreak serious socioeconomic harm.[14]

CBPP has a long incubation period before clinical signs appear. During this period, infected cattle are contagious, but it is not yet evident that they have the disease.

However, other evidence casts doubt on claims of CBPP's importance. Tambi, Maina, and Ndi (2006) found that direct production losses due to CBPP in sub-Saharan Africa total about 30 million euros ($36 million) per year.[15] While significant, this is small compared to the impact of another cattle disease, East Coast Fever, which has been estimated as having an impact of $200 million annually in Africa.[16] In 1998, Masiga, Rossiter, and Bessin stated that CBPP's economic impact in Africa is over $2 billion annually,[17] but the accuracy of this figure has been questioned.[18] A more recent analysis estimates losses in 2008 of $80 million, and the author (Fadiga) states that this figure is likely low as it relies on country reports of disease status, which is often underreported.[19]

It is hard to get a read on the exact scope of CBPP, but as mentioned above, that may be due at least in part to a lack of full and accurate reporting at the national level to the World Organisation for Animal Health (OIE), the African Union, or the U.N.'s Food and Agriculture Organization (FAO). "Reports of the disease have been very poor, but we know for a fact that the disease is causing major, major economic problems in many of these countries," stated Lab participant William Amanfu, formerly of the FAO.

Interventions

Several options exist to reduce the prevalence of CBPP in sub-Saharan Africa:

- **Movement control.** CBPP spreads with animal movement. Preventing animals from moving over wide distances by (for example) constructing fences along borders can help contain the disease. Australia used this technique, along with vaccination, to eradicate CBPP. However, in most of sub-Saharan Africa, this is generally considered too difficult to carry out logistically. Additional concerns include the environmental impact of erecting fences to restrict movement.

- **Stamping out or culling.** Slaughter of sick and potentially infected cattle is an effective method of controlling CBPP. The United States used this technique to eradicate the disease. This option is considered too expensive for use in sub-Saharan Africa, however, as governments need to compensate cattle owners whose herds are slaughtered. Animal welfare considerations and loss of valuable genetic material are also concerns.

- **Antibiotic treatment.** Antibiotics are widely used by farmers to treat CBPP, but they are not recommended and are actually illegal in some countries, as they can delay diagnosis, create chronic carriers, and encourage resistant strains. Some experts feel, however, that these criticisms are exaggerated.[20]

- **Vaccine.** The primary vaccine for CBPP, T1/44, has been in use since the 1950s. Another form of that vaccine, the T1sr, was created for the bivalent vaccine against rinderpest and CBPP. While somewhat effective at stemming the spread of disease, the current vaccines do not provide full immunity (their efficacy ranges between 50 and 80 percent). Furthermore, they confer protection for a short period of time; T1/44 provides about one year of immunity, while T1sr provides just six months. T1/44 also occasionally causes adverse reactions ("Willems reaction") in vaccinated animals. The vaccine has even been known to cause the disease in some instances.[21] Crucially, the quality of vaccines varies widely, both at manufacturers where it is produced, and in the field where it is applied.

Given the dearth of other effective options, vaccines have often been the tool of choice to control CBPP in sub-Saharan Africa. In the 1960s and 1970s, an international effort, code-named Joint Project 16 (JP16), erased the disease from most parts of Africa. But economic decline, a lack of funding for public veterinary services, and civil conflict opened the door for the disease to resurface again in the late 1980s.[22] From 1986 to 1999, the Pan-African Rinderpest Campaign (PARC) vaccinated animals against rinderpest, and in its later years, also vaccinated cattle for CBPP. Despite these efforts, the disease remains present in a number of countries.

THE FINANCIAL INNOVATIONS LAB

Given the significance of CBPP and the lack of fail-safe options to control it, the Financial Innovations Lab set out to identify solutions. Vaccines are the most viable method of CBPP control in sub-Saharan Africa, yet the existing formulations are inadequate. Is there a way to incentivize R&D and manufacturing of a more effective, second-generation vaccine for CBPP, potentially financed with pull mechanisms?

Barriers to CBPP Eradication

Lab participants began by identifying current barriers to CBPP eradication, from control strategies through vaccine administration. The challenges in each stage of the CBPP control value chain are illustrated in figure 2 (see p. 9) and described below:

- **CBPP control strategy.** Mark Rweyemamu, executive director of the Southern African Centre for Infectious Disease Surveillance, pointed out that CBPP control strategies should take into account the conditions of the affected region. Specifically, the approach should reflect whether the disease is epidemic or endemic.

While control methods for epidemic situations are relatively well developed, strategies for endemic areas are not. Very little or no data exist on the suitability of current control methods for an endemic situation, which an increasing number of African countries are becoming. Furthermore, the merits of antibiotics as a control measure have not been adequately explored. Lack of a well-developed strategy contributes to the inability to eradicate the disease.

- **Disease monitoring.** A lack of data on disease incidence and vaccinations prevents coordinated, informed action. Better data on the economic impact of the disease would motivate governments to act and donors to fund eradication efforts. CBPP diagnosis also presents a challenge, particularly when the disease is in the incubation or chronic stage. As Declan McKeever, professor at The Royal Veterinary College in London, put it, "There's a lot of room for improvement in diagnostics in CBPP."

- **Vaccine technology.** Roger Ayling, a research scientist at the Veterinary Laboratories Agency, stated, "[The T1/44 vaccine] is already 60 years old. While it has reduced disease when it was used with large coverage earlier on, it didn't actually eliminate the disease; that's why we still have a problem." Ayling also explained that because the vaccine can cause side effects in cattle, some farmers do not trust it and refuse to get their animals inoculated. Moreover, current vaccines require a cold chain, which is often difficult to maintain on the field (that is, the temperature of vaccines must be carefully controlled during transport, storage, and administration).

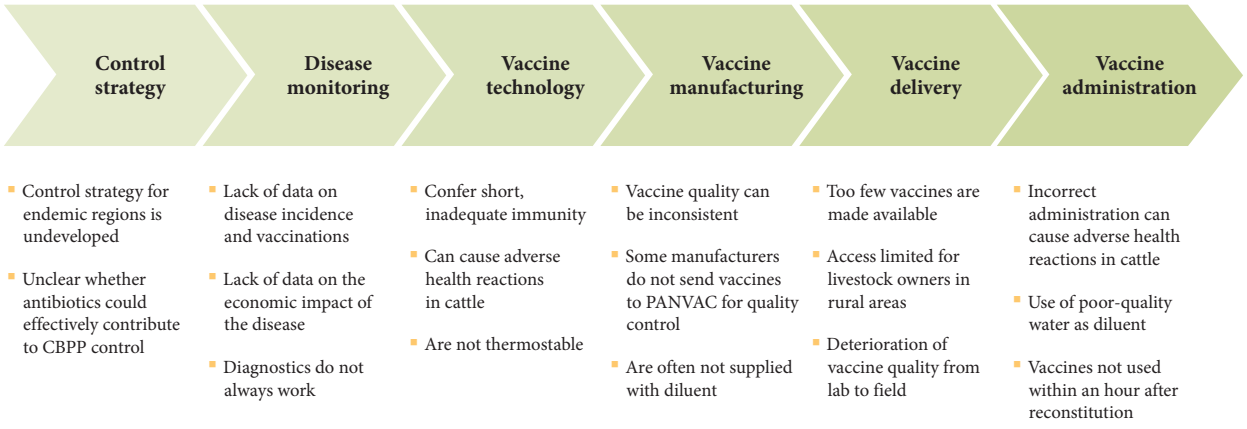
Karim Tounkara, director of the Pan African Veterinary Vaccine Center of the African Union (PANVAC), discusses his group's efforts to maintain the quality of CBPP vaccines.

- **Vaccine manufacturing.** CBPP vaccines produced in Africa are not always of consistent quality. Lab participants mentioned that some manufacturers' vaccines induce local reactions in animals while others' do not. The Pan African Veterinary Vaccine Center of the African Union (PANVAC) is the organization charged with monitoring quality of CBPP vaccines produced in national laboratories. Yet some manufacturers do not send their vaccines to PANVAC for quality control testing, and currently, it is not clear what percentage of vaccines is being tested, said Baptiste Dungu, senior director of research and development of GALVmed. Furthermore, Dungu noted that most African manufacturers do not supply vaccines with an appropriate diluent, which should be a buffered solution.

- **Vaccine delivery.** Public veterinary services in most sub-Saharan African countries are inadequately funded and often lack sufficient human resources, with the result that too few vaccines are made available or livestock owners in more remote areas cannot gain access to them. The private sector's involvement in CBPP has mostly been limited to selling antibiotics, as vaccines are less profitable. Issues also occur in maintaining the quality of the vaccine from the lab to the field.

- **Vaccine administration.** Animal health workers who administer vaccinations can exacerbate cattle's health problems. Vaccines need to be injected into subcutaneous tissue, and if they are given incorrectly, cattle have an increased risk of post-vaccinal infections. And as stated above, many vaccine manufacturers do not supply vaccines with a diluent, so animal health workers end up using water, often of questionable quality. Another issue is that freeze-dried vaccines are sometimes not used within an hour after they are reconstituted, which lessens the vaccine's efficacy.

FIGURE 2 *Barriers along the CBPP value chain*



Source: Milken Institute.

Lessons from Rinderpest?

In October 2010, the FAO stated that it was ending field operations of the Global Rinderpest Eradication Campaign (GREP), confident that it had successfully met its goal of eradicating the cattle disease. A formal declaration by the FAO and World Organisation for Animal Health (OIE) is expected in mid-2011. Eradication of an animal disease is unprecedented; rinderpest is the first ever to be wiped out, and after the eradication of smallpox 30 years ago, it will mark only the second time in history that humans have eliminated a disease.[23]

The key to conquering rinderpest was the tissue culture rinderpest vaccine (TCRV), for which its developer, Dr. Walter Plowright, won the World Food Prize in 1999. Previous vaccines had negative side effects, and in some cases caused death. They also were expensive and time-consuming to test and produce. In contrast, Plowright's vaccine, developed in 1957, conferred full, lifelong immunity; caused no side-effects; and could be produced inexpensively.[24] In addition to GREP, the Pan-African Rinderpest Campaign (PARC) used vaccination to decrease the incidence of the disease.

Lessons can surely be learned from the successful eradication of rinderpest and applied to future work on CBPP. Enumerating those lessons and applying them will be a critical stage in the fight against CBPP, which is now characterized by many as Africa's most significant remaining cattle disease.

Potential Solutions Along the Value Chain

Although the Lab originally began with a focus on the development of an improved CBPP vaccine, it soon became clear that a number of actions must be taken along the value chain to reduce the prevalence of the disease. While developing a better vaccine remains a goal, other solutions could help control the disease in the short term. Ideas proposed by Lab participants are outlined below, grouped by where they fall along the value chain. Developing solutions in each of these stages is essential. As one participant stated, "Unless it's part of an entire strategy, it's a drop in the ocean."

CBPP control strategy

- **Implement a harmonized strategy for control.** Lami Lombin, research fellow at the Agricultural Research Council of Nigeria, referred to the partial success of earlier coordinated efforts like JP16, and called for joint action in tackling the disease. Because it is a transboundary disease, cooperation among neighboring countries is critical.

- **Consider expanding use of antibiotics.** The use of antimicrobial drugs (antibiotics) on cattle with CBPP needs further structured evaluation. Because existing vaccines are sub-optimal, antibiotics may be used as an alternative strategy or in combination with vaccines to control the disease. Ayling said that controlled experiments could be conducted to show cattle do not develop resistance to the antibiotics and that antibiotics do not affect the human food chain or cause other problems. Such experiments would require

investment, but would be relatively quick compared to other options, he said. Not all scientists are in agreement with regard to using antibiotics, however. Anja Persson, senior scientist with the Royal Institute of Technology, cited concerns, including development of antibiotic resistance to other bacteria.

Disease monitoring

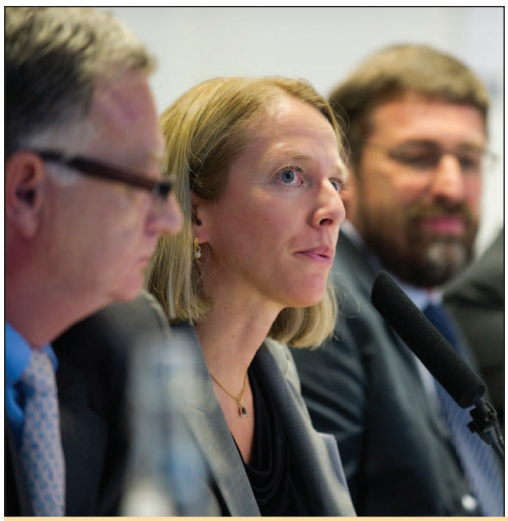
- **Increase data on the disease and its economic impact.** A lack of transparency on where and to what extent CBPP is occurring, as well as what control measures are being undertaken, prevents informed, effective action. Similarly, data on CBPP's economic impact and the economic benefit of vaccination are critical to rallying the political will and donor funds that are necessary to eradicate the disease. Francis Frey, senior programme officer in innovative finance at the Agence Française de Développement, stressed that developing the economic argument for CBPP should be a priority. "As long as we don't have that, we have little chance of convincing our government to put money into it," he said.

- **Improve diagnostics.** Better methods of diagnosing the disease would allow for early detection and action. Included with this could be the creation of a lab test to distinguish vaccinated from non-vaccinated cattle.

- **Use cell phones to improve surveillance.** Persson suggested that farmers could pair improved diagnostic tools with cell phones to alert veterinary services of outbreaks, increasing reporting. These devices should require little education or resources, and given current technology, she expects such surveillance systems could be used within five years.

Vaccine technology

- **Develop a second-generation vaccine.** Given that eradication has so far proven elusive with the current vaccine, many argue that a new vaccine represents the best path forward. However, efforts to develop a new vaccine have been ongoing for a number of years and would likely take at least a decade longer, according to scientists present at the Lab. At this point, knowledge of the disease remains incomplete, said McKeever of The Royal Veterinary College in London; its pathogenesis and molecular structure are not yet understood. Vaccine development is also an expensive process, requiring laboratory work with cattle, which is particularly costly. In communication subsequent to the Lab, Persson estimated that a research consortium focused on vaccine development—which could include the pharmaceutical industry, veterinary institutes, clinicians, and a scientific advisory board—would likely cost in the range of $20 million per year.



Anja Persson, senior scientist at the Royal Institute of Technology, argued that a new CBPP vaccine is needed.

- **Improve the existing vaccine.** Nick Nwankpa, head of CBPP research at the National Veterinary Research Institute in Nigeria, warned against relying solely on development of a new vaccine to solve the problem. "We need something to be done

in the field now. If we wait for research to be done to improve the vaccine, the situation is really going to get out of hand," he said. Improvements can be made to the current vaccine to increase its effectiveness. Amanfu, formerly of FAO, identified a few ways to improve the existing technology:

- Increase the vaccine's thermostability, precluding the need for cold chain facilities in the field.
- Buffer the growth medium to maintain a neutral pH, which would help to ensure that a minimum concentration of the vaccine remains viable.
- Add an indicator to show whether the formula has become acidic, compromising the vaccine's efficacy.

Anja Persson voiced concern over investing large amounts to improve current vaccines, as their poor efficacy limits their ability to eradicate the disease. In a follow-up communication, she said a multi-country eradication campaign using current vaccines would require farmers to agree to vaccinate all their cattle despite side effects and commit to biannual revaccinations. All herds in remote areas would have to be reached, and vaccines would have to be handled optimally. She characterized this effort as challenging and perhaps impossible. She feels that further discussion is needed to determine the degree to which investments in the current vaccine are worthwhile.

Vaccine manufacturing

- **Improve vaccine quality.** Karim Tounkara, director of PANVAC, said that his organization is working with the national vaccine labs to implement quality assurance measures throughout the production process. Frans van Gool, director of marketing and technical services at Merial International, suggested that PANVAC also impose standards on vaccine ingredients so vaccines are of uniform quality across the continent. Another Lab participant suggested consolidating vaccine production at the regional level to take advantage of economies of scale. This would mean one or two labs producing the vaccine, working in close collaboration with PANVAC to sharpen the standard operating procedures.

- **Supply vaccines with a buffer.** To avoid use of poor-quality water as a diluent, vaccine manufacturers should supply vaccines with a buffer. PANVAC should also test the accompanying buffer when examining CBPP vaccines.

Vaccine delivery

- **Involve both the public and private sectors in vaccine delivery.** Lab participants called for a mixed model of vaccine delivery, involving both the public and private sectors in CBPP control. Owen Barder, visiting fellow with the Center for Global Development, suggested that lessons might be learned from other examples of social marketing, such as the distribution of bed nets and contraception in developing countries. To help move forward, Dungu of GALVmed suggested mapping the extent to which the private sector is currently involved in distribution, as it is unclear. The case for public and private involvement is outlined below.

  - ***Need for government involvement.*** Vaccination is a public good—vaccinating some cattle for CBPP decreases the disease risk for other cattle. This "herd immunity" effect creates a social benefit warranting government involvement. Concerns were raised that if CBPP control was left entirely

to the private sector, vaccinations might be stopped too early. Livestock owners might not purchase additional vaccinations if their cattle appear healthy and the risk of CBPP is no longer apparent. But given the immunological strength of the current vaccine, the African Union's Interafrican Bureau for Animal Resources (AU-IBAR) has recommended regular vaccination against CBPP for at least five consecutive years.[25] Similarly, van Gool of Merial suggested that involving the government will ensure that a higher ratio of cattle are vaccinated; an organized public campaign could help to control the disease faster than leaving it entirely to the private sector.

- ***Need for private-sector involvement.*** African public-sector veterinarian services are often inadequately funded and may lack the human resources and proper incentive structures to carry out CBPP control. Pierre-Marie Borne, a regional director with Ceva Santé Animale, suggested that the private sector could help make CBPP control more consistent and sustainable. Christie Peacock, CEO of FARM-Africa, observed that few private-sector animal-health businesses currently offer vaccination services, but vaccinations which farmers valued could provide a large revenue stream, "which could actually lift the small-scale private sector up from the current situation of responding, selling a few drugs, and treating a handful of animals each day." Peacock asserted that pastoralists will pay for CBPP vaccines in areas where they experience the disease regularly. Lab participants said that as it's difficult to make the delivery of any one vaccine profitable, private-sector groups tackling CBPP should include it in a portfolio of diseases.

- **Combine vaccinations.** Hezron Wesonga, a scientist at the Kenya Agricultural Research Institute, suggested that CBPP vaccinations could be combined with other vaccinations "to save on costs and the time required for the farmers to assemble the animals." Merial's van Gool suggested combining CBPP with the current OIE and FAO foot and mouth disease (FMD) eradication campaign. Alternatively, CBPP vaccinations could be combined with inoculations against other animal or human diseases. Amanfu said that in Sudan, UNICEF vaccinated cattle owners' children against measles while FAO vaccinated against rinderpest.

- **Prioritize pastoralists.** Because CBPP is largely a disease spread by animal movement, McKeever suggested focusing efforts on pastoralist systems versus sedentary farms, as a starting point.

Joseph Kitalyi, principal veterinary officer at the Ministry of Livestock Development and Fisheries in Tanzania, follows the discussion closely.

Vaccine administration

- **Use a bioneedle.** Johan Vanhemelrijck, European consultant for GALVmed and secretary general of Bio.be, the Belgian biotechnology industry organization, urged veterinarians to use a bioneedle, "a vaccine that you

can use as it is and that is at the same time thermostable." Bioneedles are made from sugar and dissolve in the body, decreasing problems with hygiene. They are quicker to use than existing vaccine technology and do not require reconstitution or create waste. Bioneedles are not yet on the market but are expected to be available in about three to five years.[26]

Funding Solutions

Lab participants considered how to fund these solutions and whether pull mechanisms might provide the answer.

Barder, of the Center for Global Development, suggested that price guarantees from donors could be used to incentivize manufacturers to produce consistently high-quality vaccines. Farmers could pay the marginal cost of the vaccine, and donors could top up the price to ensure a decent return for vaccine manufacturers, distributors, and others in the value chain. He underscored a major benefit of pull mechanisms: If no vaccine is made available, or farmers do not purchase anything, donors pay nothing. Barder suggested that in setting up the pull, donors could simply specify the desired outcome (fewer cattle suffering from CBPP), rather than the technology. He stated, "Donors should say they want an effective, safe vaccine. And leave it to the researchers and the vets to figure out whether what they want to do is improve the existing vaccine or go out and develop a new one, or something else in between."

Lab participants agreed that there was a case for donor intervention in CBPP vaccines despite the fact that most of the benefit would accrue privately to the farmer. The vaccine has a herd immunity effect (that is, vaccinating one animal decreases disease risk for other animals), and without philanthropic intervention, R&D for a new vaccine would likely not be undertaken. Moreover, farmers might be too poor to afford the vaccine or they might heavily discount its benefits, deciding not to purchase it.

On the point of whether to incorporate vaccine delivery into a pull mechanism, he suggested that given the diversity of experiences in different countries, developing one model of vaccine delivery that specifies the roles of the public and private sectors would not work. Rather, donors should devise a pull mechanism for the vaccine and leave it to the various African governments to decide the best way of getting the vaccine to the animals.

Hameed Nuru of GALVmed, a participant at the Lab, is seen here vaccinating a cow owned by a Maasai herder.

Susan McAdams, director of multilateral trusteeship and innovative financing at the World Bank, suggested that push funding could complement the pull mechanism to fund R&D, surveillance, and data collection. Subsidizing R&D of a new vaccine would benefit the scientific community as knowledge could be shared.

An entirely different funding idea was put forward by Joachim Otte, senior livestock policy officer at the FAO. He suggested introducing animal health insurance, with reduced premiums for livestock owners who vaccinate their animals for CBPP. While some Lab participants agreed that insurance could potentially play a role, others mentioned that there would be a perverse incentive for livestock owners to let their cattle die to collect payment.

CONCLUSION AND NEXT STEPS

CBPP has burdened livestock owners on the African continent for almost 160 years. Despite ongoing efforts to eradicate it, the disease continues to take a toll on animals and livelihoods.

Immediate next steps should include performing a comprehensive analysis to estimate the economic impact of CBPP on sub-Saharan Africa. Efforts should include increasing the transparency of where the disease is occurring and estimating the effectiveness of the available interventions. This analysis would lay the groundwork for donor involvement and inform the strategy for tackling the disease going forward.

Once this is available, donors should consider implementing a pull mechanism to accelerate improvement of current vaccines and broader control strategies. Research on a second-generation vaccine should continue to move forward, as well. In the short term, research on the suitability of antibiotic treatment for CBPP should be encouraged. Furthermore, it is critical that PANVAC improve its monitoring and quality control of existing vaccines. Discussion among the relevant players should also involve determining how to improve delivery and develop better diagnostics.

Case II: Eradicating Aflatoxin

THE SCOPE OF THE PROBLEM

Crop diseases can pose a risk to any agricultural region, but in sub-Saharan Africa, where hunger remains endemic, they represent a particularly urgent threat.

Aflatoxin, a toxic substance emitted by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*, poisons maize, groundnuts, and other crops, and can cause severe health consequences when ingested. While aflatoxin can be found around the world, it is particularly problematic in developing countries, where regulators don't have the tools to enforce legal limits, and by necessity, the poor sometimes eat even the most visibly affected crops.

The fungi that produce aflatoxin often infect crops in the field and can then multiply many times over in poor storage conditions. Severe contamination tends to occur when crops are stressed—for instance, when there is drought before harvest, when there is high moisture at or after harvest, or when crops have suffered insect damage. Aflatoxins are unhealthful even at low levels; the United States allows just 20 parts per billion in food for human consumption. Even crops that show no visible signs of fungus infestation can be toxic.

Prevalence and Impact

The CDC estimated that 4.5 billion people in developing countries may be chronically exposed to aflatoxin through their diets.[27] Although aflatoxin is a problem across sub-Saharan Africa, Kenya has suffered the highest number of recorded deaths. While most negative health effects associated with the toxin take years to become fatal, extremely high doses can be lethal shortly following consumption.

In 2004, Kenya experienced a virulent outbreak of aflatoxin that claimed 125 lives. One study found that 34 percent of the grains in the affected districts that year had more than 50 times the maximum human tolerance level of aflatoxin.[28] Last year, the Kenyan government announced another dramatic outbreak: 2.3 million bags of maize were contaminated, primarily due to heavy rains at harvest, which prevented proper drying.[29] Due to this recent contamination, the World Food Programme is reconsidering purchasing maize from the country's food reserves, which could have a dramatic economic impact on the smallholder farmers that supply them.[30]

Generally, aflatoxin impacts two areas:

- **Health.** Human and animal health is at risk when aflatoxin-contaminated food is consumed. In humans, ingesting aflatoxin can cause liver failure and death from aflatoxicosis, but more often, chronic exposure leads to gradually unfolding health problems like liver disease, liver cancer, and reduced immune function. Individuals with hepatitis B who are exposed to aflatoxin have up to 60 times greater risk of liver cancer.[31] Although causality has not been established, aflatoxin has also been associated with stunting in children. The global annual burden of disease from aflatoxin has been estimated to be as high as 36 million disability-adjusted life years (DALYs; years of healthy life lost). Animals exposed to aflatoxin experience similar outcomes. The consequences for animals include weight loss, impaired reproduction, reduced nutritional status, and death.[32]

- **Trade.** Individual countries have adopted maximum allowable aflatoxin levels, which differ by crop and the end consumer; see table 3. These standards have greatly impacted trade, especially of groundnuts, in sub-Saharan Africa. The European Union, in particular, enforces strict standards for aflatoxin. Compared to earlier, more lenient standards, new E.U. regulations adopted in 2002 have been estimated to cost African traders $400 million annually in lost export revenue.[33] Agricultural exports from sub-Saharan Africa have declined by up to 20 percent over the past two decades due to contamination levels above the E.U. standards.[34]

TABLE 3 *Aflatoxin regulations for maize*

Country/region	Maximum allowable aflatoxin level *(parts per billion)*
European Union	
Human consumption	4
Dairy animals	5
Calves and lambs	10
Cattle, sheep, goats, pigs, and poultry	20
United States	
Human consumption	20
Immature and dairy animals	20
Breeding beef cattle and swine; mature poultry	100
Finishing swine (100 pounds or more)	200
Finishing (feedlot) beef cattle	300

Source: Food and Agriculture Organization of the United Nations, "Worldwide Regulations for Mycotoxins in Food and Feed in 2003" (2004).

Interventions

A number of interventions can reduce the public health risks of aflatoxin. They include:

- **Biocontrol.** Biocontrol involves introducing competing varieties of fungi that do not produce aflatoxins. Specially selected local non-toxic strains of *A. flavus* prevent the growth of the toxic strains in a process of competitive exclusion. Aflatoxin biocontrol is not a brand-new technology—it was first developed by the USDA and has been successfully used in the United States since 2003.[35] Furthermore, biocontrol has been shown to be very cost-effective. One study found the health benefits from using biocontrol on Nigerian maize to be 5 to 25 times greater than the costs. Given that this study looked only at aflatoxin-induced liver cancer, the benefits would likely be even greater if other aflatoxin-related health problems were included. The same study found that using biocontrol on maize in Nigeria would save approximately 144,000 DALYs annually, again taking just liver cancer into account.[36]
- **Post-harvest management.** Although they cannot reduce the contamination that occurs on the field, post-harvest management practices, including proper sorting, drying, and storage conditions (e.g., controlled temperature, low moisture, pest management), can prevent further aflatoxin accumulation.

- **Dietary supplements.** When consumed, enterosorbents such as NovaSil, often referred to as clay binders, have been found to reduce aflatoxin levels in animals and humans. These products could be taken as dietary supplements or added to existing food, like flour, to reduce aflatoxin levels.
- **Aflatoxin-resistant crop varieties.** While crops that are naturally resistant to aflatoxin have been under development for decades, there is not yet a candidate ready for commercial production.

THE FINANCIAL INNOVATIONS LAB

The Lab focused on financing aflatoxin biocontrol in Africa, since this promising technology has already proven its cost effectiveness in the U.S.

Despite the potential of biocontrol, significant challenges remain in commercializing the product. Encouraging smallholder farmers to use biocontrol is likely to be especially difficult. They have no economic incentive to purchase the product since they sell a relatively small percentage of their crops and aren't paid a premium for those that are aflatoxin-free. And with the possible exception of certain highly affected areas of Kenya, they also have very low awareness of how aflatoxin adversely affects their health and that of their children and animals.

But these farmers, ironically, are the very people at highest risk. They typically eat most of what they grow and throw little away due to food insecurity, making them more susceptible to particularly concentrated doses if their fields are contaminated. For these reasons, the Financial Innovations Lab on aflatoxin focused on how to encourage biocontrol adoption among smallholder farmers to realize the intervention's greatest public health benefits. Specifically, Lab participants examined whether pull mechanisms might be relevant in this context.

Kola Masha, managing director of Doreo Partners, describes aflatoxin awareness in Nigeria. Next to him is Ranajit Bandyopadhyay, plant pathologist at the International Institute of Tropical Agriculture.

Given that it is the furthest along in terms of biocontrol trials and registration, Nigeria served as the Lab's case study. In 2009, aflasafe™, developed by the International Institute of Tropical Agriculture (IITA), was provisionally registered by the Nigerian government, allowing up to 100 hectares of farmers' fields to be treated. In trials, it reduced contamination on maize by an average of about 80 percent at harvest and 90 percent after poor storage conditions. Up to 96 percent reduction has been demonstrated for groundnuts.[37] Because biocontrol is a natural product, involving the use of atoxigenic strains of fungus, strains need to be sourced locally. IITA is currently working to develop biocontrol products for Kenya, Burkina Faso, Senegal, and Mozambique.

Lab participants focused their discussion on maize, as it is a staple in local diets, commonly used for animal feed, and grown widely. In 2008, Nigeria produced 7.5 million tons of maize on 3.8 million hectares of land.[38] At the same time, IITA estimates

that more than 60 percent of harvested maize in Nigeria has high levels of aflatoxin.[39] By contrast, groundnuts, which are also affected by aflatoxin, are not a dietary staple and are more often used for processing. While edible oils produced from groundnuts are not toxic, groundnut meal, used for animal feed, is highly contaminated.

At a Glance: Nigeria

Population	155 million
GDP	$173 billion
Per-capita GDP	$1,118
Life expectancy	48 years
Percent of population in rural areas (as a % of total population)	51%
Agriculture (as a % of GDP)	33%
Agricultural land (as a % of land area)	86%

Source: The World Bank.

Barriers to Aflatoxin Reduction

As mentioned above, a number of barriers prevent adoption of biocontrol by smallholder farmers. These obstacles include:

- **Most maize is consumed on-farm.** Kola Masha, managing director of Doreo Partners, reported that about 70 percent of the maize grown in Nigeria is consumed by farmers, 18 percent is sold to industry (e.g., for poultry feed and maize flour), 10 percent is sold in markets within the country, and 2 percent is exported. Because smallholder farmers eat most of what they grow, they are difficult to reach through interventions in formal commercial value chains.

- **Lack of public awareness.** Awareness of aflatoxin and its effects are generally low. Masha reported that in his discussions on the topic in Nigeria, it became clear that many farmers, the general public, and even some food processors are unaware of aflatoxin's health risks. Only multinational food processors and government ministries are knowledgeable about the issue. In Kenya, because of recent outbreaks, awareness is comparatively more widespread. Dermot Cassidy, regional sanitary and phytosanitary advisor with the U.S. Department of Agriculture, observed, "Awareness is something that is actually a very, very large task… It's certainly a major problem to solve all on its own."

- **Regulation is not enforced.** Although Nigeria has regulation regarding maximum allowable aflatoxin levels, the government is not able to widely enforce its own rules. This is partly due to a lack of capacity—sufficient testing facilities don't exist. But it is also because if most maize in the country were tested today it would likely fail—removing a key source of food and devastating the economic livelihoods of millions of poor farmers.

- **No price differential for aflatoxin-free maize.** Because of the lack of awareness and regulatory enforcement, aflatoxin-free crops do not command a premium price in markets. When smallholder farmers do sell their crops, they tend to do so locally, where little distinction is made between contaminated and aflatoxin-free products.

- **Inexpensive diagnostics are unavailable.** Testing is not a regular part of the agricultural supply chain in Nigeria. Existing diagnostics are expensive because they require very large sample sizes to measure aflatoxin in the parts-per-billion levels. Inexpensive diagnostics are currently not available.

Biocontrol: Application and Costs[40]

Application: Farmers should broadcast 10 kilograms per hectare of the product onto their fields two to three weeks before flowering of the crop (between June and August).

Frequency of application: Once per year, though effects are cumulative (i.e., less biocontrol is needed per farm to achieve the same effect in subsequent years) and there is spillover of the product onto neighboring farms.

Cost of biocontrol: $10-$20 per hectare.

Aggregate cost of biocontrol for Nigeria (estimate): $42–$51 million[41]

Potential Solutions

Orin Hasson, associate program officer for development finance and economic policy at the Bill & Melinda Gates Foundation, presented several ideas for discussion on how pull mechanisms might be used to encourage farmer demand for aflasafe. Interventions could occur at multiple points in the maize value chain.

Option 1. Buy aflasafe directly from manufacturers. Donors could buy aflasafe from manufacturers and distribute it for free through the government or a private-sector contractor. Alternatively, distribution could occur through the market by highly subsidizing the product and bundling it with other inputs, such as fertilizer. Masha likened the idea of bundling aflasafe to fortifying products like flour and sugar with vitamins—taking "something that the farmer already wants, uses, and is willing to buy, and in a sense, you develop a system that fortifies it." Fertilizer is a good choice for bundling with aflasafe in Nigeria, because fertilizer is in high demand there (almost all Nigerian farmers use at least a minimal amount of fertilizer, according to Masha). Both products are applied in the same manner at roughly the same time, and they can be packaged together. In other countries, bundling with other products like seeds, insecticides, or herbicides could also be considered. Market research on farmers' willingness to pay could inform pricing decisions for the bundled product.

FIGURE 3 *Buy aflasafe directly from manufacturers*

Source: Orin Hasson, the Bill & Melinda Gates Foundation.

Advantage of this option:

- **Likely to incentivize manufacturing.** Large purchases of aflasafe would provide a clear market signal and stimulate private-sector investment in manufacturing biocontrol.

Drawbacks of this option:

- **Farmers unlikely to purchase the bundled product.** Lab participants doubted that farmers would pay a higher price for a product that included aflasafe. Tom Adlam, managing director of African Agricultural Capital Ltd., stated that smallholders are typically reluctant to invest in their crops even when there is a yield benefit. To pay more for an input to realize a *health* benefit is unlikely unless farmers are made aware of aflatoxin's effects and perceive the benefits to be greater than the cost of biocontrol.

Dr. Prem Warrior, senior program officer at the Bill & Melinda Gates Foundation, discusses incentives for farmers to utilize biocontrol products that reduce aflatoxin contamination. Also pictured is Dr. Salisu Ingawa, special advisor to Nigeria's minister of agriculture.

- **Difficult to ensure wide distribution.** It may be difficult to ensure that farmers gain access to the product, as there is no accountability mechanism tied to the distribution. Rebekah Young, senior economist at the Canadian Department of Finance, stated, "There is a bit of growing skepticism among donors about purchasing things up front, and then hoping distribution happens."

- **Establishes precedent of giving aflasafe away for free or at a discount.** Devesh Roy, senior research staff at the International Food Policy Research Institute, expressed concern at the idea of subsidizing aflasafe, stating that once you provide a subsidy, it "becomes very, very difficult to roll back." But Masha countered that "companies apply subsidies all the time… They don't call it a subsidy, they call it a discount, and they're able to then take them away as demand for the product grows." Salisu Ingawa, special adviser to the minister at the Nigerian Ministry of Agriculture, said that he thinks a subsidy is necessary to introduce a new product into the market. He estimated that the subsidy would have to be fairly large at first, perhaps 50 percent or more, but could be reduced as awareness builds. Steve Collins, chief of party for the Kenya Maize Development Project, added, "The idea of subsidies can be a short-term thing, but farmers will pay if they can see the benefits."

- **Ratio of fertilizer to aflasafe use will likely change over time.** Masha suggested bundling 10 kilograms of aflasafe with an equal amount of fertilizer, as that is the amount of fertilizer farmers typically use today. Collins of the Kenya Maize Development Project pointed out that the amount of fertilizer will need to be adjusted over time as fertilizer application rates will hopefully go up.

Option 2. Pay for performance. A pay-for-performance model would provide rewards to a designated party based on the prevalence of aflasafe strains on farmers' fields and/or in markets. (An alternative would be to reward based on the annual reduction in aflatoxin, but given that aflatoxin levels can vary greatly from year to year, it would be impossible to compare aflatoxin levels from one year to the next).[42] In this model, a contractor purchases aflasafe from the manufacturer and distributes it to farmers, again for free or at a subsidized price. Baseline and subsequent surveys measuring the prevalence of aflasafe would allow calculation of the use of the biocontrol and determine payment.

This model could be implemented at the farm level, where donors reward the contractor (and potentially the farmer) based on the prevalence of aflasafe. Alternatively, Young, from the Canadian Department of Finance, suggested this model could be implemented at the national level, meaning that donors would reward governments based on macro-indicators of aflasafe prevalence. Lab participants agreed that the latter model would likely be most effective. The points below relate to implementing pay-for-performance at the national level.

FIGURE 4 *Pay for performance*

Source: Orin Hasson, the Bill & Melinda Gates Foundation.

Advantages of this option:

- **Likely to incentivize manufacturing.** Large purchases of aflasafe would stimulate private-sector investment in manufacturing biocontrol.
- **Provides contractor with the incentive to distribute widely.** Compared to option 1, this model adds an accountability measure. If the government rewards contractors for alfasafe prevelance, it would help ensure wide distribution.
- **Creates an incentive for the government to increase awareness.** Implementing this model at the national level has some advantages, as it would incentivize the government to build awareness so as to increase the use of aflasafe (and therefore the award amount). Ingawa affirmed that this model would motivate the government to launch an awareness campaign. He stated that the country's agricultural extension system, which has been the normal channel of reaching small-scale farmers, would be willing to take on this task.
- **Could attract funding despite a difficult budgetary environment.** In a time of limited public and philanthropic funds, this option could attract funding because it would implement an innovative model where donors would only pay for the results they're looking to achieve.

Drawbacks of this option:

- **Difficult to reach smallholder farmers.** Alan Tollervey, team leader in agriculture research at the Department for International Development (DfID), pointed out that if a country is paid on its aggregate performance, governments would have an incentive to focus interventions on large farms because they are more cost-effective. In a follow-up to the Lab, the Gates Foundation's Hasson suggested that this could be remedied with an award formula that heavily weighted small farms.

- **Establishes precedent of giving aflasafe away for free or at a discount.** See the discussion on p. 21, under option 1.

- **Difficulty in determining the award amount.** It may be challenging to decide how much donors would award Nigeria for aflasafe coverage. Susan McAdams, director of multilateral trusteeship and innovative financing at the World Bank, suggested starting with an estimate of DALYs impacted and then paying per DALY. "Generally as a rule of thumb, if you can save a DALY for $100 or lower, it's a good public health intervention," she said.

Susan McAdams, director of the Multilateral Trusteeship and Innovative Financing at the World Bank, weighs the options for aflatoxin reduction from a donor's perspective.

- **Challenges with administering surveys.** McAdams stressed that the survey would need to be administered by a credible, independent third party, and done very carefully to be accurate and not contentious. Surveys may also be expensive and would add to the cost of this intervention.

- **Insufficient government capacity.** Masha questioned whether the government would be able to take on the role of increasing biocontrol use. "Governments inherently are not organized to be able to drive financial incentives down the line to front-line workers," he argued. Young disagreed, asserting that this model could be valuable in building government's capacity to play this role. Owen Barder, visiting fellow with the Center for Global Development, recalled that when the Global Alliance for Vaccines and Immunisation (GAVI) awarded Kenya a sum for each person immunized, suddenly there was internal coordination between the country's finance and health ministries, both of which had an incentive to increase immunizations. In follow-up to the Lab, Hasson suggested that a consulting firm could help organize the government's effort, and cooperation from senior levels would be essential to the success of this model.

Option 3. Provide a premium for aflatoxin-free maize. In this model, donors create a market for aflatoxin-free maize. Large buyers, like the World Food Programme, could agree to pay a premium price for aflatoxin-free maize. Since 2005, WFP has purchased crops from Nigerian small-scale farmers in support of Nigeria's home-grown school feeding program, which provides locally produced food to students.[43] In other countries, like Kenya, the

WFP sources food from smallholder farmers through its Purchase for Progress initiative. Where WFP buys maize for these programs from national grain reserves, they could agree to pay a higher price for maize that has been tested for aflatoxin and guaranteed to be uncontaminated.

FIGURE 5 *Provide a premium for aflatoxin-free maize*

Source: Orin Hasson, the Bill & Melinda Gates Foundation.

Advantages of this option:

- **Creates a new commodity category.** Aflatoxin-free maize would command a premium price, giving farmers the incentive to purchase and use the biocontrol product.
- **Establishes precedent for farmers buying aflasafe.** The goal is for farmers to find the cost of aflasafe to be less than the premium awarded for aflatoxin-free crops. If they find it cost-effective, they will purchase the biocontrol for the opportunity to sell at a premium price.
- **Does not mandate use of aflasafe.** If crops are tested for aflatoxin levels, farmers would feel free to use any intervention to lower contamination, such as better storage or handling.

Drawbacks of this option:

- **Unlikely to benefit smallholders.** Lab participants viewed this option as providing an unlikely incentive for smallholder farmers. Andrew Emmott, senior nut trader and project manager with Twin & Twin Trading, pointed out that some farmers might not purchase aflasafe, and to secure the premium price, they would sort out the contaminated pieces to consume themselves. In this way, bad maize would still be concentrated in the hands of smallholder farmers, perhaps even more so.
- **Premium needs to be sufficiently large to get farmers to use aflasafe on their entire fields.** Barder pointed out that because farmers sell only 30 percent of their crop, the premium for aflatoxin-free maize would need to be large enough to cover farmers' costs of applying aflasafe to their entire fields, not just the portion that will be sold, in order to realize the public health benefit.
- **Requires coordination among a large number of players.** Because the value chain is long in this intervention, coordination of the various players is crucial and difficult.

- **May be difficult to incentivize aflasafe manufacturing.** Compared to the other two proposed options, this model would be more difficult to explain to manufacturers when trying to incentivize investment.

- **Testing might be difficult.** Richard Kettlewell, a nut trader consultant, raised concerns about testing. Current diagnostics can be expensive and require very large sample sizes to measure aflatoxin in parts-per-billion. Masha argued that a large aggregator could test efficiently so that the costs would not be burdensome. Strategies would need to be developed to determine how to test individual farmers' submissions, which would likely come in relatively small amounts.

The fungi that produce aflatoxin often infect crops in the field and can then multiply many times over in poor storage conditions. Eating contaminated maize or groundnuts can lead to liver disease, reduced immune function and even death.

Suggestions:

- **Consider targeting to larger farms first.** Philippe Muheim, head of business development at ( )pen E-Commerce Innovators, suggested targeting a premium for aflatoxin-free maize to large farms first. "The best strategy might not be to start with the small farmers, but perhaps with more of the commercially oriented farmers, then lead by example." He said that sequencing in this way might allow donors to "capture the low-hanging fruit."

Other financing solutions. Glenn Yago, executive director of financial research at the Milken Institute, suggested that short-term credit could help farmers purchase aflasafe. Access to credit is critical in enabling farmers to purchase agricultural inputs. In Kenya, advances in cell phone technology allow users of M-PESA, operated by Safaricom, to receive microloans. Yago suggested that such technology could be tapped so that farmers can easily access credit to purchase biocontrol. Finally, in follow-up to the Lab, Muheim of ( )pen E-Commerce Innovators also suggested providing insurance for aflasafe, giving farmers a refund if crops fail. During the Lab, Wilson Songa, Kenya's agriculture secretary, described how Syngenta is currently using this approach to insure fertilizer in Kenya.

Complementary solutions:

- **Assess the size of the aflatoxin burden in sub-Saharan Africa.** Francis Frey, senior program officer for innovative finance at the Agence Française de Développement, stated that to make the case for intervention even stronger, "what we need…is probably a better mapping of the extent of the issue, continent-wise or regional-wise."

  The World Health Organization is currently working on a project measuring the global burden of aflatoxin in terms of healthy years of life lost and economic cost. The International Food Policy Research Institute (IFPRI) is also leading a study to calculate the economic impact of aflatoxin and assess the extent of the problem in Kenya and Mali, among other objectives.[44] Data on the spread and severity of the aflatoxin burden would help inform strategy and provide a baseline against which to measure future progress.

- **Increase awareness of aflatoxin, its effects on health, and how biocontrol works.** No matter which option is implemented, awareness is a critical part of the path forward. Ranajit Bandyopadhyay, plant pathologist at the International Institute of Tropical Agriculture, observed, "Awareness is a key to the whole thing, and if you go and talk to the farmer, we actually talk about the health implications that they don't understand,…then the perception of the whole problem and the willingness to pay, that perception actually changes. … You need to educate the growers about what the value of the product is, just like any other company would do when they do marketing." To the extent that awareness can be fostered regionally, this would help grain move freely between neighboring countries.

- **Improve storage.** Songa, from Kenya's Ministry of Agriculture, stated that current "storage structures definitely also leave a lot to be desired." He said more work should be done to ensure that storage structures allow the proper aeration of grain. Bandyopadhyay agreed, noting that biocontrol can only reduce aflatoxin levels and not eliminate contamination, so drying technologies should also be part of the solution.

- **Institute a system of credible certification.** Roy, of IFPRI, pointed to the need for credible certification so people could trust that food they purchased was below the maximum allowable aflatoxin levels. Songa agreed, citing that due to Kenya's publicized aflatoxin outbreaks, consumers avoid purchasing even some of the good grain. Songa suggested that a system of credible certification should be recognized inter-regionally to benefit trade with nearby countries.

- **Develop an inexpensive diagnostic.** As described above, existing diagnostics are expensive. Efforts are currently being funded by the Bill & Melinda Gates Foundation to lower the costs of effective diagnostic tools.

CONCLUSION AND NEXT STEPS

A pay-for-performance model was viewed as the most promising approach. In order to pilot this model, surveys need to be carefully planned and determinations of the award amounts need to be made. Details would also need to be worked out on the length of time donors should commit to providing the award, when they might be able to exit the commitment, and, when they do exit, how sustainable aflatoxin reduction will be in their absence. It's also important to consider how the models presented above could be sequenced for greatest impact. Options 1 and 3, for example, could be incorporated into a broader pay-for-performance model.

Collaboration is the key to moving forward. The Gates Foundation has kicked off a round of discussions on developing an African-led Partnership for Aflatoxin Control, which could involve foundations, donors, research organizations, governments, the private sector, the media, and non-governmental organizations.

While Nigeria is serving as the pilot country, a biocontrol product will hopefully be available in Kenya sometime in 2012, with other African countries to follow. Lessons from implementing a pull mechanism and related solutions in Nigeria could then help inform the adoption of biocontrol in other countries in sub-Saharan Africa.

APPENDIX I

Financial Innovations Lab Participants (CBPP Session)

(Affiliations at time of Lab)

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Roger Ayling
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Randip Basra
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Gregg BeVier
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Pierre-Marie Borne
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Alain Dehove
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Baptiste Dungu
Senior Director of Research & Development, GALVmed

Kimberly Elliott
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Musa Fanikiso
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Francis Frey
Senior Programme Officer, Innovative Finance, Agence Française de Développement

Kerstin S. Garcia
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Orin Hasson
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Salisu Ingawa
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Emenike Irokanulo
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Peter Jeffries
Group Director, Global Alliances & Business Development, Europe, Africa and the Middle East, Pfizer Inc.

Emma Kambewa
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Joseph Kitalyi
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Joachim Otte
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Executive Director, Southern African Centre for Infectious Disease Surveillance

Massimo Scacchia
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Senior Research Analyst, Milken Institute

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Alan Tollervey
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Karim Tounkara
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Frans van Gool
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Johan Vanhemelrijck
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Hezron Wesonga
Scientist, Kenya Agricultural Research Institute

Glenn Yago
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Rebekah Young
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APPENDIX II

Financial Innovations Lab Participants (Aflatoxin Session)

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