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Strategies to Prevent (STOP) Spillover

Risky Interfaces Hiding in Plain Sight

Year 3 Annual Report

1 October 2022–30 September 2023

December 2023

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Strategies to Prevent (STOP) Spillover

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Cover photograph: Bat guano collectors harvest guano at a cave in Cambodia.
Photo credit: Tetra Tech

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Acronyms & Abbreviations

AFROHUN	Africa One Health University Network
BFD	Bangladesh Forest Department
CDI	Côte d'Ivoire
CoV	Coronavirus
DARD	Department of Agriculture and Rural Development
DLS	Department of Livestock Services
DNCC	Dhaka North City Corporation
DOH	Department of Health
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
IEDCR	Institute of Epidemiology, Disease Control and Research
IPC	Institut Pasteur du Cambodge
IPCI	Institut Pasteur de Côte d'Ivoire
IRB	Institutional Review Board
KII	Key Informant Interview
KPIs	Key Performance Indicators
LANADA	National Laboratory for Agriculture Development Support
LBM	Live Bird Market
LoD	Limit of Detection
LWSC	Liberia Water and Sewer Corporation
MERS	Middle East Respiratory Syndrome
NGO	Non-Governmental Organization
NPHIL	National Public Health Institute of Liberia
OH-DReaM	One Health-Design Research and Mentorship
OHS	One Health Secretariat
OM	Outcome Mapping
PDAFF	Provincial Department of Agriculture, Forestry and Fisheries
PHD	Provincial Health Department
PPE	Personal protective equipment
SARS	Severe Acute Respiratory Syndrome
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SBC	Social and behavior change
SOP	Standardized Operating Procedure
STOP	Spillover Strategies to Prevent Spillover USAID Program
TIPs	Trials of Improved Practices
UNMC	University of Nebraska Medical Center
USAID	United States Agency for International Development
UVRI	Uganda Virus Research Institute
VOHUN	Viet Nam One Health University Network

From the Director

Human behavior drives the evolution and epidemiology of infectious diseases, and we share pathogens with species we contact most closely and consistently. Some of our shared pathogens—often viruses—cause outbreaks, epidemics, and pandemics that leave indelible marks on our societies. Human behaviors are fundamentally linked to planetary changes and our globalized economy, and are deeply embedded in cultural beliefs, practices, and preferences. Evidence-based mitigation efforts can fall short without understanding the cultural systems, behaviors, and institutional weaknesses that facilitate spillover and spread. The Strategies to Prevent Spillover (STOP Spillover) project offers a critical opportunity to enhance our global understanding of the complex drivers of zoonotic viral spillover, to augment sustainable national capacities in surveillance and risk analysis and to develop interventions that reduce the risk of spillover in multiple countries. Many of the high risk interfaces where we are working are hiding in plain sight. For instance in live bird markets in Bangladesh people, live birds, processed birds, wild and domestic animals (such as pets that feed on offal) are all in close proximity with one another. In wild meat markets in Côte d'Ivoire and Sierra Leone there is constant handling, processing, and consumption of meat from the wild with little attention to biosafety and biosecurity. In Viet Nam wildlife farms raise multiple species in close contact with one another, an environment that creates opportunities for cross species transmission of pathogens. As is possible in each of the above examples, zoonotic spillover requires multiple factors to align, including the ecological, epidemiological and behavioral determinants of pathogen exposure, and the human factors that affect susceptibility to infection.

With a new leadership team in place for STOP Spillover, the project's vision remains clear. We are focused on strengthening the capacity of and preparing countries to identify high-risk interfaces, control zoonotic diseases at their source before they become epidemics or pandemics, and develop interventions that reduce risks of exposure in human populations. We are privileged to work closely with strong country teams and government counterparts, as well as with consortium partners who bring expertise in wildlife health, infectious disease, social behavior change, and environmental issues. From the outset, our consortium of experts in human, animal, and environmental health has been heavily focused on engagement, working with stakeholders at the national, regional, and local levels to reduce risks of exposure to and mitigate the spread of selected zoonotic viral pathogens, including coronaviruses, filoviruses (Ebola and Marburg viruses), avian influenza, and Lassa virus, among others.

On the ground at the local level—in wildlife farms in Dong Nai province, Viet Nam, and wild animal meat markets in Kenema, Sierra Leone—community-led workshops have provided important data about the interactions humans have with wild and domestic animals in these settings, as well as the barriers they face in adopting practices that reduce spillover risk. In Liberia, STOP Spillover is conducting research to understand Lassa virus distribution in rodent reservoir hosts both within what is referred to as the "Lassa belt" and beyond. Working with the Ministry of Health, National Public Health Institute of Liberia, the Ministry of Agriculture, and local communities, teams are collecting and testing samples from *Mastomys natalensis* and other rodents for the presence of Lassa virus RNA (an indication of infection) within and outside of the Lassa belt. The documentation of the true distribution of Lassa virus in reservoir hosts is critical to public health policy and practice to increase Lassa awareness outside the 'Lassa belt', put it on the list of differential diagnosis for febrile patients, and enable early diagnosis, treatment, and improved survival. In addition, it informs future research and the need to increase efforts to diagnose and detect cases outside of the mislabeled 'Lassa belt'.

At live bird markets in Dhaka, Bangladesh, where the threat of highly pathogenic avian influenza is a concern, efforts are underway to develop a coordinated and sustainable platform for pathogen early detection and data sharing. A mobile application has been developed enabling the public to report sick and dead poultry as well as sudden febrile illness among market vendors. Moreover, the STOP Spillover team is working with public health experts and engineers to redesign market spaces so that biosafety is optimized, and consumer and vendor health protected.

In Côte d'Ivoire, Cambodia, and Liberia, teams have been trained to safely collect samples for surveillance of food, water, surfaces, wastewater, and liquid waste effluent, with potential testing for multiple zoonotic viruses. The aim of these activities is to increase countries' capacities to detect and develop early warning systems for potential spillover events. As demonstrated by these examples, STOP Spillover exemplifies the One Health approach: the interconnection of human, animal, and environmental health.

As we finish the third year and begin the fourth, we continue to place emphasis on evidence-based interventions and deliverables, to strengthen in-country capacity to urgently prepare and respond to spillover events in concurrence with the GHSA and JEE. and to align partners' expectations with our STOP Spillover objectives. We greatly appreciate our country teams and consortium partners who are working tirelessly to ensure we deliver on our commitment to reduce spillover across countries.

Thank you,
Hellen Amuguni

Introduction

Strategies to Prevent Spillover (STOP Spillover) is a five-year, U.S. Agency for International Development (USAID)-funded cooperative agreement to support priority countries in Asia and Africa to strengthen their capacities to identify, assess, and monitor risk associated with emerging zoonotic viruses and to develop and introduce proven and novel risk-reduction measures. STOP Spillover builds on more than 15 years of USAID investments in promoting a multisectoral, One Health approach to addressing emerging zoonotic viruses before they pose epidemic or pandemic threats to human health. Led by Tufts University, STOP Spillover is a global consortium of 15 partner organizations with expertise in human, animal, and environmental health who are taking the next step in understanding and addressing the risks posed by known zoonotic viruses that have the potential to spill over and cause pandemic crises.

STOP Spillover focuses on prioritized zoonotic viruses(Ebola, Marburg, Lassa, and Nipah), animal-origin coronaviruses (including SARS-CoV, SARS-CoV-2, and MERS-CoV), and animal-origin zoonotic influenza viruses. In each STOP Spillover host country, the specific viruses to be addressed and the prioritized high-risk interfaces are determined with in-country stakeholders. By implementing locally designed interventions in each country over the life of the project, and evaluating the social, gender, economic, and environmental acceptability and effectiveness of each intervention, participating countries are strengthening their capacity to develop, validate, and implement interventions to reduce spillover of prioritized zoonotic viruses.

In Year 3, STOP Spillover supported seven USAID priority countries. The overall goal of STOP Spillover is to enhance understanding of the causes of viral emergence from animals to humans and to use this information to reduce risk of zoonotic viral spillover, amplification, and spread. In support of this goal, STOP Spillover has three objectives, all of which were central to achievements and successes during the third year of implementation (Figure 1).

Objective 1 focuses on understanding the risk of spillover of zoonotic viruses and areas where interventions may be most effective at specific high-risk animal-human interfaces. In Year 3, Objective 1 activities included a study in Bangladesh which assessed live-bird market consumers' willingness to pay for safer poultry products, and a study evaluating contamination of food, water, and household surfaces to assess Lassa virus presence and spillover risk in Liberia, among other studies. Objective 2 focuses on utilizing that improved understanding to develop and test interventions that reduce the risk of spillover at the community level. During Year 3, significant focus was placed on Objective 2 activities, specifically the design, implementation, and evaluation of comprehensive and holistic interventions. For example, several interventions focused on promotion of biosafety and safer handling practices of wild meat at markets in Sierra Leone and Côte D'Ivoire. Elsewhere, interventions were implemented to increase biosafety, waste management, and health promotion on wildlife farms in Viet Nam, and promote uptake of a community-based bat-human interface monitoring program for zoonotic spillover early warning and response in Uganda. All innovative interventions implemented across STOP Spillover countries, including preliminary and final results where appropriate, are featured in this report. Recognizing that it will not be possible to prevent all spillover events from wildlife, Objective 3 focuses on assisting countries to limit the impact of spillover events should they occur. For example, in Year 3, Objective 3 activities honed in on local media capacity building in Côte d'Ivoire, Sierra Leone and Bangladesh to strengthen risk communication systems, and outbreak risk management training in Sierra Leone and Cambodia.

Figure 1. STOP Spillover objectives and expected results.

<table>
<tr><th>OBJECTIVE 1</th><th>OBJECTIVE 2</th><th>OBJECTIVE 3</th></tr>
<tr><td>Strengthen country capacity to monitor, analyze and characterize the risk of priority emerging zoonotic viruses spilling over from animals to people</td><td>Strengthen country capacity to develop, validate, and implement interventions to reduce risk of priority emerging zoonotic viruses spilling over from animals to people</td><td>Strengthen country capacity to mitigate amplification and spread priority zoonotic diseases in human populations</td></tr>
<tr><th colspan="3">EXPECTED RESULTS</th></tr>
<tr><td>Countries are able to update risk assignments and identify key knowledge gaps related to risks of spillover, amplification, and spread of priority emerging zoonotic viruses in animal and human populations.

Countries have strengthened capacity to address these key knowledge gaps</td><td>Countries are able to use available information to test and validate the effectiveness of interventions to reduce spillover of priority emerging zoonotic viruses from animals to humans.

Countries are able to implement interventions, policies, and regulations to reduce spillover of priority emerging zoonotic viruses from animals to humans.

Countries can develop, analyze, validate, and implement gender-responsive and culturally appropriate interventions relevant to women, girls, men, and boys to limit direct contact with animals and animal products.

Countries are able to implement interventions and are working towards implementing policies and regulations to reduce spillover of priority emerging zoonotic viruses from animals to humans.</td><td>Countries have the capacity to understand risk and plan an appropriate response to contain amplification and spread of zoonotic disease events originating from wildlife.

High-risk communities, workers, and health facilities in up to 10 countries can rapidly recognize and respond to suspect zoonotic disease events originating from wildlife.

Countries have the ability to integrate research findings and best practices into risk mitigation efforts to directly impact gender and sex-specific risks.</td></tr>
<tr><th colspan="3">STOP SPILLOVER'S SUPPORT TO GHSA PRIORITY INDICATORS</th></tr>
<tr><td colspan="2">Zoonotic Disease</td><td></td></tr>
<tr><td></td><td>Biosafety and Biosecurity</td><td></td></tr>
<tr><td>National Laboratory System</td><td></td><td></td></tr>
<tr><td></td><td>Surveillance
Human Resources
Health Emergency Management
Infection Prevention and Control (IPC)</td><td></td></tr>
<tr><td></td><td>Risk Communication and Community Engagement (RCCE)</td><td></td></tr>
</table>

Figure 2. Prioritized interfaces and pathogens in STOP Spillover countries.

COUNTRY	PRIORITIZED INTERFACE	PATHOGEN(S)	SPECIFIC LOCATION
UGANDA	Bat-Human	Ebola, Marburg	Bundibugyo District
LIBERIA	Rodent-Human	Lassa	Nimba, Bong, and Grand Bassa Counties
SIERRA LEONE	Wildlife-Human	Ebola, Lassa	Rural communities bordering Gola Rainforest National Park
COTE D'IVOIRE	Wildlife-Human	Ebola, Marburg	District des Montagnes
BANGLADESH	Poultry-Human	HPAI	Live bird markets in Dhaka
VIET NAM	wildlife-Human	Coronaviruses	Wildlife farms in Dong Nai Province
CAMBODIA	Bat-Human	Coronaviruses	Kampung Cham Province

Locally led approaches are fundamental to achieving the goals of STOP Spillover. To prevent the next pandemic, STOP Spillover helps institutionalize knowledge in local communities and governments and works together with these stakeholders to develop and implement contextually adapted and appropriate, innovative activities and interventions. In each target country, STOP Spillover is led by a country team composed of in-country personnel who are supported by experts across all 15 consortium partner organizations partner organizations. Local transdisciplinary and trans-sectoral stakeholders are actively engaged by STOP Spillover country teams to ensure that governments are engaged throughout the STOP Spillover project and well positioned to sustain activities into the future. In all focal countries, local stakeholders have been engaged through Outcome Mapping (OM)—a participatory planning methodology—to prioritize the viral pathogen(s) of focus, the high-risk interfaces at which to focus efforts, key stakeholders to engage, potential interventions to mitigate the risk of viral spillover, and gaps in knowledge that need to be addressed in order to design appropriate and effective interventions. Figure 2 shows the specific viral pathogens and high-risk interfaces prioritized by in-country stakeholders through the OM process in each STOP Spillover target country.

Once priority pathogens, high-risk interfaces, and potential interventions have been identified by local stakeholders through OM, One Health-Design, Research and Mentorship (OH-DReaM) working groups are established to design, implement, and evaluate interventions to reduce the risk of viral spillover. Each OH-DReaM working group includes in-country representatives chosen specifically for the intervention, interface, and activity of interest. Each OH-DReaM working group is overseen by a country team member and supported by subject matter experts and mentors from the global-level STOP Spillover consortium.

Activities conducted on STOP Spillover's three objectives during this reporting period can be categorized as follows: Outcome Mapping; Studies at prioritized interfaces; surveillance; risk-reduction interventions at prioritized interfaces; supporting activities; media capacity strengthening; and outbreak response scenario planning (Figure 3). STOP Spillover began in October 2020. This report describes STOP Spillover's activities conducted under these categories, by objective, from October 1, 2022, through September 30, 2023.

In Year 3 of STOP Spillover, the project met multiple milestones, including the launch and implementation of research studies (many of which have been completed and contribute to knowledge of viral threats) and multiple interventions that are well established to decrease viral threats to human populations. The entire STOP Spillover consortium looks forward to advancing knowledge of zoonotic viral threats in subsequent years of the project cycle.

Figure 3. Categories of activities conducted across STOP Spillover's three objectives during the current reporting period

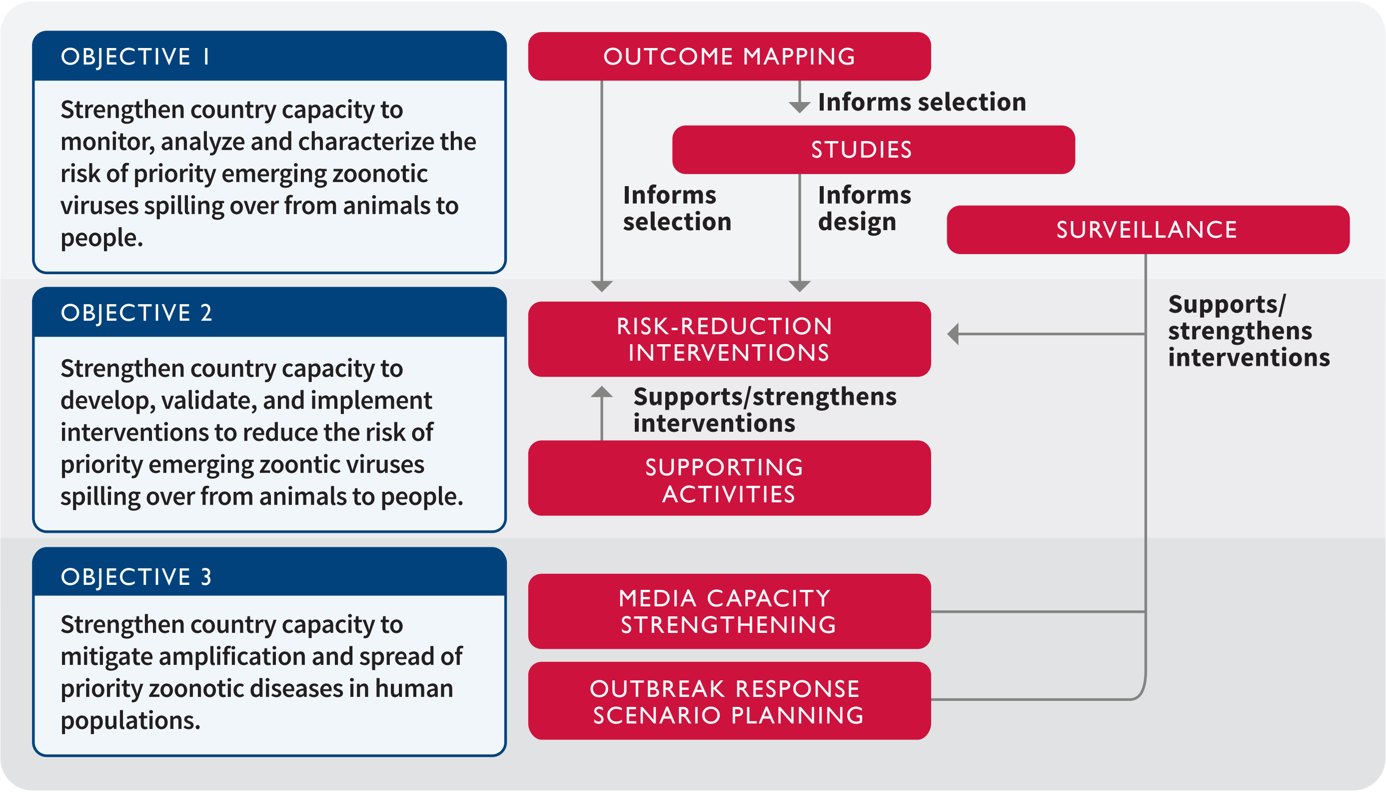


Figure 4. Individuals trained

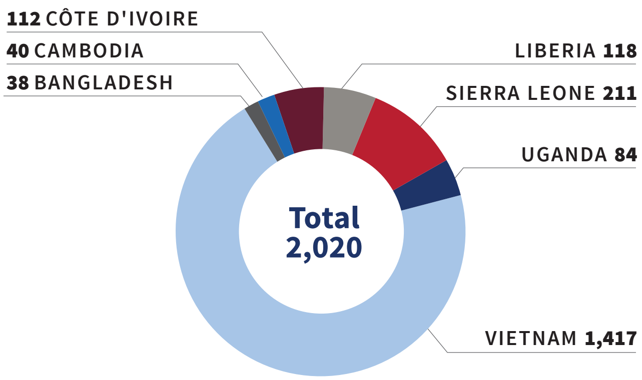


Figure 5. Stakeholders engaged

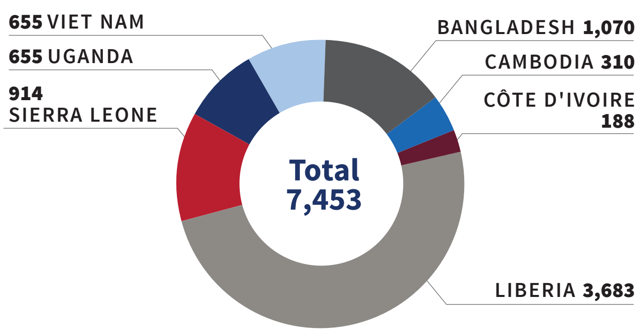
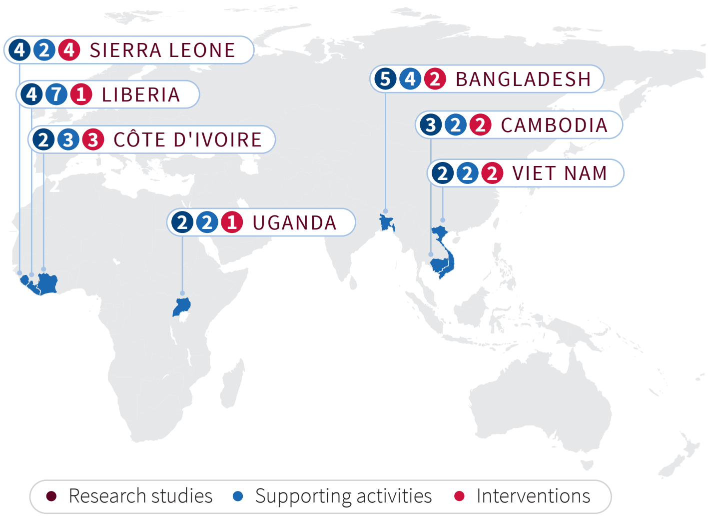


Figure 6. Research studies, supporting activities, and interventions by country



Activities & Accomplishments

OBJECTIVE 1

Objective 1 focuses on assisting countries to improve their understanding of how priority zoonotic viruses spill over from animals to people. Improved understanding of risk directly feeds into and supports Objectives 2 and 3, including the development of risk-reduction interventions. This section outlines STOP Spillover's achievements and accomplishments for Objective 1 during Project Year 3.

Building capacity and empowering countries to monitor, analyze and characterize factors that increase risk of spillover

1. Exploring successes and failures of previous Live Bird Market (LBM) risk reduction interventions in Bangladesh

In Bangladesh, the HPAI H5N1 virus is endemic in poultry. Live Bird Markets (LBMs) are a high-risk interface for HPAI virus transmission in Bangladesh, where year-round circulation in poultry has been recorded. Multiple poultry species, including chickens, ducks, geese, pigeons, and quail are typically sold together in markets that potentially facilitate cross-species transmission of avian influenza viruses (AIVs). Vegetables, fish, grocery products, poultry shops, and butcher shops operate businesses in the same areas, and millions of people visit LBMs every day, which elevates exposure to live poultry infected with AIVs. Poor biosafety and personal hygiene practices at LBMs may be an important risk pathway that facilitates AIV transmission between poultry and humans.

Risky feast: Canine curiosity and risk of avian flu in Bangladesh.
Photo credit: icddr,b

Previous LBM interventions in Bangladesh have typically focused on cleaning, disinfection, infrastructural changes, logistics supply, and training poultry workers to prevent transmission of avian influenza. To date, the effect of interventions has been limited or did not significantly reduce viral circulation. Although sustainability, financial concerns, and low-risk perception have been identified as major limitations of previous interventions, a detailed account of the contributing factors to their failures and recommendations by the implementers on how to overcome these barriers to inform future interventions is warranted.

To better understand contributing factors to the successes and failures of previous interventions, STOP Spillover Bangladesh undertook integrated scoping and policy reviews, and gathered qualitative information from implementers and evaluators of previous interventions in 29 group discussions and in-person interviews. Two additional group discussions were held with LBM actors, and 10 informal observations in 10 previously intervened LBMs were completed to observe the current status of compliance with previous interventions, which included the use of infrastructure, PPE, handwashing and cleaning practices, as well as the condition of the infrastructure and equipment that had been provided.

Despite numerous efforts and investments of significant resources, the conditions of the LBMs did not change over time in terms of biosafety or hygiene because the policies were not implemented optimally, and the interventions were not sustained. A number of factors influenced the uptake and sustainability but the most important ones are: the absence of a phase-out plan; limited ownership, motivation, coordination, and resources among regulatory authorities and market committees for LBM monitoring; inadequate advocacy and efforts in policy implementation or law enforcement; lack of risk perception, motivation and perceived benefit among vendors; and the lack of a holistic approach considering different perspectives of various LBM actors/stakeholders.

Based on this study, STOP Spillover identified several factors that they recommended for future interventions. Future intervention design should consider a holistic perspective – from implementers, regulatory authorities, and LBM actors. Improved biosafety and hygiene practices need to be normalized into daily life as 'norms'. Changes incurring regular costs need to be embedded into the system (policy, government order, budget, revenue, job responsibility) instead of borne by individual actors. The mayor of the city corporation or municipality should be involved as the key driver for compliance monitoring. The maintenance and monitoring cost of ensuring hygiene at the LBMs should be included into the government's revenue plan. The role of the Department of Livestock Services (DLS) is critical in monitoring, coordinating and linking with other government bodies, like City Corporation and Public Health, to enforce cleaning, washing and disinfection of LBMs and vehicles. For practices and behaviors to change, the perceived benefits must outweigh the perceived costs. This exploration provides recommendations to inform future design of interventions to improve LBM biosafety/hygiene (Table 1).

Table 1. Recommendations

INTERVENTION COMPONENT	RECOMMENDATIONS
Water Supply and Handwashing Facility	• Centrally connected and managed water supply; • Exclusive water points in slaughtering area with drainage system; • BCC to motivate using running water
Drainage	• Covered and sloped drain • Network drainage for SH and individual shops • Maintenance cost and accountability managed centrally

INTERVENTION COMPONENT	RECOMMENDATIONS
Slaughterhouse	Zoning or separating slaughtering/processing area with - adequate platform/slab to work in standing position, - water supply, - dressing machine, - adequate ventilation, and - solid and liquid waste management systems,
Workstation	Washable low-cost worktop to process poultry in standing position
Slaughtering equipment	Barrel with lid for Dhaka LBMs
Tiling	• Non-slip durable tiles for shops and SH • Parking or no tile for corridor/walkways • Maintenance cost and accountability managed centrally
Poultry Keeping Cage	Washable and sturdy cage with feces management system
Use of PPE and Personal Hygiene	• Rigorous BCC to motivate LBM actors • Protective equipment for cleaners
Cleaning and Disinfection (C&D)	• Cleaning and washing every day after closing • Thorough C&D at least once a week (using low cost disinfectant $NaHCO_3$) • Maintenance cost, monitoring and accountability managed centrally
Karcher pressure washer Machine	• Locally available low-cost option • Maintenance cost and accountability managed centrally
Waste Disposal	• Need context-oriented number and size of bins • Supply of PPE and anti-tetanus serum to cleaners • Safety equipment for sewer divers • Staff and cost managed centrally
Training and Awareness Raising	• Tailored messages developed for different LBM actors • Training on safe handling of poultry waste and identifying sick poultry • Govt./NGOs arranging health check-up/doctor visit for cleaners/workers

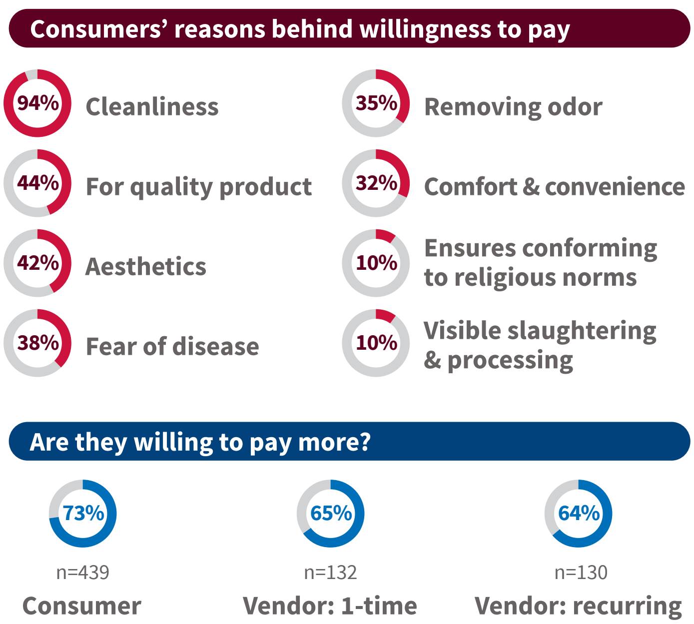
The findings of this work directly inform the work of STOP Spillover Bangladesh, including the holistic intervention design (activity 2.2.2.1), and enhancement of coordinated surveillance platform (activity 2.2.2.2) and early warning system (2.2.2.3).

2. Consumers' willingness to pay for safer poultry products in Bangladesh

Studies regarding consumers' willingness-to-pay (WTP) for safer, environmentally friendly, and quality poultry meat have been conducted in many countries, including Bangladesh. However, there is little empirical evidence on appropriate indicators of improved bio-secure live bird market (LBM) attributes that consumers might understand and use in their purchasing decisions, their preferences for these attributes, and whether their willingness-to-pay for such attributes can sustain safer practices in LBMs. Exploring chicken vendors' WTP for developing and maintaining LBMs that ensure better biosafety and hygienic practices is also of immense importance to ensure the sustainability of interventions targeting bio-secure LBM attributes. STOP Spillover Bangladesh used contingent valuation, an approach where respondents express their preferences regarding hypothetical market scenarios, to evaluate the LBM attributes that consumers use in their purchasing decisions and how much they are willing to pay for these. We also assessed chicken vendors' WTP for improved and more bio-secure poultry handling practices. This information was gathered from chicken consumers and vendors in two city corporations of Dhaka city: Dhaka South City Corporation (DSCC) and Dhaka North City Corporation (DNCC).

To understand the LBM attributes that influence purchasing decisions, 40 in-depth interviews (IDIs) were conducted with 40 chicken consumers who purchased chicken from LBMs, and eight IDIs were conducted with eight chicken consumers who purchased chicken from supermarkets. The attributes most commonly cited—such as cleanliness of LBM walkways and stalls, use of protective equipment by workers, zoning of markets, and hygiene practice—were summarized and listed on a survey tool. A total of 600 consumers recruited in equal numbers from 60 LBMs in Dhaka City, were asked to rank the list of attributes in order of importance and to indicate how much they would be willing to pay for each attribute.

Figures 7 . Analysis of consumer and vendor willingness to pay for poultry for improved biosecurity: a study in live bird markets of Dhaka city



Cleanliness was one of the most important motivating factors for the consumers' willingness to pay. The majority of the consumers who wanted to pay because of fear of disease (91%) and to have healthy and clean poultry (94%) also wanted cleanliness of the market environment in response to paying more for poultry meat. Vendors showed a great willingness to invest, with a significant increase of 20% over their current operating costs for improved LBMs. Increasing sales in an improved shop was one of the prime motivating factors for vendors' willingness to pay. Vendors expected to receive an increased price from the consumers for an improved market and safer product – from the current average of BDT 14 to 21 (USD 0.13 to 0.19) per kg for various types of chickens. There is a small gap between the consumers' WTP and vendors' expectations.

Income was one of the influencing factors for WTP of the consumers and vendors, as the higher income groups had a significantly greater readiness to pay for an improved bio-secure LBM. The economic rationale behind this positive relationship is that higher-income individuals typically have more disposable income, allowing them to allocate a larger portion of their budget toward purchasing premium goods and services, such as improved market facilities for poultry products. Similar to income, higher-educated individuals were more willing to pay to contribute to the funding mechanism for improved LBMs.

Our study found that both consumers and vendors are willing to provide extra money to build and maintain improved bio-secure LBMs in Dhaka city. The majority of consumers (73%) expressed willingness to pay premium prices, from the current average of BDT 12 to 17 (USD 0.11 to 0.16) (3-7% above the current price) per kg and BDT 19 to 25 (USD 0.18 to 0.23) (4-9% above the current price) per bird for various types of chickens, assuming improved LBM conditions.

These findings are informing the design of improved LBMs to be trialed by STOP Spillover (see Objective 2, Bangladesh Activity 2.2.2.1) and can inform government decision-making about reforming chicken pricing. The findings can also be used to design the modern infrastructure of bio-secure LBMs and increase public investment to develop improved bio-secure LBMs.

3. Engaging national stakeholders to identify important bat-human interfaces across Cambodia

Bats are known or suspected hosts of a range of important zoonotic pathogens and their role as disease reservoirs cannot be ignored. At the same time, bats are also a critical target for conservation - they represent a significant portion of mammalian biodiversity, second only to the rodents in species richness; bats provide a range of important ecosystem services, and they are also evolutionarily unique as the only group of flying mammals. The conservation challenges and public health risks associated with bats often intersect at critical bat-human interfaces, ranging from fruit farms to caves, homes to temples.

In Cambodia, STOP Spillover's National Stakeholder Engagement event and Outcome Mapping workshops identified artificial roost bat guano farms as the first bat-human interface project site for STOP Spillover's work. These workshops also identified that there were other potentially higher risk locations in Cambodia where spillover risk existed and could be mitigated. A national-level risk assessment process was therefore designed to assess and prioritize additional locations for the future work of STOP Spillover.

The objectives of this workshop were to identify bat-human interface locations, select and discuss a subset of these in-depth to better characterize their features, before finally prioritizing a set of sites for future STOP Spillover work. The scope was limited to sites with relevance to transmission risks of STOP Spillover priority pathogens, coronaviruses and Nipah virus chief among them. The National Risk Assessment Workshop was conducted on March 1-2, 2023 via a combination of online engagements and a one-day in-person workshop in Phnom Penh, Cambodia. The workshops were attended by 24 participants, including National, Provincial and District-level government officials from Communicable Diseases Control (CDC), General Directorate of Animal Health and Production (GDAHP), National Animal Health and Production Research Institute (NAHPRI), Provincial Health Department (PHD), Provincial Department of Agriculture, Forestry and Fisheries (PDAFF), and Forestry Administration of Battambang, Kampot and Steung Treng provinces, as well as academic participants from Royal University of Phnom Penh (RUPP), and the NGOs including WCS, FAO and IPC.

A total of 35 sites were identified and 15 of these sites were raised by multiple groups across in-person and online working groups. The top priority subset of bat-human interface locations was determined by participant voting. Top ranked locations were subject to more in-depth characterization including ecological factors, socio-cultural factors, identified hazards, key behaviors, knowledge gaps, and ideas for risk reduction approaches. Many of the top-ranked sites contained primarily cave-dwelling insectivorous bats, with these caves subject to variable combinations of guano harvest, religious/cultural visitation, and foreign tourism. Significant bat hunting likely occurs at many sites. Several sites were identified as inhabited by fruit bats at interface locations such as markets and pagodas, where significant opportunity for incidental exposure exists, as well as some bat hunting. Finally, a small number of caveroosting fruit bat sites were identified. The main activity at these sites was bat hunting, though all these populations are already small and in decline. Six locations in Battambang and Kampot provinces were selected for site visits to ground-truth information from the workshops and to inform intervention design.

Group photo, National Risk Assessment Workshop, Phnom Penh, Cambodia, March 2, 2023.
Photo credit: Tetra Tech

The key knowledge gaps identified center mainly around aspects of host-virus ecology for high priority viral pathogens including SARS-like coronaviruses and Nipah virus, which have been detected in Cambodian bats. There are also question marks remaining over the relative importance of different exposure pathways. Though ample opportunities for direct exposure to bat-borne viruses have been documented in Cambodia (e.g. bat hunting, guano harvest), all the major zoonotic coronavirus spillovers to date are suspected to have involved a bridging host of another mammalian species, and whether this is necessary remains unknown. STOP Spillover is now in the process of designing interventions to reduce spillover risk at new sites in Cambodia, including sites identified in this risk assessment activity. STOP Spillover will co-design effective risk reduction interventions hand-in-hand with local stakeholders. Interventions will be targeted to the interface locations where risk (combination of hazard presence and likelihood of spillover) is greatest. Interventions will be selected based on the strength of the evidence base (both in terms of risk presence and likely risk reduction impact), enabling environment (external barriers, community support), suitability for rapid implementation, scalability of impact and potential for positive synergistic conservation impact.

Developing and Optimizing Methods For Detection of Viral Threats

4. BROAD CRISPR based assay: validating a point of care diagnostic test for Lassa Fever in Liberia

With the technical challenges provided by using PCR, one of the goals of STOP Spillover working with the Broad Institute of Harvard and MIT is to develop a field-based, low cost, and efficient Point- of- Care (POC) test for Lassa virus and other priority viral pathogens. A key challenge highlighted by National Public Health Institute of Liberia (NPHIL) is the ineffectiveness of Ribavirin treatment for Lassa fever when administration is delayed while awaiting diagnosis based on PCR results, since the antiviral is most effective when given early in the course of illness. Liberia is facing a serious problem in Lassa fever laboratory diagnostics. Although the sample transportation system is satisfactory with the support of the Riders for Health project, challenges remain in sample collection due to the limited number of phlebotomists and lack of motivation. Further, retrieval of laboratory results has been a challenge, e.g. there are reports of delays due to ineffective email reporting systems.. A POC test will allow early patient diagnosis and treatment with Ribavirin early in the course of illness, which should reduce the case fatality rate which is currently at 60%.

As part of the effort to enhance and strengthen the capacity of the health laboratory system in various USAID partner countries, the Sabeti Lab at the Broad Institute, with guidance from STOP Spillover, has developed multiple versions of their nucleic acid and CRISPR-based POC assays targeting Lassa virus, a hemorrhagic fever virus endemic to multiple West African countries including Liberia. This assay, called SHINE (Streamlined Highlighting of Navigating Epidemics), targets nucleic acid, using an isothermal amplification step via recombinase polymerase amplification (RPA) coupled with CRISPR-Cas13 as a detection mechanism. SHINE is designed to be a simple diagnostic tool, with a focus on ease of use in low- or middle-income countries (LMIC) settings, compared to PCR. The latest iteration of the SHINE assay (SHINE V2) has a simplified protocol, can be run with minimal equipment, and can be read out on LFA strips. First, the Sabeti Lab focused on the development of a pan-Lassa assay, which would capture the separate Lassa clades (named I through VII, with the majority of circulating Lassa falling within Clade II and IV). A pan-Lassa approach would allow much greater utility of the assay, as there are multiple diverse clades of Lassa virus that affect different parts of West Africa, but is a more challenging development project for the team both computationally and experimentally. The initial design of the assay was conducted using ADAPT (Activity-informed Design with All-inclusive Patrolling of Targets), an algorithm developed specifically to design RPA/Cas13 assays such as SHINE. However, because of the unique nature of the assay with targets encompassing multiple Lassa virus clades and the extraordinary nucleotide sequence diversity across Lassa virus clades, the team needed to develop multiple software engineering solutions to address this challenge. The solutions included new options for weighting sequences (given the biased nature of different clade sequences in public databases) and incorporating phylogenetic analyses in the assay design prediction and output. The team optimized the pan Lassa SHINE assay using these solutions, but ultimately, the Pan Lassa assay had limited detection for the Liberia strain of Lassa fever virus, as compared to the strains circulating in Sierra Leone and Nigeria.

Given the results from a Limit-of-Detection (LoD) study and the challenges of validating an assay for a BSL4 pathogen, the Broad team, in conjunction with STOP Spillover technical experts, determined it was best to shift development to a single target SHINE assay aimed at the Liberia specific strain. It was determined that an assay targeting this strain independent of other assays would be expected to have a vastly improved LoD, similar to other single-strain assays that have been developed for SHINE (e.g. 1,000-10,000 cp/ul.) It was also decided at this time to develop a simple solution to the problem of not being able to test on live (or attenuated) Lassa samples for validation of the SHINE assays. A project was undertaken to express inert Lassa virus RNA sequences, representing the target of a nucleic acid assay (like SHINE), in a human cell line, thus acting as a proxy for Lassa-infected cells in a given testing experiment.

Using ADAPT and focusing on the Liberian strain sequences, several new SHINE assays have been designed and experimentally verified on a single assay design for targeting the Liberian strain. The Broad team is carrying forward these two Liberian strain-specific assays and optimizing the lyophilization and LFA readout of the assay for each. Both assays have been tested using our Lassa proxy system, as described above, and determine the assay with the best performance in terms of LoD, sensitivity, and specificity. The Liberia-specific Lassa SHINE assay was ready for deployment in Liberia in mid-November 2023, to meet the needs of the Liberian Year 4 activities.

The Year 4 work plan for Liberia includes using the developed and optimized Lassa (Liberia strain) assay to (1) assess the relative sensitivity and specificity of Lassa SHINE compared with two PCR assays (Altona and Nikisins) in detecting Lassa virus in samples, and (2) to evaluate the implementation of Lassa SHINE for detecting Lassa virus in human blood samples at clinical sites. A subset of samples tested with Lassa SHINE will be verified using best-in-class PCR tests for validation purposes using clinical samples. These initial field tests will demonstrate the SHINE POC platform's utility in a clinical setting and provide an alternative diagnostic assay to existing systems, an alternative that will lead to a reduced time to diagnose and treat patients and an increase in survival rates.

5. Strengthen the diagnostic capacity of existing environmental health and diagnostic laboratory

As part of the effort to enhance and strengthen the capacity of the health laboratory system in Liberia the STOP Spillover team, working with The Broad Institute, conducted training in Liberia at the National Reference Laboratory (NRL) for members of the National Public Health Institute of Liberia (NPHIL). The training focused on the introduction of the SHINE POC assay, to the

Liberia NPHIL team trained on SHINE technology.
Photo credit: AFROHUN

Liberian team, and was led in Liberia by Dr. Bruno Ghersi, with remote support from the Sabeti Lab at the Broad Institute by Dr. Bidhan Dhar, Jeremy Johnson, and Maya Razmi. The training used a lyophilized version of the SHINE assay (SHINE V2) which has a simplified protocol, can be run with minimal equipment, and can be read out on lateral flow assay (LFA) strips (Figure 7).

The training used a version of the assay targeting SARS-CoV-2 (CoV-2) due to the availability of archived samples at NRL which were previously determined as SARS-CoV-2 'positive' using a PCR screen. The usage of the CoV-2 assay as a training tool serves a dual role: it eases biosafety concerns of a higher biosafety level (BSL) pathogen (e.g. Lassa virus) and can utilize existing previously characterized respiratory samples as a test set, without having to utilize more valuable/rare Lassa samples. The training took place over two days and provided both theoretical and hands-on experience with the SHINE assay. Day 1 consisted of an overview of the technology by the Broad Institute and the STOP Spillover team, including a detailed walkthrough of the protocol. Other topics pertinent for future engagement (e.g. laboratory biosafety considerations, assay design, small-batch assay creation) were also discussed. There was a question and answer session for the NRL team, and the STOP Spillover team became familiarized with the workspace in preparation for the next day. Day 2 consisted of hands-on implementation of the SHINE CoV-2 assay protocol by NRL trainees and was overseen by Dr. Ghersi.

Twenty-five additional SARS-CoV-2 SHINE assays were left with the NRL team for additional practice, training of new assay users, and/or limited incorporation into the future CoV-2 testing pipeline. The trained individuals will be a strong asset in supporting STOP Spillover Y4 diagnostic testing activities in Liberia, including the testing of a version of the SHINE assay targeting Clade IV of the Lassa virus. The SHINE Lassa virus assays (~300 in total) will be delivered to NPHIL in Q1 of Y4. The protocol that participants were trained on is exactly the same for the Lassa SHINE assay, therefore NPHIL now has five experienced SHINE implementers to potentially contribute to Lassa-focused activities in Y4.

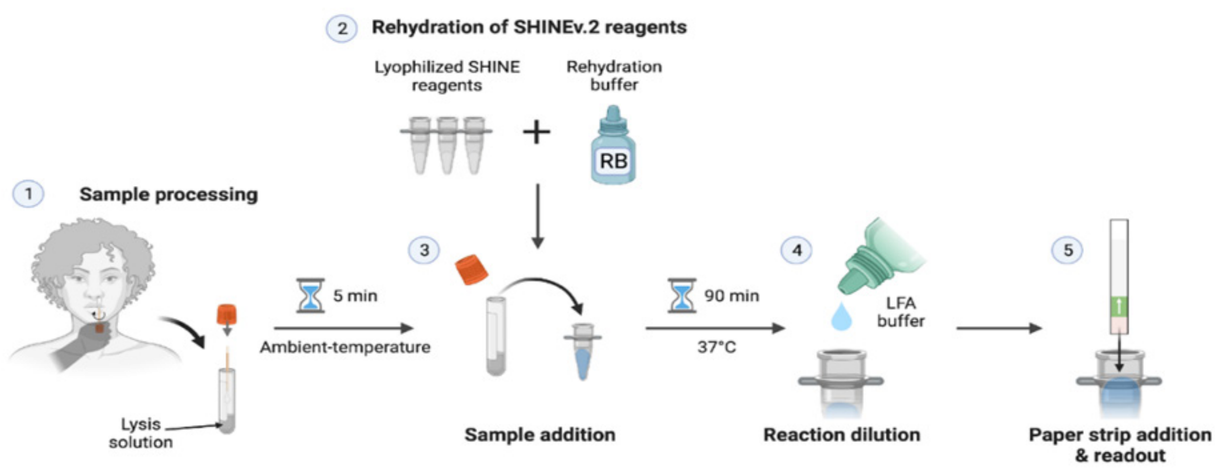
6. Wastewater, waste effluent and surface sampling (Liberia, Côte d'Ivoire, Uganda, and Cambodia)

Global research shows that treatment of both human and agricultural wastewater is frequently incomplete and that known pathogens can continue to survive even in drinking water. The STOP Spillover team has put in place an array of sampling that targets environmental sinks and syndromic sampling. In both Southeast Asia and Africa, the sampling plan includes animal and human syndromic sampling. With partners in government, and private and public health lab systems, we are building capacity for critical surveillance efforts through a combination of sampling environmental wastewater, waste effluent sinks, and syndromic surveillance. Our focus is on underused environmental wastewater resources and surfaces where current approaches enable efficient, broad-scale screening for capture of priority viruses. Highly efficient and cost-effective wastewater and waste effluent surveillance allows the examination of pooled samples from many thousands of individuals compared to indicator-based surveillance in individuals. It complements event-based surveillance and improves the early detection of public health threats to build health security. STOP Spillover is focusing on training researchers in partner countries to perform sampling and testing in Liberia, Côte d'Ivoire, Uganda, and Cambodia.

7. Training in sample collection for wastewater and waste effluent surveillance

Prior work shows that wastewater surveillance can provide two to three weeks of 'early warning' of emerging trends in the prevalence of certain pathogens, including viruses, and can help identify clusters of disease. In the context of this activity

Figure 8. SHINE Version 2 assay workflow.



monitored human and/or animal waste streams can include contaminated surface water downstream of contamination source sites, effluent from livestock production facilities, wild meat or live bird markets, heavily contaminated environmental water in wildlife reserves or game parks, watering sites, and others. It can be expected that some STOP Spillover prioritized pathogens will only be detected rarely (e.g., detection of Ebola in wastewater from human settlements); in other cases, it might be common or seasonally variable (e.g., detection of Lassa fever virus in pooled effluent samples from wild meat markets).

STOP Spillover is collaborating with stakeholders focused on pathogen detection and discovery, and disease surveillance to share resources and samples. Such collaboration will enhance efficiency through the optimal use of resources and help ensure long-term sustainability.

In Côte d'Ivoire and Liberia, a sample collection and analysis protocol developed by STOP Spillover consortium experts and approved by USAID was validated by stakeholders for the Wastewater Surveillance (WWS) and Liquid Effluent Surveillance (WES) activity.

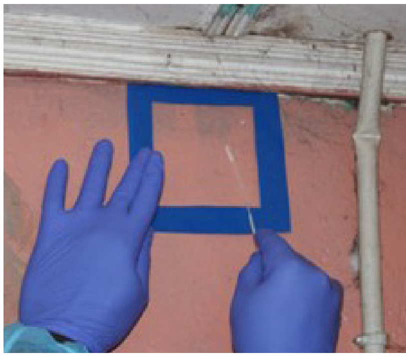
Training for collectors designated by laboratories and entities at the national level was held in the District des Montagnes, Yopougon, and Grand-Bassam in Greater Abidjan. The goal was to train collectors to gather samples for pathogenic monitoring of wastewater and liquid effluents.

In Yopougon, two collection points were identified at the canal level, and both active and passive collection methods were used. For passive sampling, the technique involved attaching a heavy object (e.g., a stone) to the collection device before dipping it into the wastewater. In Grand Bassam, one site was identified at the poultry market, and the passive sampling method was chosen. In CDI, fifteen people participated in the training, and represented various sectors, including Direction des Services Vétérinaires, Laboratoire National d'Appui au Développement Agricole (LANADA), Institut Pasteur de Côte d'Ivoire (IPCI), Centre Ivoirien Antipollution, Institut National d'Hygiène Publique, Centre d'Entomologie Médicale et Vétérinaire de l'Université Alassane Ouattara, Unité de Formation et de Recherches en Biosciences de l'Université Félix Houphouët Boigny and the STOP Spillover team. At the end of the training, collection and analysis equipment were handed over to IPCI and LANADA for sample collection. The training focused on the following points: the presentation of wastewater, and a review of the wastewater and liquid effluent collection protocol, including the equipment required for collection. This was followed by field-level training for the collection agents. Teams of collection agents from the various stakeholders, including partners LANADA and IPCI, were trained to effectively collect WWS and WES samples from different sites. The methods for sample packing and shipping to laboratories were demonstrated. The LANADA and IPCI laboratories were assessed for their capacity to implement the biosafety and biosecurity protocols and to effectively test the samples. The trained collection personnel will begin wastewater and waste effluent sampling and testing for COVID-19 and HPAI in Year 4. This will be done regularly, and test results will be used as a monitoring and /or early warning system for these pathogens.

8. Sampling food, water, and household surfaces to assess Lassa virus presence and spillover risk in Liberia

Mastomys natalensis, the multimammate mouse, is the main reservoir host for Lassa virus and likely the main source of Lassa virus transmission to humans. Zoonotic transmission of Lassa virus is thought to occur through contact with infectious *Mastomys natalensis* tissue or excretions/secretions (e.g., blood, feces, urine, saliva). This can be through direct contact with the reservoir host, or indirectly through contact with food, water, and surfaces contaminated by excretions from Lassa-infected rodents, or through inhalation of aerosolized virus from infectious rodent urine or feces. Sampling of food, water, and household surfaces to test for Lassa virus RNA in environments suspected to have a high level of contamination was done to offer critical insights into the risk of Lassa transmission through these routes.

Preparations included a comprehensive one-day training session for the team and the organization of necessary sampling tools and equipment. The training equipped team members with essential skills and knowledge to efficiently conduct sampling activities and collect accurate data. Once trained, the team collected 340 food and surface samples from 30 households in six communities: Blaygay Pa, Compound III, Nuopea, Gbarpa, Phebe Airstrip Community, and Gokai. These



Surface sample collection (left: swabbing a floor; right: swabbing a table). Six communities at risk for Lassa fever sampled (Blaygay Pa, Compound III, Nuopea, Gbarpa, Phebe Airstrip Community, and Gokai). Photo credit: AFROHUN samples serve as a valuable resource for subsequent laboratory analysis (pending, but planned to be completed by the end of 2023), enabling the identification of potential pathogens and an understanding of the spillover risks in these communities while primarily testing for Lassa virus RNA. Concurrently, surveys with 30 household heads from sampled households were conducted to understand likely levels of contamination of food, water, and household surfaces. The analysis of the samples is currently underway at the National Reference Laboratory (NRL) in Liberia. Results from our assessment of food, water, and surfaces will provide key information regarding their contribution to Lassa virus transmission risk. This information will be critical to the design of interventions to reduce the risk of spillover from rodents to humans and promote safer practices to avoid contamination from rodents.

9.Food, Water, and Surface Contamination Assessment in a Bat Guano Producing Community in Cambodia

Bat guano-producing communities face the very real possibility of viral contamination of food, water, and surfaces from viruses or other pathogens carried by bats. Discussions with key stakeholders in Kampong Cham province in July 2022 indicated that there is a knowledge gap regarding the role of food, water, and surface contamination coronavirus spillover risks. Participants were not aware that viruses could be transmitted from contaminated food, water, and surfaces at the bat-human interface. During discussions with the bat guano-producer community, high-risk spillover activities were identified, including consuming water contaminated by bat guano or urine. Based on these discussions and previous desk research, the STOP Spillover team determined that an assessment of food, water, and surfaces in bat guano-producing communities was necessary to fill knowledge gaps related to understanding possible spillover routes.

This assessment aimed to understand community practices and behaviors that may increase the risk of human contact with bat-contaminated food and water. In April 2023, the STOP Spillover Cambodia team, together with four OH-DReaM Working Group members and two consortium technical advisors, conducted a household survey paired with sampling of food, water, and household surfaces in bat guano-producing households at bat guano-producing households and neighboring non-bat guano-producing households in Kang Meas district, Kampong Cham province, to understand viral spillover risks and exposure pathways in bat guano-producing households and neighboring households. Over four days of sampling and survey data collection, the research team visited and interviewed 10 bat guano-producing households and 10 non-bat guano producing neighboring households , and collected 70 food samples, 75 water samples, and 376 household surface samples for analysis.

Sampling (left to right) a water container, a kitchen table, and a mango. Photo credit: Tetra Tech

Survey results and field observations determined that both bat and non-bat guano-producing households are situated close to bat roosts (less than 20 meters). Survey findings also showed a lack of water treatment and insufficient management or protection of water resources. Ninety percent of households did not cover drinking water storage containers, 55 percent did not cover containers of water used for vegetable production, and 60 percent did not treat drinking water in their homes. In addition, 80 percent of surveyed households did not cover food and meat while drying it. Survey data and field observations suggested that improved hygiene and innovative food, water, and surface contamination interventions in bat guano-producing households are required to mitigate the risk of viral spillover from bats to humans.

Laboratory testing indicated that 1.4 percent of all food samples and 2.9 percent of all household surface samples were contaminated with Alphacoronaviruses and Infectious Bronchitis Virus (IBV). No water samples tested positive. Surface samples tested positive for potential bat-associated coronavirus RNA, whereas IBV RNA was found both outside and on interior surfaces, as well as on food surfaces. These findings suggest that priority community-level risk reduction interventions should focus on the disinfection of high-touch household surfaces, frequent hand washing, and covering foods left to dry or food stored in open containers in open kitchens.

This work identified risk factors for and levels of contamination on food and household surfaces. These findings informed the priority practices for the trials of improved practices (TIPs), and social and behavior change (SBC) interventions designed to support the adoption of improved practices.

Combining findings from this study with household practices and behavioral data facilitated the design and implementation of highly targeted interventions to reduce spillover risks through training, education, and awareness campaigns in bat-human interface communities and households (see Objective 2, Cambodia Activity 2.2.2.1).

Creating Coordination Systems To Improve Surveillance

10. Provincial Coordination Mechanism in Dong Nai province, Viet Nam

Effective detection and control of zoonosis requires well-coordinated action from human health, animal health, and environmental actors. This is especially important at the interface level where people have first contact with infected animals.

In project Year 2, STOP Spillover supported the province of Dong Nai to develop detailed guidelines for implementing inter-sectoral coordination in zoonotic disease prevention and control (work plan activity 2.1.1.1: establish a coordinated mechanism at the provincial level and community collaborator groups). The mechanism was completed and issued by Dong Nai province on September 30, 2022 (No 6555/QCPH-SYT-SNNPTNT), and a steering committee to oversee implementation was established on October 27, 2022 (No 7077SYT-NV), across the province.

In project Year 3, STOP Spillover supported Dong Nai province in disseminating the approved mechanism and conducting a series of MEL activities linked to its implementation, with the aim of promoting the application and compliance with the mechanism for inter-sectoral coordination in zoonotic diseases prevention and control province wide.

STOP Spillover worked collaboratively with the government to conduct a dissemination workshop targeting provincial and district-level stakeholders. A total of 62 implementers at the provincial and district levels (47 men and 15 women) were given detailed instructions on how to apply the guidelines in their work, and were trained on facilitating collaboration on outbreak investigation and response. Additionally, the project collaborated with local government agencies to organize a series of 11 workshops targeting commune-level stakeholders.

A total of 581 participants (387 men and 193 women) attended the 11 one-day workshops.

The STOP Spillover team also collaborated with local representatives to gather preliminary data on the Coordination Mechanism for Zoonotic Disease prevention and control at various administrative levels. This data played a crucial role in shaping the Monitoring, Evaluation, and Learning (MEL) plan, guiding indicators and targets, and tracking changes in stakeholder knowledge and practices related to zoonotic disease

Organizing Committee Presents Course Participation Certificates to Students at provincial dissemination workshop in Dong Nai province.
Photo credit: VOHUN

coordination. In the subsequent months, a series of in-person and online meetings facilitated feedback for refining the MEL framework. The finalized MEL plan underwent further scrutiny through an official review process involving both health and agriculture sectors. The plan was officially issued on September 6, 2023, marked by its endorsement (No. 5497/SYT-NV) by the Departments of Health and Agriculture and Rural Development.

The activity provided essential information and worked towards improving Viet Nam's score in the Joint External Evaluation index (P5.1. Surveillance of zoonotic diseases; D3.1. Multisectoral workforce strategy; D3.3. Workforce training) and Global Health Security Agenda indicators for Viet Nam (Zoonotic diseases (1.2) and biosafety (1.4) through the development of a multisectoral surveillance system to minimize risk).

11. Creating coordination systems to improve multisectoral surveillance for zoonotic spillover Côte D'Ivoire

Creating coordination systems to improve multisectoral surveillance for zoonotic disease spillover involves establishing collaborative frameworks among various sectors to monitor and respond to the potential transmission of diseases from animals to humans. Zoonotic spillover events have significant public health implications and effective surveillance is crucial for early detection and intervention.

STOP Spillover is supporting the strengthening of Côte d'Ivoire's surveillance system, focused on the human-wildlife interface. This is due to the Government of Côte D'Ivoire's interest in veterinary public health, multiple stakeholders and donors being invested in surveillance, and the country's need for greater One Health surveillance and outbreak response capacity, In collaboration with the One Health Platform

Surveillance Technical Working Group and the FAO Emergency Center for Transboundary Animal Diseases (FAO ECTAD), we have given technical expertise to enhance the abilities of government agencies, line ministries, and other relevant stakeholders to successfully conduct disease surveillance and outbreak response at the human-wildlife interface.

In Year 3, STOP Spillover did a surveillance assessment which provided a situational analysis of the surveillance in Côte d'Ivoire revealing inadequate surveillance coordination at district, regional, and national levels, especially at the human-wildlife interfaces where spillover is most likely to occur. A shared information-gathering framework was developed to summarize relevant country resources and capacity with

Table 2. Identified gaps and opportunities in CDI

STOP SPILLOVER OBJECTIVES	GAPS IDENTIFIED	OPPORTUNITIES	POTENTIAL FOCUS AREAS FOR STOP SPILLOVER
Strengthen country capacity to monitor, analyze and characterize the risk of priority emerging zoonotic viruses from animals to people	Few projects in human-animal sector	Several projects exist in the environmental health sector Some projects and facilities working on STOP Spillover priority pathogens exist (e.g. the WHS project is working on birds in Taï and Comoé region and five rest areas for migratory birds in the regions of Grand-Bassam, Grand-Lahou, Abidjan, Assinie and Soubré).[1]	Increase the number of projects that take into account the human and animal sectors
	Weak coordination of activities by multi-sector actors	Existing internal coordination in each sector	Help to establish an intersectoral coordination mechanism
	Lack of activity on the country's priority pathogens (Ebola and Marburg) in the animal and environmental sectors	Some laboratories are active on priority pathogens	Help to develop interventions on these pathogens; e.g. Activity 221, 222, 223, 146
	Lack of risk-based and event-based surveillance	Existence of active and passive surveillance in sectors Epidemiological surveillance, indicator-based surveillance, early alert surveillance exists in the human sector in CDI	Help set up risk- and event-based surveillance at interfaces
	Low variability of funding sources, most laboratories have a biosafety level less than 2 Few laboratories are able to test priority viruses targeted by STOP Spillover Low sample storage capacity for most laboratories Insufficient storage equipment and electricity generators Very few samples are processed per day by most laboratories except LANADA and IPCI	Involvement of the government in funding laboratories Willingness of labs to have a high level of biosafety Existence of labs with BSL 3 and collaborating with external partners Space available for storage equipment	Help to build the capacity of laboratory staff
		All tests are performed in CDI lab	Help to increase routine collection and daily analysis of samples
	No inter-operational information system between human, animal and environmental sectors	Existence of electronic data collection	Help to interoperate information systems
	No studies in progress in the human health sector Very few studies in progress in the human and environmental health sector.	Existing experience in conducting environmental and human health studies	Help to develop multidisciplinary studies

respect to surveillance systems, research networks, and laboratory diagnostics, as well as banked and prospectively collected biological samples. This shared framework helps in identifying common gaps and potential synergies and allows STOP Spillover to compare and learn across countries.

STOP Spillover worked collaboratively with the government to conduct a One Health risk assessment of pathogen spillover at selected sites in the District des Montagnes using the WHO-FAO-WOAH Tripartite Joint Risk Assessment Operational (JRA-OT) tool. Twenty-five people were trained in the use of JRA.

The training was followed by an actual joint risk assessment session to analyze the risk related to Ebola and Lassa viruses.

Regarding the risk linked to the Ebola virus, the following question was analyzed: *What are the probability and impact of at least one actor in the wild meat value chain in the Tonkpi region being infected with the Ebola virus by handling or consuming carcasses of non-human primates and/or bats infected with Ebola virus in the next 12 months?* It was concluded with low uncertainty that the probability of such an event was high, and the impact would be moderate. This worrying risk requires effective management and communication across all parties.

For the Lassa virus, the following question was analyzed: *What is the probability and impact of at least one person from the local population on the Tonkpi-Liberia border, coming into regular contact with neighboring villages in Liberia through cross-border socio-economic exchanges, being infected by the Lassa virus in*

Figure 9. Studies To Identify And Reduce Risk: How Studies Inform Risk Reduction Activities By Country

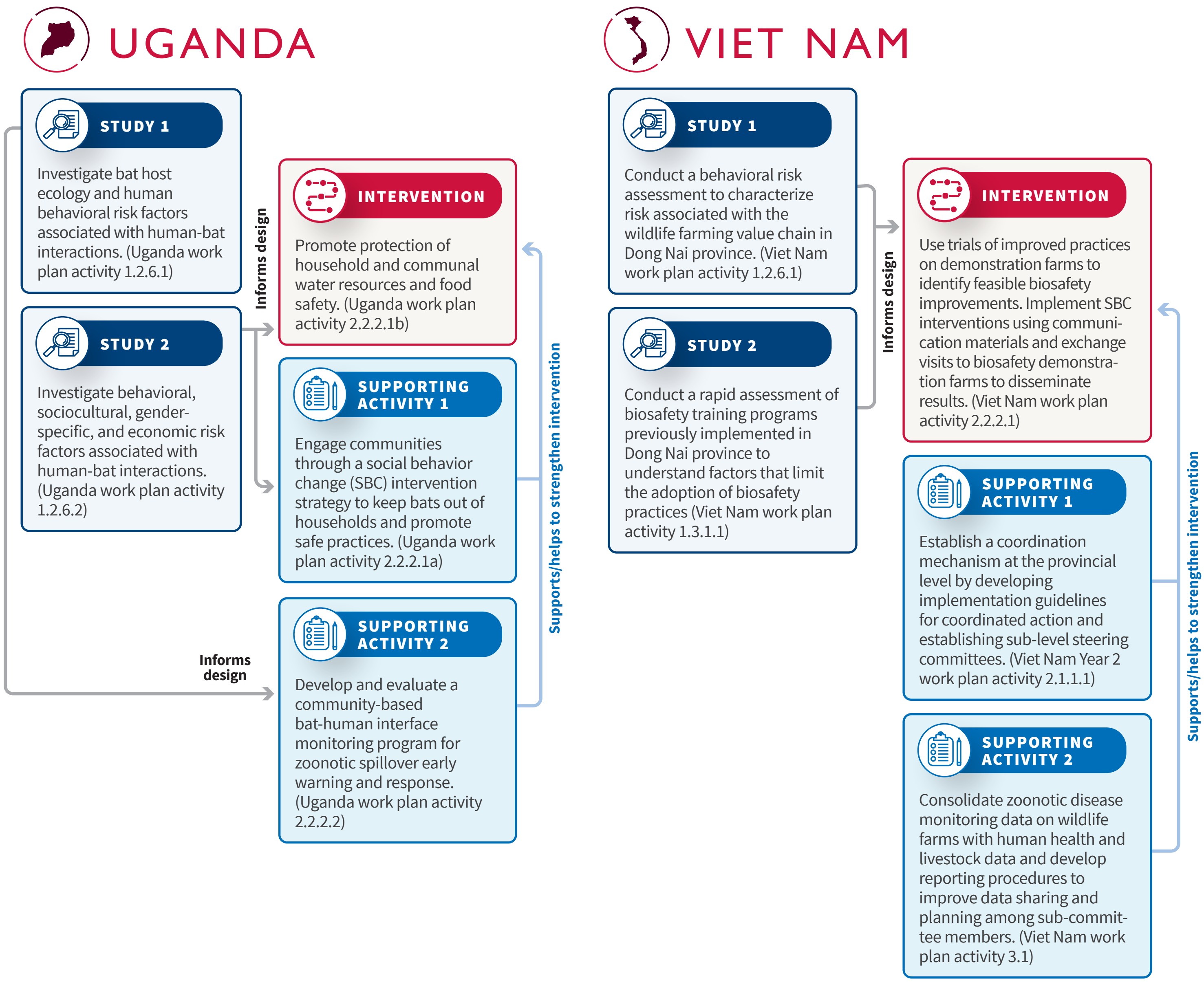
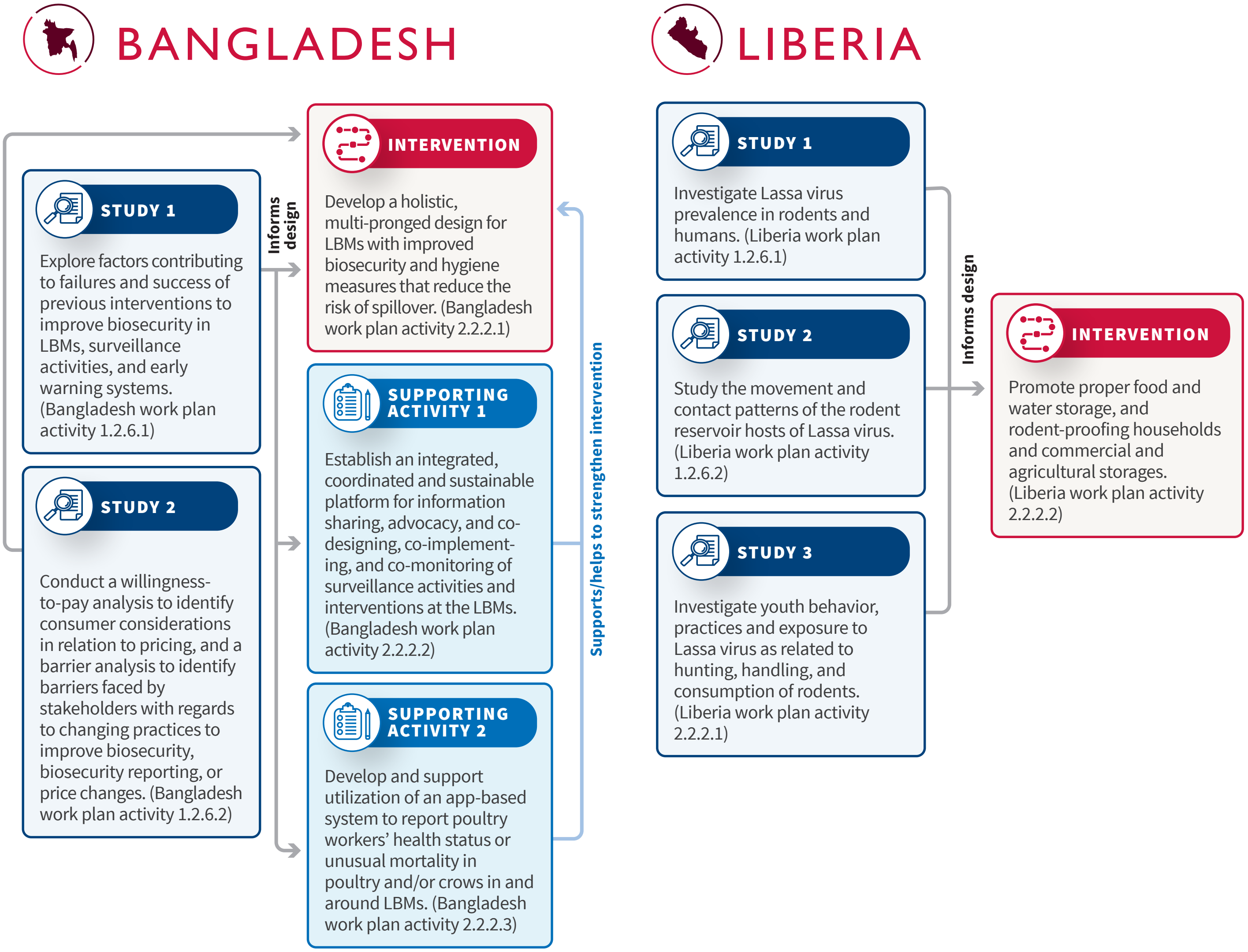


Figure 9. Studies To Identify And Reduce Risk: How Studies Inform Risk Reduction Activities By Country (cont.)



the next 12 months? It was concluded with high uncertainty that the probability of such an event was medium. The impact of such an event would be minor with low uncertainty.

Based on the results of this risk assessment, the One Health Platform proposed several risk management and communication actions such as conducting simulation exercises, strengthening surveillance, and reviewing the communication plan. In order to reduce uncertainty, some studies are proposed on the characterization of population movements in relation to Lassa Fever, the serology of humans and animals in order to determine the pathogens circulating at the human-wildlife interfaces, and the mapping of human-wildlife interfaces to better target interventions.

At the same time, STOP Spillover is conducting a mapping of the specific high-risk human-wildlife interfaces within District des Montagnes using GIS tools. In Côte d'Ivoire, surveillance systems do not cover human-wildlife interfaces where there is a potential risk of pathogen spillover. STOP Spillover, therefore, focuses its interventions on these interfaces and supports the government in setting up mechanisms to coordinate surveillance and monitor the risk of zoonotic spillovers at human-wildlife interfaces in the District des Montagnes. Various data on the physical environment, administrative boundaries, spatial distribution of wildlife and the road network were collected and processed by GIS to produce thematic maps. The goal is to develop a tool for locating areas of high human-wildlife interaction to better target surveillance and risk monitoring activities.

In Year 4, STOP Spillover will capitalize on interface mapping and disease risk assessment done in Year 3 to extend the joint risk assessment to the Guémon and Cavally regions and also guide discussions to achieve a multisectoral coordination of

Figure 9. Studies To Identify And Reduce Risk: How Studies Inform Risk Reduction Activities By Country (cont.)

CAMBODIA

STUDY 1

Research on bat ecology and prevalence of pathogens carried by bats at bat guano farms

STUDY 2

Food and water contamination assessment

Informs design

INTERVENTION

Community-level risk reduction interventions.

SUPPORTING ACTIVITY 1

Coordination and capacity building of sentinel surveillance team

Supports/helps to strengthen intervention

STUDY 3

National risk assessment to prioritize high-risk bat-human interfaces throughout Cambodia

Informs decisions for expanding STOP Spillover activities beyond Kampong Cham

Future risk-reduction interventions/ activities at bat-human interfaces

SIERRA LEONE

STUDY 1

Investigate environmental variables, and sociodemographic and human behaviors and practices that increase the risk of exposure to Mastomys rodents. (Sierra Leone Year 2 work plan activity 1.2.6.1)

Informs design

STUDY 2

Conduct a wild meat value chain analysis and characterize risk of spillover of Ebola virus along the entire value chain. (Sierra Leone Year 2 work plan activity 1.2.6.2)

Informs design

INTERVENTION

Promote improved biosafety practices for actors involved in the wild meat value chain to reduce the risk of Ebola spillover associated with wild meat hunting, trading, and consumption. (Sierra Leone Year 2 work plan activity 2.2.2.2)

SUPPORTING ACTIVITY 1

Promote rodent-proofing of household foods and stored grains to reduce human exposure to Lassa-infected rodents. (Sierra Leone Year 2 work plan activity 2.2.2.1)

Supports/helps to strengthen activity

SUPPORTING ACTIVITY 2

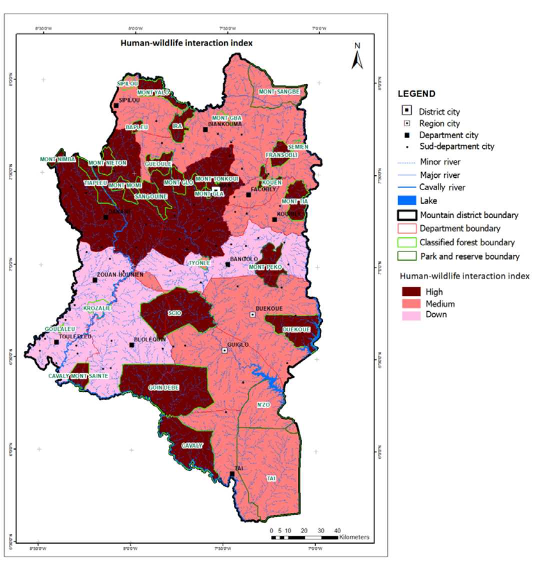
Lassa SBC Activity (Sierra Leone work plan activity 2.3.1.1)

SUPPORTING ACTIVITY 3

Ebola SBC Activity (Sierra Leone work plan activity 2.3.1.2)

Supports/helps to strengthen intervention

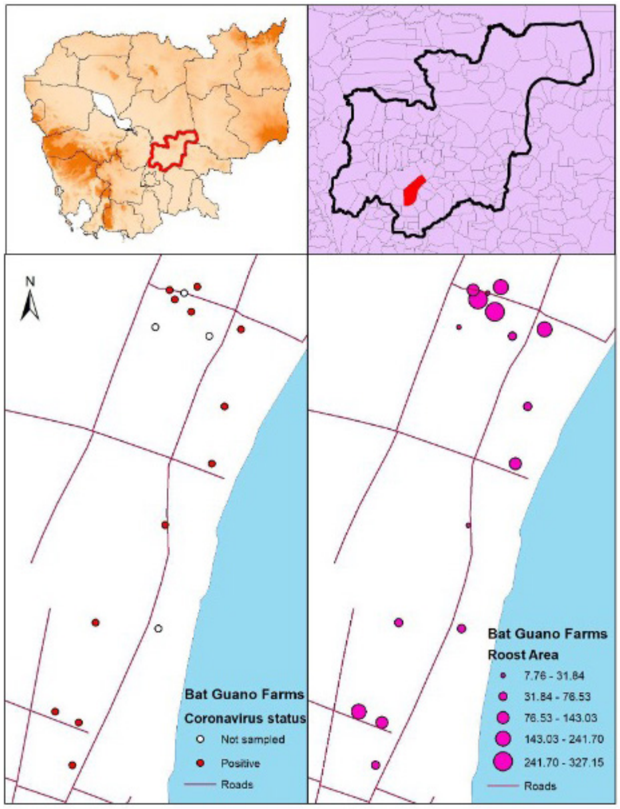
Figure 10: Human/wildlife interaction index in District des Montagnes.



surveillance and risk assessment. In collaboration with the One Health Platform Surveillance Technical Working Group and the FAO Emergency Center for Transboundary Animal Diseases (FAO ECTAD) STOP Spillover will continue to provide technical expertise to enhance the abilities of government agencies, line ministries, and other relevant stakeholders to successfully conduct disease surveillance and outbreak response at the human-wildlife interface. The project will also work with partners to develop a framework for the risk assessment of pathogenic zoonotic filoviruses (e.g. Ebola and Marburg) and other zoonotic pathogens of interest in Côte d'Ivoire.

This activity aligns with the GHSA Category 1: Preventing the emergence or release of pathogens with potential for international concern: Zoonotic diseases (1.2) and biosafety (1.4) through the development of a multisectoral surveillance system to minimize risk and aims to improve the JEE score P5.1 Surveillance of zoonotic diseases and D3.1. Multisectoral workforce strategy: Score (2).

Figure 11. Size of farms (roost area) and coronavirus status during first round of sampling



Using OH-DReaM Working groups, STOP Spillover countries formed teams to characterize risks through data collection. These risks were assessed to better understand the human drivers of viral emergence, transmission, and spread, along with virus and reservoir host ecology. The groups used the evidence found to inform the development of population and/or policy-level intervention strategies. Some OH-DReaM teams focused on systematically assembling and organizing existing data on disease surveillance, laboratory capacity and monitoring, while others addressed key knowledge gaps through research. We conducted in-depth qualitative and quantitative research on high-risk human populations to characterize the biology, ecology, incentives, behaviors and practices that put them at risk. These results informed development and testing of interventions to reduce risk. Depending on the country level gaps and the pathogens of interest, the focus varied from drivers of human exposure to animal pathogens, such as environmental factors, socio-economic willingness to pay studies, behavioral factors, food insecurity, land use, and wildlife trade. Qualitative and quantitative risk analysis and assessment is a fundamental component of identifying and addressing spillover risk vectors. We have used a One Health systems-based risk analysis framework to work with stakeholders in and around critical hot spots and at-risk communities. This multi-phased risk assessment plan includes model cases and country specific risk assessments such as the JRA in CDI.

12. Bat guano farming and prevalence of pathogens on bat guano farms, Cambodia

In Cambodia, bat guano farming has been practiced for many years, but there is little formal scientific documentation of the farms or the practices of farmers. These farms may represent a high-risk interface for zoonotic spillover, but there is inadequate scientific knowledge to assess the real level of risk.

Coronaviruses (CoVs) have been detected in bats worldwide but seasonal patterns of CoV shedding in bats in Asia are complex and not well understood. Alphacoronaviruses, which are generally believed to have low pathogenicity in humans, have been reported at guano farms, but to date, neither betacoronaviruses nor any other coronavirus known to have significance to human health have been found. Only limited sampling has occurred, and uncertainty remains as to whether viruses with pandemic potential could occur at this interface and whether seasonal patterns of shedding exist, which may impact the effectiveness of surveillance.

STOP Spillover Cambodia is studying bat guano farms in Kampong Cham province to (i) assess the scale and distribution of bat guano farming in Kang Meas District; (ii) identify the bat species and zoonotic pathogens present at bat guano farms; and (iii) evaluate the frequency and seasonality of CoV shedding by bats at bat guano farms. The data from this study will inform the design of interventions that reduce the risk of human exposure to bat-associated pathogens.

To address these objectives, we conducted: (i) a household survey of all bat guano farm owners in the target area focused on general information regarding bat roost ownership and scale of bat guano production; (ii) installation of a DVR camera system to estimate the number of bats emerging from selected bat roosts; (iii) acoustic monitoring combined with morphological identification of bat carcasses and interviews with bat farmers to identify the bat species present; (iv) collection of bat urine and fecal samples at bat guano-producing households; and (v) testing of samples for the presence of CoV RNA to quantitatively assess viral spillover risk from bats.

Over the course of eight days of sampling in April-May 2023, 16 bat guano producing households were visited and interviewed, and 256 samples were collected and sent to the laboratory of Institut Pasteur du Cambodge (IPC) to be tested for CoV RNA. A second guano sampling trip was conducted in August 2023 and two further trips are planned for project Year 4.

All farms used bunches of sugar palm leaves as roost material suspended either from palm trees or from human-made structures of timber, steel and/or concrete. Farms had an average of 124 m2 of roost area and reported an average of 12-47 kg guano production per week depending on the season. A distinct seasonal pattern in both respondent-observed bat abundance and guano production was apparent, which aligned with typical weather patterns in Cambodia. The wet season (June to December) represents the time when most farmers reported the highest bat abundance and guano production, whereas the lowest abundance and production estimates occurred during the dry season (January to May).

Respondents showed a high level of interest in and understanding of the bats on their farms. Over 80 percent could correctly identify the dominant species of bat on guano farms (*Scotophilus kuhlii*) from a lineup of anonymous images, and respondents could generally predict accurately the time and direction of emergence of the bats.

Preliminary lab testing results showed that all **12 farms sampled had PCR positive samples**. Bat fecal samples returned a higher proportion of positives than urine. All positive detections at this stage were ≥98 percent identical to known alphacoronaviruses associated with bats in southeast Asia. None of the closest matches were betacoronaviruses or known human/zoonotic pathogens.

Alphacoronaviruses so far have only been associated with mild respiratory disease (cold-like symptoms) in humans, but some alphacoronaviruses do have the ability to infect humans and therefore the possibility of a harmful CoV outbreak associated with zoonotic alphacoronavirus transmission cannot be entirely ruled out. In-depth phylogenetic analysis as well as examination of seasonal patterns of shedding will only be possible once data collection is complete. Field and lab work on this activity will continue in project Year 4. The end of fieldwork is anticipated in February or March 2024 with lab work also scheduled for completion within project Year 4.

Training on data collection (left) and interviewing with a wildlife farmer for data collection (right).
Photo credit: VOHUN

13. Wildlife farming in Viet Nam

Conduct a behavioral risk assessment to characterize risk associated with the wildlife farming value chain in Dong Nai provinces

In Viet Nam, wildlife farms and the wildlife value chains are perceived as high-risk interfaces for disease emergence, particularly for animal coronaviruses. As a result of extensive outcome mapping and community and stakeholder input, a social behavior risk study was conducted in 2022 in Dong Nai province to identify (i) actors who are involved in the wildlife value chain (at the individual and household level); (ii) social, economic, gender, cultural, environmental, and other drivers of spillover risk; and (iii) the level of knowledge of biosecurity and behavior risk factors of wildlife farmers that can spread viral pathogens (e.g. SARS-CoV-2, other coronaviruses). In the implementation process, the study also identified the risk perceptions of participants and their knowledge and practices that can contribute to or offer opportunities for risk reduction. This study focused on legal wildlife farm production of four species and selected aspects of value chains for wildlife traded from farms. The four species considered were bamboo rats, porcupines, civets, and sambar deer.

A cross-sectional study was conducted from July to September 2022 (Year 2) using both qualitative and quantitative methods. Three different types of individual questionnaire interviews were conducted with 267 individuals representing 147 farms, 43 wildlife traders, wholesalers, retailers, and restaurant operators and 103 wildlife farm neighbors and consumers. Sixteen key informant interviews (KII) and four focus group discussions (FGD) were conducted with representatives of leaders and staff of the health, veterinary, environment, agricultural and rural and forestry sub-sectors from provincial to commune levels. Lastly, 20 behavior observation sessions on farms were completed.

The principal findings and recommendations of the behavioral risk assessment are summarized. Since farmers are the central actors in the wildlife value chain, from breeding supply and production to processing, slaughter, and sales, future interventions should focus primarily on wildlife farmers.

Almost all actors lack sufficient knowledge on zoonotic disease control and biosecurity. Wildlife farming practices and animal treatments are largely based on experience in livestock production due to the absence of training, extension or good educational materials. 46.3 percent of respondents are concerned about the possibility of disease transmission affecting humans or animal health, which reflects an awareness of this potential risk. Biosecurity practices on wildlife farms were often poor. Some positive factors were evident: many farms were entirely operated by a single individual and kept only one species. Moderate use of PPE was reported but was sporadic and often ill-matched to the hazards involved. There is no clear guidance on practical, effective practices regarding the use of PPE. Although many farms demonstrated good hygiene standards, others exhibited poor hygiene with no barriers to entry of pests or free-ranging wildlife. Contact with free-ranging wildlife can be a significant risk. Sanitation was highly variable with untreated wastewater and excrement were disposed of on the premises in many cases. The wide diversity in the level of biosecurity offers an opportunity for positive deviance approaches where successful practices in the community can be used to lead change. Positive deviance is the observation that in most settings a few at-risk individuals follow uncommon, beneficial practices and consequently experience better outcomes than their neighbors who share similar risks.

The engagement of government agencies across the One Health sectors exhibited some gaps both internally and externally. Environmental agencies have limited regulations on environmental management functions pertaining to wildlife farms. The Forest Protection Department plays a vital role in management of wildlife farms regarding the origin of captive wildlife and the licensing of wildlife farms but does not routinely perform any animal health management or surveillance functions for farmed wildlife. Some zoonotic diseases that are currently monitored by the human health sector do not include all serious potential emerging threats relevant to wildlife farming. The animal health agencies manage quarantine of domestic animals but lack adequate training on biosecurity, especially in relation to farmed wildlife. They also lack knowledge on the recognition and treatment of common wildlife diseases.

Informed by the study, the STOP Spillover team in Viet Nam selected several key risk reduction practices and then conducted a series of TIPs to test the feasibility of farmers adopting the practices. Those include improving treatment of animal waste, increasing use of personal protective equipment and improving biosafety and biosecurity through disease control and monitoring. Stakeholder engagement in One Health sectors including human health, veterinary services, forest protection, environment, food safety and other sectors under the direction of the Provincial Peoples' Committee and training for One Health staff on biosafety wildlife farming have been implemented. In Year 3, the results of a behavioral risk assessment were synthesized into scientific papers and peer-reviewed by experts across the consortium and the local OH-DreaM Working Group. This led to the development of two manuscripts for international journals and three manuscripts for Vietnamese journals

Conduct a rapid assessment of prior biosafety training programs conducted at the stakeholder level, to improve the design and adoption of appropriate and feasible biosafety recommendations using barrier analysis tools and ethnographic decision trees.

This activity included a rapid assessment of prior biosafety training programs at the Dong Nai wildlife farming interface level, to determine who received biosafety training and the degree to which they have been able to adopt improved biosafety practices after the training, as well as the reasons why they have or have not. We used barrier analysis tools and focus group discussions with actors along the wildlife farming value chain to describe barriers that limit the adoption of biosafety practices. This information was used to improve the design and roll out of appropriate and feasible biosafety recommendations using a "trials of improved practices" approach on biosafety demonstration/model farms (Activity 2.2.2.1).

The Rapid Biosafety Assessment was conducted from July-September 2022 (Year 2) and was divided into two parts for different target groups: (1) a Biosafety Training Assessment focused on establishing an understanding of the existing capacity of 29 government officers working on agriculture and forest protection from national to commune levels; and (2) a Biosafety-related Knowledge, Attitudes, and Practices (KAP) assessment of 66 wildlife farmers in Dinh Quan district.

The assessment included:

KAP survey questionnaires with 66 individuals

2 focus group discussions with among 20 wildlife value chain actors

The key enumerators for both were the leaders and staff from the human health, veterinary, environment, agricultural, rural development, and forest protection subsectors from provincial to commune levels.

Group discussion for data collection (left) and OHDWG meeting to develop a detailed action plan (right).
Photo credit: VOHUN

With regards to Biosafety Training Assessment, in general, there was insufficient training on biosafety and zoonotic diseases for both government officers and wildlife farmers. There were large gaps in knowledge related to zoonotic disease prevention and biosafety/biosecurity standards among both target groups. The most important reasons identified for these gaps were unclear regulations for wild animal health monitoring, food safety, and wildlife value chain inspection and a lack of mechanisms to promote capacity strengthening among government staff and to promote compliance by wildlife farm owners. There are limited One Health-relevant mechanisms for coordination and information sharing among domestic animal health, wildlife health, human health, and environmental health sectors. The barriers to biosafety/biosecurity training are mainly lack of funding for training, and insufficient materials. While most wildlife management staff reported that they had never or rarely been trained in biosafety and biosecurity in general, or specifically on wildlife-specific biosafety and biosecurity issues, 100 percent of government staff considered training on biosafety and biosecurity in wildlife farming as necessary, or even extremely necessary. Most government officers chose all four suggested content categories for additional training, including: (i) basic biosecurity practices, (ii) technical solutions for breeding and facilities, (ii) biosecurity practices for wildlife farms, and (iv) bio-risk reduction measures. Some requested additional content more relevant to their work or personal needs.

According to the KAP survey, only 63% of farmers reported using one or more kinds of personal protective equipment (PPE) during their contact with wildlife.

The most commonly used types of PPE reported by respondents were masks and gloves. Fewer people mentioned other PPE such as dedicated clothing or boots. Most wildlife farmers have never been trained in biosafety and biosecurity practices, and 76 percent of farmers did not think their current farm could cause zoonotic disease outbreaks. Eighty percent of farmers believed that they could or might be able to adopt required biosafety and biosecurity practices with their current resources. The assessment found that biosafety and biosecurity practices are considered socially acceptable. The wildlife farmers' top three priorities for improved biosecurity/biosafety were better use of PPE, improved disease control, and enhanced waste management. Breeding practices, farming techniques, and methods for treatment of sick animals are learned from other wildlife farmers who successfully rear each respective species. This indicates that peers influence the farmers' behavior. This influence can be leveraged for social and behavior change (SBC) interventions. There is a wide range of biosafety and biosecurity levels across operations. Most are cleaned daily, but PPE use in waste handling is limited. To store wastewater and excrement from wildlife production, farmers use both open and covered pits. These waste products are also used for plant fertilizer, biogas, or spread in fishponds. The farmers reported that they treat sick animals by administering medications according to cattle or poultry dosages, adjusted for the weight of the animal. This is understandable as most medications are not labeled for use in wildlife. The most important barriers to implementing biosafety and biosecurity measures as reported by wildlife farmers are the cost of measures, discomfort of wearing PPE, and the lack of available information on biosafety and biosecurity practices for wildlife. In Year 3, the result of a survey had been synthesized and improved in the Viet Nam Rapid Biosafety Assessment.

Drawing from the research findings, in Year 3, the STOP Spillover team initially suggested and conducted a training agenda to improve knowledge and general capacity for biosafety, biosecurity, and zoonotic diseases for managers in One Health relevant agencies at all levels. Communication materials, manuals on farm biosafety and biosecurity have been developed to fill the gap in training materials and will be continued next year. Pilot interventions to test and refine biosafety and biosecurity practices on selected farms accomplished using the TIPs methodology have been implemented, addressing the wildlife farmers' top three priorities (better use of PPE, improved disease control and enhanced waste management). One Health volunteers in the community were selected to support farmers' access to wildlife healthcare and disease reporting in collaboration with appropriately trained animal health professionals. An SBC approach that builds appropriate conditions for adoption of new practices for wildlife farmers and related stakeholders in the wildlife value chain in Dong Nai and throughout Viet Nam is proposed for the Year 4 work plan.

14. Lassa research studies in Liberia and Sierra Leone

1. Understanding the distribution of Lassa Fever in Liberia

Lassa virus infects humans and rodents and can cause the disease Lassa fever in humans. Roughly 80 percent of people who become infected with Lassa virus (LASV) have no or mild symptoms. In the remaining 20 percent, symptoms vary from moderate to severe reflecting viral infection of multiple organs including the liver, spleen, and kidneys (CDC 2019). In pregnant patients, Lassa fever presents special challenges in diagnosis, management, and outcome. Lassa fever is an endemic zoonotic disease in Guinea, Liberia, Nigeria, and Sierra Leone. The primary reservoir of LASV and source of spillover to humans is *Mastomys natalensis*, a type of rodent, which is found in fields, grain storage facilities, and homes throughout sub-Saharan Africa.

Zoonotic transmission of Lassa virus is thought to occur through contact with infectious *Mastomys natalensis* tissue or excretions/secretions (e.g., blood, feces, urine, saliva), through contact with food or water contaminated by excretions from Lassa-infected rodents, or inhalation of aerosolized virus from rodent urine or feces (Amodu et al 2019; Asogun et al 2019). *Mastomys natalensis* can be found living inside homes, which might facilitate indirect rodent-to-human transmission of Lassa virus through rodent contamination of food, water, surfaces or cooking/eating utensils, and *Mastomys natalensis* movement between houses and nearby fields may facilitate Lassa transmission and maintenance within the *Mastomys natalensis* reservoir host population. Humans living in rural homes or near agricultural and garden areas are at higher risk of direct or indirect rodent contact, and thus Lassa transmission. Similarly, humans living in more poorly constructed housing and homes with high human density have been shown to be at higher risk (Gibb et al. 2017; Bonwitt et al. 2017b). Rodent-to-human Lassa transmission may also occur through direct contact with Mastomys natalensis blood, tissues or secretions during activities such as rodent hunting, processing, cooking, and eating (Bonwitt, 2016).

In Liberia, Lassa fever cases have predominantly been reported in a region referred to as the 'Lassa belt' which includes Bong, Lofa, and Nimba counties. However, a distribution model using Lassa case locations and environmental conditions predicted the presence of the virus outside the "Lassa belt" (Fichet-Calvet, 2009), and recent outbreaks in Grand Bassa, Margibi, Montserrado, and Grand Kru counties in Liberia have confirmed this. Based on these results, STOP Spillover hypothesized that the true distribution of Lassa fever in Liberia extends well beyond the so-called "Lassa belt" and that this terminology is inappropriate. To test this hypothesis, we are working with the Ministry of Health (MOH), NPHIL, the Ministry of Agriculture, and local communities to collect and test samples from *Mastomys natalensis* and other rodents for the presence of Lassa virus RNA (an indication of infection). Sampling is being conducted in two communities in Liberia that have reported Lassa cases within the last five years (what would previously have been referred to as 'the Lassa belt') and, critically, in six communities that have not reported Lassa cases within the last five years.

A typical local barn used for storing harvested crops in target communities around the Sierra Leone's Gola Rainforest National Park (left) and Liberia team in full PPE collecting a sample from a trapped rodent (right).
Photo credit: Tetra Tech and AFROHUN

In Liberia in Year 3, STOP Spillover performed studies to determine the real distribution of Lassa virus and its host (*Mastomys natalensis*) with the following objectives:

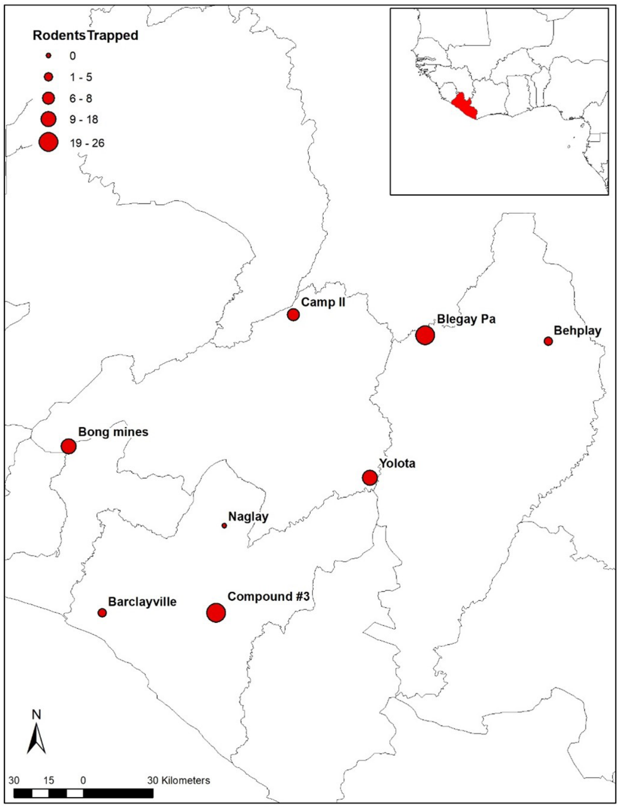
1. Quantify Lassa virus infection and exposure prevalence in *Mastomys natalensis* populations, and, when sample sizes are sufficient, in other rodent hosts within and outside of the Lassa belt. Identify all rodents to the species level.

2. Determine whether Lassa surveillance in the rodent hosts can be conducted using rodent feces found in the environment (e.g. from within homes, food storage areas, food preparation areas and kitchens), and whether results (presence/absence) are equivalent to those obtained through rodent trapping efforts.

3. Estimate population abundance for *Mastomys natalensis*, and, when sample sizes are sufficient, for other rodent hosts within and outside of the Lassa belt.

4. Characterize *Mastomys natalensis* movement between fields/bush and the community.

Figure 12. Map of sites sampled. The size of the red circle is proportional to the number of rodents caught at that site during round one of trapping. Sampling will continue in Year 4.



Two rounds of rodent trapping were completed. In round 1, after an effort of 2206 trap nights, 101 rodents were trapped, with an overall trap rate of 4.7 percent. Ninety-three rodents were trapped inside houses (trap rate of 8.26 percent) and 32 of all captured rodents were preliminarily identified in the field by physical characteristics as Mastomys sp (31 of them captured inside houses). Genetic confirmation of species is pending. Two-hundred and ninety-two specimens were collected from 100 of the trapped rodents, including blood, oral swabs, feces (or rectal swabs), and serum. Twelve environmental fecal specimens were collected from the same households where trapping occurred. Results from these environmental fecal specimens will be compared with results from specimens collected from rodents trapped in the same house in order to compare the effectiveness of these more easily collected fecal specimens to detect Lassa virus. All specimens were delivered to the National Reference Laboratory (NRL) for storage and testing. Results are still being analyzed but to date, 128 of 211 specimens collected during round 1 have been tested, with 5 specimens testing positive, representing 3 individuals from 1 non-Lassa community. Results from an additional 197 specimens from round two are also pending.

2. Socio-demographic, environmental, cultural factors, drivers and practices that increase the risk of human exposure to Mastomys natalensis (and potentially to Lassa virus in Sierra Leone and Liberia)

Few studies have investigated the short and long-term impacts of environmental conditions, human behaviors and practices, and rodent Lassa virus presence on Lassa virus transmission, dynamics, and control. In the context of interfaces selected for STOP Spillover, results from the studies conducted in Liberia and Sierra Leone (Activities 2.2.2.1 and 1.2.6.1) give a comprehensive picture of the complex interactions between the human, ecological, and environmental drivers of Lassa transmission and persistence within the rodent reservoir, and opportunities for spillover to humans. Together, this work will fill important knowledge gaps, better characterize pathogen spillover risks, and incorporate critical influences of farming, household, and food and water storage practices on *Mastomys natalensis* behavior, abundance, and Lassa virus spillover risks. Understanding environmental and sociodemographic factors, drivers, and practices that increase the risk of human exposure to *Mastomys natalensis* informs:

- The design of interventions and pilot test approaches that reduce household members' exposure and interactions with rodents;

- Evaluation of the effectiveness of improved grain storage methods and community hygiene and sanitation practices to reduce rodent (and rodent saliva, blood, feces, and urine) and human interactions at the farm, household, and community levels to reduce Lassa spillover risk.

In Sierra Leone, the STOP Spillover team conducted research in eight communities around the Gola Rainforest National Park (GRNP) in eastern Sierra Leone in March 2023. Three hundred and forty-four respondents participated in the study through Focus Group Discussions (FDGs), Key Informant Interviews (KIIs), and household, farming, and community observations. FGD target groups included male and female farmers, male and female youth, and women who manage household food and water storage systems. KIIs were conducted with traditional chiefs, older farmers, and community health workers (CHWs). The study also included direct observation (DO) of community farming, household grain storage and health and hygiene practices in each community using a checklist developed by the STOP Spillover team, in collaboration with OH-DReaM working group members.

This study filled key knowledge gaps about human-rodent interactions and risk factors in forest edge communities in Kenema district. This information was used to identify and co-design community based Lassa spillover risk reduction interventions with local stakeholders. Most FGD participants identified household and community cleanliness and waste management as critical factors in rodent control and in the frequency and intensity of human-rodent interactions. Several traditional chiefs mentioned existing bylaws that result in fines to community members who do not follow existing sector-wide trash management systems. However, despite these bylaws, direct observations in all eight communities found that there were open garbage dumps close to houses, garbage sites that were not fenced, infrequent use of pit latrines, and open defecation practices, all of which contribute to poor community hygiene and sanitation. Community members felt that improved hygiene and sanitation practices (in particular garbage and solid waste management practices) and improved food and grain storage methods would significantly reduce human-rodent interactions. As a result, STOP Spillover is working with communities to improve grain storage, working closely with critical institutional partners in Sierra Leone including MAFS, MOHS and MECC, local universities, international NGOs (GOAL, WHH, CRS), USAID-funded projects in Sierra Leone and globally (WABILED, WASH-FIN, WASH-PALS2, innovation labs, etc.) and international institutions (WHO, FAO, etc.) and local stakeholders to ensure proven, evidence-based approaches are adapted for local implementation, and validated with local input. Environmental and rodent trapping data from STOP Spillover research efforts will be combined with rodent tracking data to validate the efficacy of interventions over time vis-a-vis the impact on rodent population density in farmers' homes, and the frequency and types of rodent-human contact at home and in farmers' fields.

Set forth below is a summary of key Lassa risk factors disaggregated by gender and age group in Sierra Leone:

Table 3. Summary of key Lassa risk factors disaggregated by gender and age group

	MEN	WOMEN	MALE YOUTH	FEMALE YOUTH
Social cultural practices and behaviors	Men hunt rodents. Men build huts and fences. Elderly men are highly respected and influential in their communities and serve as agents of social change. Women and men use poison to kill rodents.	Women take care of sick people. Women sweep and clean the home and the area around the house. Women dispose of trash and waste Elderly women are respected and influential. Women and men use poison to kill rodents.	Male youth hunt rodents. Male youth transport sick people to the hospital. Male youth dispose of and burn household waste. Young men join secret societies where rodents are consumed. Sometimes youth eat cats, negatively impacting household rodent control measures.	Young women watch over children, who are considered more vulnerable to Lassa. Young women sweep and clean the home and the area around the house. Young women fetch and store water. Young women are responsible for cleaning dishes and storing prepared food. Young women join secret societies where rodents are consumed.
Farming practices	Men perform farming activities including brushing, felling, burning, clearing, plowing and harvesting fields.	Women actively participate in on-farm activities including crop planting, weeding and harvesting. Women are largely responsible for food storage in the home, and grain drying and storage practices.	Male youth are hired as farm labor to clear trees, plow soil, and burn brush.	Female youth plant, weed, harvest, and cook food for workers (Kondae). Young women serve as hired laborers for planting, weeding and harvesting crops.

Table 3. Summary of key Lassa risk factors disaggregated by gender and age group (cont.)

	MEN	WOMEN	MALE YOUTH	FEMALE YOUTH
Environmental factors	Men spend more time in fields when rodents are present.	Women spend more time at home when rodents are present.		
Biological factors		Pregnant and lactating women are at higher risk of suffering severe cases of Lassa fever. Recent data suggests women are more likely to suffer from severe cases of LF generally (58%).	Male and female youth 20 – 30 years of age and children 0 – 9 years of age are more likely to test positive for LF in Sierra Leone.	
Economic factors	Farmers store crops in their homes because it is cheaper and less prone to theft than using community storage. People eat food that has been contaminated by rodents because they are poor and cannot afford to throw it away.			

In recent years, Liberia has experienced several outbreaks of emerging and re-emerging diseases, including Ebola (2014–2016), COVID-19, and repeated, sporadic Lassa fever outbreaks. Subsistence farming and land expansion, especially in rural communities, have increased human and livestock interaction with wildlife. As Liberia faces shifting health threats due to human population growth, economic development, climate change, and human migration, the multisectoral nature of public health challenges arising from interactions among humans, animals, and the environment requires a holistic One Health (OH) approach. People living in rural homes or near agricultural and garden areas are at higher risk of direct or indirect rodent contact and, thus, Lassa transmission. Similarly, people living in more poorly constructed housing and homes with high human density have been shown to be at higher risk (Rory Gibb, 2017).

Compound 3 Community, Grand Bassa County Liberia.
Photo credit: AFROHUN

Waste management may also influence Lassa risk as waste piles are attractive to rodents as food or nesting sites.

In the absence of a vaccine for the Lassa virus (for use in either humans or rodents), options to reduce Lassa fever infections in humans rely on control of the rodent reservoir host and reducing opportunities for rodent-human contact through human behavior change. Interventions that may reduce the risk of transmission include:

- **storing food and water in rodent-proof containers;**
- **reducing opportunities for rodent entry into homes, commercial and agricultural storage areas, and buildings;**
- **keeping communities clean to discourage rodent entry, invasion, and contamination;**
- **and discouraging activities that put people in direct contact with rodents, such as rodent hunting.**

To address these concerns, the STOP Spillover team conducted a Lassa virus risk behavior and exposure study which was designed to acquire additional data and evidence to inform the design of rodent proofing and social and behavior change interventions to address identified risk factors. Given that as many as 80 percent of Lassa virus cases are subclinical or asymptomatic, it is likely that in older age groups, one may have been previously exposed and possess protective antibodies. Thus, the fact that most Lassa fever cases are among those under 30 years of age may not be due to lower exposure in older age groups but possibly due to having acquired immunity over time through subclinical prior infection. As a result, this study aimed to identify the most likely exposure factors to Lassa virus across various age groups.

The qualitative study built upon findings from earlier outcome mapping activities and the Liberia rodent summit to explore specific knowledge, behaviors, practices, and exposures to rodents potentially carrying the Lassa virus. The study aimed to identify risk factors within households and communities that could expose people to the Lassa virus. These included farming and hunting activities, food and water storage practices, health-seeking behaviors, traditional practices and beliefs, and environmental and sanitation conditions at household and community levels. The study covered 12 communities across three counties, observing differences in gender, age, and geographic locations to identify additional risks. These 12 communities fell into one of two categories: Six were communities that had reported Lassa cases within the last five years and six were communities that had not. The rodent trapping and sampling work (see above, Liberia activity 1261) is being conducted in all six communities in which no Lassa cases have been reported in the last five years, and in two of the six communities for which Lassa cases have been reported. The insights gained from this risk behavior study laid the foundation for informed decision-making and targeted interventions to mitigate the risk of transmission in Liberia.

FGDs, KIIs, and community observations were used to obtain data. A total of 48 FGDs were conducted with a distribution of participants based on age and gender. A total of 36 in-home observations were conducted in selected households and 12 environmental and infrastructure conditions (EIC) observed in each community that was visited. The 36 observations were distributed equally between the 12 communities. A total of 460 people participated in the 48 FGDs, with 234 women and 226 men. Thirty-four KIIs were conducted across the three counties, involving various categories of participants, including traditional leaders, religious leaders (both Muslim imams and Christian pastors), and healthcare workers (officers in charge and supervisors of CHWs). The study identified potential pathways of exposure to Lassa virus via direct or indirect contact with infected rodents and their excreta, including:

- hunting, preparation, and consumption of rodents,
- rodent infestation of households, and contamination of food, utensils, and surfaces with infectious rodent saliva, feces, and/or urine,
- exposure during farming activities, and
- environmental contamination/poor sanitation in the community (rodents infesting or contaminating trash dumps, unprotected water sources).

Results were organized under the following four key thematic areas:

- Knowledge, attitudes, & beliefs related to Lassa
- Risk of Lassa from hunting & eating rats
- Risk of Lassa from consuming contaminated food & water
- Risk of Lassa through environmental exposure: household, community, & farm

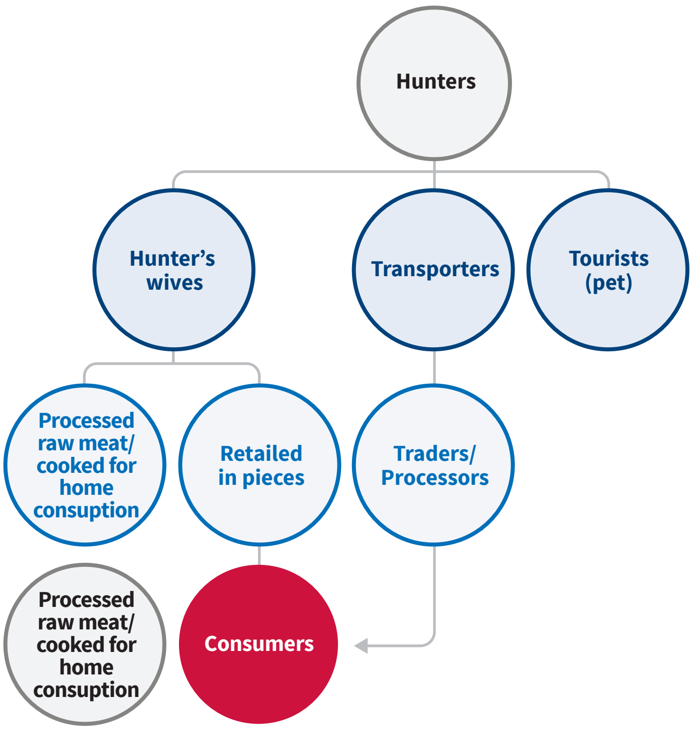
The results showed that the community had an overall accurate knowledge of transmission, and that rodents transmit Lassa through feces, urine, and saliva left on uncovered food or water that is then consumed, and that an unsanitary environment is a risk factor for increased interaction with rodents and thus Lassa virus. Gender-specific differences in knowledge demonstrated that men are more likely to mention eating rats as a risk factor. Some older women (e.g. 25+ years old) had misconceptions that Lassa is transmitted through roaches, bats, mosquitoes, and through eating lizards. Traditional and religious leaders had a mix of accurate and incorrect knowledge about Lassa transmission. Examples of incorrect knowledge included: sharing communal objects, such as a kettle in the mosque; eating together; and cultural practices such as washing dead bodies and praying over sick people. There were increased risks from eating contaminated food and drinking contaminated water due to food and water storage and processing practices, and increased interaction with rodents due to the household infrastructure and hygiene and sanitation practices. The results of this study informed three key interventions: (1) improvement in food storage practices; (2) promotion of proper environmental hygiene and sanitation and waste management; and (3) implementation of a comprehensive SBC campaign to increase awareness about Lassa virus and uptake of safer Lassa virus prevention practices.

15. Examining the wild meat value chain in Sierra Leone

The wild meat trade and wild meat consumption are widely practiced in the communities around the Gola Rainforest National Park (GRNP) and are associated with a complex value chain that varies between rural and urban communities. To design effective approaches to mitigate transmission risk from wild meat consumption and trade, STOP Spillover collected qualitative data to describe the local wild meat trade value chain. This rapid research effort identified the types of species traded or consumed and the frequency of exposure to potential hazards (contact with animal species known or suspected to be Ebola virus hosts) along the wild meat value chain. The STOP Spillover team used FGDs, KIIs and direct observation to identify the critical control points along the wild meat value chain, social drivers and determinants of wildlife hunting and consumption, and specific behaviors by value chain actors which may be associated with an increased risk of zoonotic spillover.

Research findings revealed that wild meat trade and consumption are widely practiced in Kenema district within

Figure 13. Wild meat value chain structure in forest communities around Gola Rainforest National Park, Kenema District, Sierra Leone



a complex value chain structure that varies between rural and urban communities. Key actors in the wild meat trade include hunters, transporters, traders, processors, chop-bar operators, retailers, and consumers. The hunting and processing nodes along the value chain were identified as the two highest risk contact points due to the frequency and nature of human contact with animal fluids including blood, feces, and urine. Hunters and wild meat transporters are mostly young men, while wild meat retail traders and processors (both at the community level and in the wild meat market) are predominantly women. The gendered roles and norms related to wild meat hunting and processing impact intervention design and target audiences.

Contact with animal feces and fluids (e.g., urine, blood, saliva, and intestinal contents) occurs throughout the value chain, from the point of hunting in rural areas to the processing and sale of wild meat in urban areas. The frequency and duration of contact with these fluids varies between actors and communities. Most study respondents stated that they do not use any protective gear while working with wild meat. There is no transportation or packaging of wild meat in local rural markets. However, transportation, primarily in the form of motorbikes, is used to deliver wild meat to urban markets.

The most important drivers of wild meat hunting and trade are cultural and influenced by socioeconomic factors. Wild meat is an important source of protein in all of the communities that were surveyed. Wild meat is also used for medicinal purposes and during initiation processes into the Poro and Bondo secret societies. Wild meat hunting has shifted over the years from subsistence hunting for food and gifts, to hunting for profit. Hunting is a major source of income in hunting households. Hunting revenue is used for various household needs including school fees. It is important to recognize these cultural and economic factors when designing interventions to reduce spillover risk. Without alternate livelihoods, these communities will continue to be greatly impacted by changes in wild meat availability and demand due to climate change, deforestation, seasonality and policies. Supporting these communities to reduce real and perceived risks associated with the wild meat trade and helping them to identify less risky, legal (non-CITES protected) wild meat species and other animal source protein could substantially reduce zoonotic spillover risks.

Focus group discussion in Kenema Sierra Leone.
Photo credit: Tetra Tech

A study on social norms and external factors that affect or influence the adoption of Ebola prevention behaviors revealed that most community members are aware and knowledgeable of Ebola and described the disease as a dangerous sickness that can be transmitted from one person to another and through eating wild animals such as bats, chimpanzees, and monkeys. The STOP Spillover team developed typical personas or archetypes that can be used to design tailored SBC approaches to improve the adoption of Ebola virus disease risk reduction interventions in target communities, by specifically identifying the complex risk factors and risk drivers for each value chain actor.

Findings from this research revealed zoonotic spillover risks along the wild meat value chain and gave insights into the type and design of interventions that might succeed in reducing zoonotic spillover risk at the wild meat interface. Interventions that STOP has initiated include improving infection prevention and monitoring measures at critical control points such as markets and trade zones; improving hygiene and sanitation and food safety measures in wild meat markets; and strengthening health promotion through increased understanding of risks from wild meat contact (described elsewhere in this report). Associated SBC activities increase the likelihood that these interventions can be sustainably adopted by target groups. Interventions to reduce spillover risks will reduce the frequency and intensity of human contact with potential Ebola reservoirs, including bats, duikers, monkeys, and other non-human primates. Engaging local leaders and traditional societies will be critical to the design, promotion, and implementation of interventions to reduce zoonotic spillover risks.

16. Investigating bat host ecology and human behavioral risk factors in Uganda

1. Bat host ecology in Uganda

To inform the previous work plan, barriers at the bat-human interface were identified and these included critical knowledge gaps about bat host biology and ecology, limited community engagement with and awareness of the potential risks related to bat interactions, and the common practices that put humans at risk. In addition to key barriers, stakeholders identified challenges to overcoming these knowledge gaps and barriers such as collaboration between national level actors and local communities and operationalizing One Health approaches.

To begin to fill knowledge gaps about bat biology, ecology, and community uses of bats, the team characterized the presence and distribution of bat species, described bat feeding practices and behaviors, and uses of bats and bat products (e.g. guano) by human communities. The goal of this research was to identify where risk exposure pathways exist within communities and associated potential risk factors for Marburg virus and potentially Ebola virus transmission, which would in turn inform the risk framework and subsequent development of a community-driven participatory bat monitoring system.

The team generated preliminary data for 138 species (~2,000 records, although in some cases we have only few observations per species), and for 10 families. *Pteropodidae, Vespertillionidae, Molossidae,* and *Rhinolophidae* were the most represented genera in our dataset.

Bat in Bundibugyo district, Uganda.
Photo credit: AFROHUN

Initial risk-characterization research on bat-host ecology and formative research to inform SBC interventions were done to contribute to intervention design. Interventions designed aimed to improve household and community practices to reduce human contact with bats, and to support the development and evaluation of a community-based bat-human interface monitoring program to provide early warnings and decrease contact with bats. This research provided information about spillover risk factors, local knowledge, practices and beliefs in Bundibugyo, and strengthened local capacity and skills to design and implement future risk reduction interventions.

Bat-human interfaces in Bundibugyo involve interactions like bat hunting, bat consumption, farming, bats in household and community structures, traditional healers, and local and foreign tourism among others. At this bat-human interaction value chain, the following spillover risks were identified that could inform interventions:

1. Hunting of bats with risks of bat bites and contact with bat fluids like saliva and blood.

2. Bat consumption, especially during handling to remove viscera and actual consumption, especially if not well cooked.

3. Consumption of raw blood from bats as this is believed to treat neonatal anemia and malnutrition.

4. Consumption of damaged fruits, in most cases by children who are not aware of the risk. Observations indicated that adults either discard or clean damaged fruits.

5. Interaction with bat guano and bat aerosols in households and community structures like schools, churches, and mosques.

6. Consumption of water and food contaminated with bat guano. This is common in households and community water collection points where bats go to feed or bat roosts found at watering points.

7. Cave tourism, especially in communities and national parks. Exposure risk is common to foreign tourists, and local tourists especially school children, tour guides, and rangers.

8. Traditional healers that utilize bats and bat products as treatment for various ailments.

9. Farming activities that increased contact with bats.

10. Behavioral, social, cultural, economic, and gender-based risk factors that can lead to zoonotic spillover.

A focus group discussion showing participants doing proportional piling, a participatory epidemiological technique.
Photo credit: AFROHUN

To inform the identification of potential interventions to reduce the risk of zoonotic disease spillover at the bat human interface, community surveys and FGDs were conducted in March 2023 in the three sub-counties of Bundibugyo, namely, Harugale, Ntandi, and Burondo. The research explored the behavioral, socio-cultural, gender-specific, and economic risk factors associated with bat-human interaction in the study areas. A report was done giving preliminary results arising from data collected during this field research and presents highlights of the key findings related to community knowledge, perceptions, and interactions with bats and potentially risky practices. The team originally intended to survey 900 households, 24 FGDs, and 24 KIIs. It was able to do 313 household surveys, all of the 24 planned FGDs, but was not able to perform any KIIs due to the early closure of the Uganda office, which limited the ability to draw conclusions from this study.

The interviews showed that a significant proportion of participants (107/313) were unaware of the risks posed to humans by bats. While many community members had no scientific source of information about bats, others listed sources such as health workers and radio (Fig. X). In FGDs, communities generally described two broad types of bats. These included large bats that are brown in color (locally known as emelema) and small ones that are black in color (locally known as kakolokombe / kelibo). The habitats for bats in the communities mentioned included banana plantations, mango trees, caves/ stones/ culverts, cocoa plantations, houses, church ceilings, and school ceilings.

Community members observed that bat population numbers are lowest in January, with a reduction from November through February according to the participants. Bat numbers were observed to be highest in October compared to other months and begin rising in July.

The study demonstrated that community members have extensive knowledge about bats, including the different species, their habitats, and the factors that attract them to the communities. This knowledge is rooted in their experiences, with many stating that they have lived with bats for as long as they can remember. The study also revealed that the two most common species of bats in the communities are the big brown or black bats (fruit/frugivorous/mega bats) and the small black bats (insectivorous/ microbats), locally known as Omulema and “akakorokombe” /kelibo, respectively. “Omulima” brown or

Figure 14. Trends in bat numbers during the year in Bundibugyo

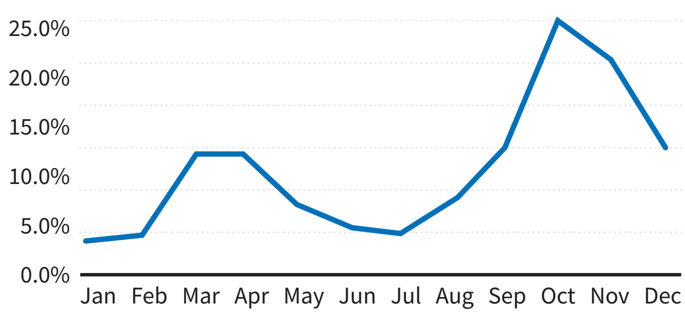


Table 4. Use of bats for traditional medicine

CONDITION	MODE OF PREPARATION
Anaemia	The bats are captured, killed and the blood collected and given to the sick child to drink. Then it is further cooked, and the meat also given to the child.
Love portion	They kill the bat, burn it and crush it into ash/powder and put in husband's food or tea
Stomach complications	For kids who have stomach complications they burn the mouth and the wings of the bat and smear on the stomach of the child with that problem
Delivery complications	Bats are tied around the wastes of pregnant women to help them during delivery. It's believed that it provides ease of delivery
Manpower	Bats are captured, killed, roasted, and dried, crushed it into ash, then using a razorblade, cut at the back of their husband's back and they start to dig very well.
Boosting brain and immunity	When it eats on the fruit, then you give it to a child to eat it, you cut part of the fruit that is not eaten by the bat, it brings knowledge to the child and does not normally get sick all the time.
Wounds	They also cure wounds when they are burnt into ashes and the ash is smeared on the wound
Boosting walking in children	Bat legs are tied on the legs of children to enhance and speed up walking.

black in color, has a dog like face, big wings with umbrella like shape, big eyes and sharp teeth, and feed on crops and fruits. These are mainly found hanging upside down in trees. The small bats commonly termed as "akakorokombe" are black and small in size, nostrils short with split lips, produce rat-like sounds, live in dark places and feed on insects like mosquitoes, and are mainly found in houses.

The study also found that the community members have mixed feelings about bats, with some perceiving them as beneficial due to their role in controlling insect populations, especially mosquitos, while others view them as a nuisance due to their noise, bad smell, and droppings. Despite the mixed feelings, it was evident that the community members were not fully aware of the risks posed by bats, including the potential for zoonotic disease spillover. Community uses of bats and bat products varied across the three sub-counties. Some community members use bats for food, traditional medicine, and as a source of income through the sale of bat guano used as fertilizers in gardens. Others viewed bats as a cultural symbol, with bat-related stories and myths being an integral part of their cultural heritage. Barriers to bat-human interactions included fear of bats, and negative perceptions about bats.

The study employed a methodology of community engagement, which involved focus group discussions with community members. This type of engagement is a vital component in studying human-bat interactions, as involving community members in the data collection process can improve the accuracy and reliability of the data collected. The study also revealed that socio-cultural, economic, behavioral, and gender-based risk factors in the community contribute to the potential for spillover of zoonotic diseases from bats. These factors include poor housing conditions, hunting and consumption of bats, lack of awareness about zoonotic diseases, poor animal husbandry practices like sharing the same house with animals and gender-based differences in use of bats in traditional medicine and exposure to bats. Many households visited during the field visit were unaware of the risks associated with human-animal interaction. This lack of knowledge together with poor animal husbandry practices, improper sanitation, and low household income leading to minimal or no vaccination, increases the risk of zoonotic disease transmission. The study highlights the importance of understanding local knowledge, beliefs, and practices related to bats in the context of zoonotic disease spillover. The results underscore the need for targeted education and awareness-raising campaigns to improve community understanding of the risks posed by bats and the importance of taking measures to prevent zoonotic disease spillover. It is also essential to explore sustainable alternatives to the use of bats and bat products, including promoting alternative sources of protein and income, such as mushroom, bee keeping, livestock farming among others for the communities involved in bat-related economic activities.

IMPLEMENTATION SPOTLIGHT

Research to Understand the Risks Posed to Communities of Artificial Bat Roosts in Cambodia

The Cambodia team is training OH-DReaM Working Groups to survey bat guano harvest sites to document the scale of bat guano production, and carry out non-invasive bat sampling to monitor bat species and pathogens over time at bat guano farms (Activity 1.2.6.1). STOP Spillover has trained government and other stakeholders to conduct food and water contamination assessment by sampling food, water and other sources such as bat roosts, building roofs, and other relevant surfaces as a potential location of bat guano production resulting in public health risks for surrounding communities. The study examines the presence of bat DNA and coronavirus RNA in food, water, and other surface samples to quantitatively assess viral spillover risk from bats to human households.

Context-specific knowledge will be generated from our research to inform intervention design, implementation and surveillance strategies. Results from the assessment will inform the design of SBC interventions to reduce the risk of spillover from bats to humans.

OH-DReaM Working Group and country team members being trained on surface and food sampling.
Photo credit: Tetra Tech

IMPLEMENTATION SPOTLIGHT

Research on the Seasonal Abundance of Rodents and Changes in Lassa virus Prevalence in Gola Rainforest Communities in Sierra Leone

This study is designed to better understand Lassa virus spillover risks in high-risk interfaces (rural forest-edge communities in South Eastern Sierra Leone, along the Gola Rainforest) and to identify ways to reduce the risk of Lassa virus spillover in these communities, especially in the face of potential climate change impacts.

In September 2023, STOP Spillover trained a team of field ecologists in rodent trapping, identification, sample collection, rodent release, and sample storage, with support from a rodent ecologist from Tufts University and ecologists from Njala University. Following classroom training, the team conducted rodent trapping in eight communities around Gola Rainforest in Kenema district, to better understand environmental variables that influence rodent abundance in these communities.

In total, 126 rodents were trapped in eight communities, from which 374 samples were taken (Table 1).

The laboratory testing is underway and results will be uploaded to the secure STOP Spillover cloud system. Samples will be tested using real time-polymerase chain reaction (RT-PCR) assays to determine Lassa virus infection among captured rodents, and DNA barcoding will be used to identify all captured and sampled rodent species. An additional round of capture and testing will take place in December 2023 to analyze seasonal trends in Lassa virus among reservoir rodent hosts.

Chiefdom	Community	Total trap effort (trap nights)	Houses targeted	Rodents captured			Total rodents	Trap success (trap nights/ capture)	Samples collected
				Mastomys natalensis	*Rattus rattus*	Shrew			
Tunkia	Belebu	375	25	9	10	1	20	5.33	57
	Gegbewema	510	34	12	9	0	21	4.12	62
	Kongohun	297	25	13	1	0	14	4.71	42
	Gorahun	450	30	2	17	0	19	4.22	57
Koya	Baoma	450	30	1	15	0	16	3.56	48
	Borgbaubu	315	21	2	9	0	11	3.49	33
	Njalahun	207	14	1	11	0	12	5.79	36
	Mapum	135	9	2	11	0	13	9.62	39
Total		**2,739**	**188**	**42**	**83**	**1**	**126**	**4.60**	**374**

Activities & Accomplishments

OBJECTIVE 2

Objective 2 focuses on assisting countries to design and implement interventions to reduce the risk of priority zoonotic viruses spilling over from animals to people. Risk-reduction activities implemented as part of STOP Spillover are informed by Outcome Mapping (OM) and research conducted under Objective 1. STOP Spillover works with country-level partners to design, implement, and validate interventions to reduce spillover. STOP Spillover's validation process will focus on whether interventions are effective, low cost, sustainable, scalable, context appropriate, gender responsive and/or culturally acceptable. This section of the report outlines STOP Spillover's achievements and accomplishments related to Objective 2 during Project Year 3.

Risk-Reduction Interventions at Prioritized Interfaces

To reduce spillover of zoonotic viruses from animals to people, evidence-based interventions contextualized to specific interfaces that account for cultural, gender, economic and other factors are needed. As part of the effort towards this agenda, STOP Spillover is working with country-level partners to design, implement, and validate interventions to reduce spillover. Interventions designed and implemented in project Year 3 included rodent-proof food storage systems, promotion of improved farming techniques and biosafety practices, protection of household and communal water sources, and development of a bat monitoring framework, among others. Each of these interventions was supplemented with SBC activities to support adoption of behaviors that will reduce risk. These risk-reduction interventions build on learning from Year 2 and previous USAID and U.S. Government investments.

1. Biosafety and biosecurity initiatives at wild meat markets

A rapid 30-day promotion of appropriate use of personal protection equipment among wild meat traders and processors at markets in Sierra Leone

In Sierra Leone hunting wild meat for protein is a common practice. According to wild meat research conducted by the Department of Animal Science and Biological Science of Njala University, primates, rodents, ungulates, cats, rats, and herptiles are sold in markets. Presently, actors involved in the wild meat trade do not practice any form of protection to reduce contact with wildlife fluids (feces, urine, saliva, and blood) that may result in zoonotic spillover, including high priority pathogens such as filoviruses (e.g., Ebola and Marburg).

In Year 3, STOP Spillover designed an intervention to reduce Ebola spillover risks by promoting the use of improved biosafety practices and developing biosafety guidelines for wild meat traders in the Kenema market, the largest and best-known wild meat market in eastern Sierra Leone. A total of 46 wild meat sellers and traders benefited from the intervention.

In collaboration with local stakeholders including wild meat traders, processors and multisectoral district level authorities, the STOP Spillover team co-designed a rapid 30-day intervention to promote the adoption and appropriate use of personal protective equipment (PPE). The design phase started with an initial stakeholder engagement, conducted in February 2023 with18 female market workers to identify biosafety interventions desired by critical partners (e.g., wild meat traders and processors). The stakeholders reviewed a menu of options describing potential biosafety and food safety interventions, including the use of PPE, which have been shown to be effective in reducing wildlife actors' exposure to zoonotic pathogens (OHHLEP 2023; Garland-Lewis et al., 2017; National Park Service, 2014). The stakeholders also identified two to three improved biosafety practices from the menu of options presented by STOP Spillover that they wished to test and evaluate over a 30-day period.

Forty-six wild meat sellers and traders were enrolled in the intervention. They received biosafety materials and training on the use of each of them. OH-DReaM Working Group members engaged them on several topics to improve their knowledge and awareness of safety practices to reduce direct contact with wild meat. This included training on the appropriate use of the biosafety materials, recommended waste disposal practice, and handwashing and hygiene practices. A handwashing station was provided in the market to facilitate adoption of handwashing with soap. Findings from the evaluation of this intervention indicated a high acceptance and use of all types of biosafety measures (110 percent) except for face shields (97.8 percent).

Safe handling and processing of wildlife meat using appropriate biosafety practices at wild meat markets and restaurants in Côte d'Ivoire

In Côte d'Ivoire, an earlier observation on practices conducted in wild meat restaurants and markets in Abidjan and in the District des Montagnes showed poor biosafety practices and hygiene. Moreover, these can pose significant risks for the transmission of infectious diseases, including zoonotic diseases that spillover from animals to humans.

To mitigate spillover risks that may arise from poor biosafety practices and hygiene in handling and processing wild meat at markets and restaurants, STOP Spillover worked with multiple stakeholders in Côte d'Ivoire including public health agencies, ministry of environment, conservation organizations, and local communities to develop standard operating procedures and guidelines for wild meat processing and handling. Fifteen actors were trained in the safe handling of wild meat at markets and restaurants in District des Montagnes.

Development of wild meat processing and handling SOP and protocols

To develop SOPs and guidelines for wild meat handling, a two-day workshop was held in July 2023 with 16 stakeholders from government departments, universities, and research centers to identify and develop the topics and guidelines that would

Hand washing station at Kenema Market in Sierra Leone.
Photo credit: Tetra Tech

be used for training of wild meat processors in CDI. Workshop participants included veterinary services, National Institute of Public Hygiene, National Institute of Public Health, Infection prevention and control platform, Primature, Université Nangui Abrogoua, Université Félix Houphouët Boigny, Université Alassane Ouattara de Bouaké, Centre Suisse de Recherches Scientifiques en Côte d'Ivoire, and the STOP Spillover country team. Participants identified a total of six main topics including: safe wild meat handling techniques, proper use of protective personal equipment, cleaning, disinfection and sanitization of surfaces and equipment, risks and behaviors that lead to increased zoonotic disease transmission through wild meat, endangered wildlife species and conservation, and waste disposal and management.

Training on appropriate use of biosafety materials and equipment for wild meat processing

In September 2023, STOP Spillover team conducted a two-day training of 15 wild meat processors from restaurants and markets in the District des Montagnes. The overall goal of the training was to ensure wild meat processors in markets and restaurants use proper biosafety practices and hygiene measures to reduce the contact with, exposure to, and spread of infectious pathogens while handling and processing wild meat. Participants also learned how to identify and report an endangered species. The training was facilitated by a team comprised of experts from various universities and research centers of Côte d'Ivoire. During the training, participants admitted to not taking any protective actions in the operation of meat processing at all stages of the processing. They were however interested in the simple biosafety principles shared with them, such as "never touch an animal with an unusual smell, color, or appearance; or very quickly and properly remove the digestive tract from the carcasses to prevent meat flesh contamination". Participants suggested that (i) the training be expanded to the hunters in order to have greater impact on preserving threatened wild animals; (ii) that more actors of restaurants and markets selling wild meat receive the training and the biosafety materials; and (iii) that advocacy to the gove rnment be made in order to permit them to conduct their activity within a legal framework. Some of the restaurant owners committed to purchasing PPE for the rest of the workers in their restaurants because they understood the risks posed if they were not all protected.

2. Carcass disposal initiatives

Development of district level capacity for wildlife carcass identification and disposal in Côte d'Ivoire

In Côte d'Ivoire, STOP Spillover is working closely with the Directorate for Veterinary Services (DVS), the local government of the District des Montagnes, the national agency for the rural development (ANADER), the regional directors of environment and health, the One Health Platform, and local communities to build capacity for wildlife carcass identification, disposal, and wildlife mortality event reporting. During Year 3, the project trained 15 government personnel from the ministry of animal resources and engaged a community to contribute in carcass disposal. The training emphasized high-risk species such as non-human primates, duikers, and bats. In addition, specific protocols were developed for proper disposal of carcasses from high-risk species. The protocols included a clear carcass disposal decision criterion for unusual events, even if they do not involve high-risk species.

Demonstration of amimal carcass disposal
Photo credit: AFROHUN

In August 2023, a training of trainers was held in Man, District des Montagnes to strengthen the capacities of government agents in the management of wild animal carcasses. A community engagement activity on wildlife carcass notification also took place in the Gbêpleu community. The three-day workshop was organized around classroom sessions and field based practical demonstrations. Participants were trained in appropriate carcass disposal techniques in a wildlife context, and in biosecurity measures.

3. Rodent-proofing, food and water protection initiatives

Co-designing and testing of rodent-proofing systems for household foods and stored grains to reduce human exposure to rodent contaminants in Liberia.

Lassa fever is endemic in Liberia. Between 2016 and 2020, a total of 168 confirmed cases of Lassa fever and 70 deaths were reported (www.outbreakobservatory.org). With no proven licensed vaccines for Lassa fever in humans, current recommendations for the prevention of primary transmission focus on reducing rodent abundance in houses and surrounding spaces, improving sanitation (rodent proofing houses and/or stored food), and avoiding direct contact with rodents as occurs during hunting and consumption (Jetoh, 2022). In Year 3, STOP Spillover continued to work with stakeholders to mitigate the risks associated with the Lassa virus. The project co-designed and tested rodent-proofing systems for household foods and stored grains to reduce human exposure to rodent contaminants in Liberia.

The design of the interventions was done through several stakeholder engagements. First, on August 3, 2023, the project and the OH-DReaM team members convened a two-day co-design meeting in Monrovia, Liberia. The meeting which was attended by 17 stakeholders at national and sub-national level aimed to review and provide feedback on STOP Spillover's proposed structural and social behavioral change (SBC) interventions. Following the national level co-design meeting, the STOP Spillover country team, in partnership with NPHIL, MOH and MOA, conducted a four-day co-design workshop for 46 community members at community level from Nimba county and Grand Bassa County. The purpose of these workshops was to solicit buy-in and locally tailor the proposed interventions to individual households and community environments. The stakeholders discussed the strengths and weaknesses of the proposed interventions and made suggestions for changes, including additional interventions deemed advantageous and well-suited to the local setting.

Image shows the structural interventions developed including an elevated table with metal/zinc wrapped legs, a cupboard with closing doors also wrapped in zinc/metal and finally, on top, a metal screened fufu and geebee (pounded casava) box to allow food to be kept overnight without being contaminated by rodents.
Photo credit: AFROHUN

The interventions designed included elevated tables with legs wrapped with metal zinc for water storage, food boxes made of wood and metal zinc for food storage, and geebee and fufu boxes made of wood, mesh wire, and screens.

By the end of September, 30 selected homes for the pilot phase had benefited from this intervention across two counties (Nimba and Grand Bassa). Community members took ownership of the interventions by providing their own tables to be designed with the metal zinc.

> "I will give my own table because it is my family who will benefit".
>
> *- One community member in Blegay-pa, Nimba County, remarked*

4. Interventions to reduce risk to wildlife farmers

Trials of Improved Practices (TIPs) in Viet Nam

In Viet Nam, the wildlife human interface was prioritized as the interface of focus for STOP Spillover. One of the key strategies for preventing the spread of zoonotic diseases from wildlife is to improve biosecurity and waste management practices in captive wildlife facilities. This section provides information on the adaptation of the Trials of Improved Practices (TIPs) approach implemented in Viet Nam to improve biosafety practices at the farm level. TIPs is a participatory formative research method that can be used to test and refine potential interventions on a small scale, prior to broader implementation. The approach enlists members of the target population to pilot test the practices and recommend modifications.

The adapted pilot TIPs implementation focused on four captive farmed wildlife species of civet, porcupine, bamboo rat, and sambar deer commercially farmed in three high-risk targeted districts of Tan Phu, Dinh Quan, and Vinh Cuu of Dong Nai province over a period of 10 months as summarized in the flowchart (figure 14).

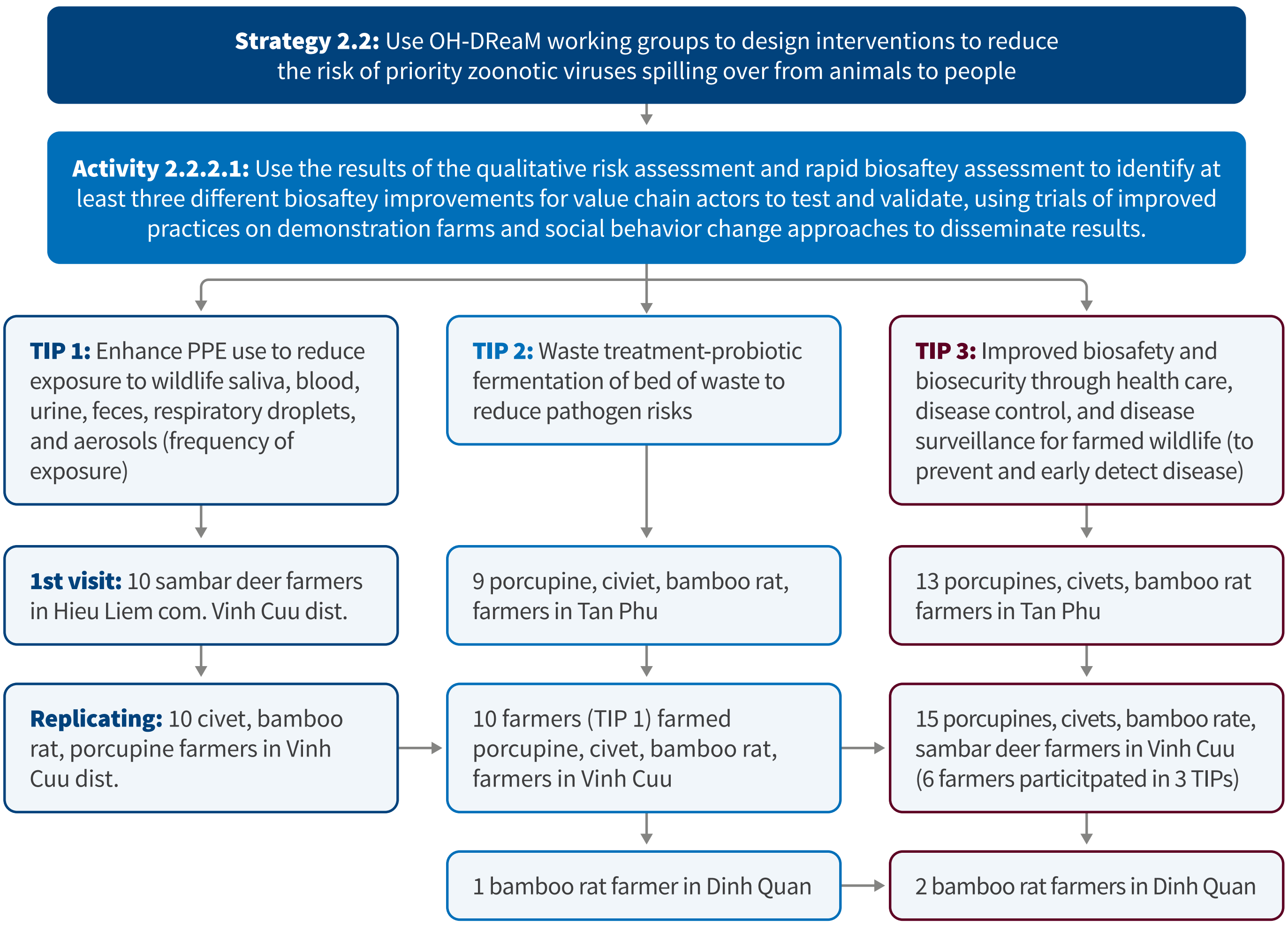
The table disaggregates the number of wildlife farms by the number of men and women participating in the adapted TIPs implementation in three focus districts in Dong Nai province, Viet Nam, including:

- 20 wildlife farms/households (20 actors) participated in TIP 1, of which 6 of the 20 actors joined TIP 2, 11 of the 20 actors joined TIP 3.
- 20 wildlife farms/ households (20 actors, 4 females and 16 males) participated in TIP 2.
- 30 wildlife farms/ households (33 actors, of which 7 females and 26 males) participated in TIP 3, six households of which joined all three TIPs and 20 households joined in TIP 2.

There have been strong results from implementation of the three TIPs with high appreciation from farmers and local implementing partners, including:

- The awareness of wildlife farmers on the use of PPE has changed. PPE use has expanded from limited use to maintain cleanliness to more widespread adoption to prevent pathogen transmission from animals to humans and vice versa. Currently, the use of PPE among wildlife farming participants in the three districts is recognized as essential to biosecure and safe farming.

Figure 15. Summary of TIPs implementation in three districts focused on four captive farming wildlife species of civet, porcupine, bamboo rat and sambar deer



- A new level of trust and enthusiasm has been built between the local veterinarians and the wildlife farmers through participation in the TIPs. Both farmers and veterinarians are actively networking to improve wildlife health. The response to two distemper outbreaks in civets in Tan Phu district was an important learning opportunity for all and has led to better information on disease prevention and awareness among veterinarians including the importance of vaccination in civets.
- The indoor environment of civet farms participating in TIPs has been significantly improved as the odor and ammonia from the animal waste has been reduced through treatment of the manure with fermented Balasa No. 1 Probiotics.
- The waste of bamboo rats composted using fermented Balasa No1 Probiotics has been converted to a safe and economical organic fertilizer for crops. The process should reduce pathogens and farming costs and improve the environment, contributing to increased crop productivity in a circular economy.

Farmers donning their dedicated clothing/boots for wildlife husbandry (left) and emonstration of preparing bedding for probiotic composting of wildlife farming waste (right).
Photo credit: VOHUN

Knowledge, Attitudes, and Practices regarding zoonotic spillover risks in bat guano farms and communities in Cambodia

The construction of artificial roosts to attract insectivorous bats and facilitate the collection of bat guano for agricultural fertilizer has been increasing throughout the last several decades in rural communities in Cambodia, especially in Kampong Cham province. In Kang Meas district, bat guano production farms shelter numerous resident bats, posing a potential public health threat to bat guano-producing households (BGPHs) and neighboring communities. Bat guano producers (BGPs) and their family members, as well as communities that surround bat guano farms, experience elevated risk of contracting bat-borne viral pathogens due to frequent contact with bats, bat feces, and urine produced by the high concentration of bats present in and around their communities.

Using a quantitative survey and qualitative household interviews, this study sought to identify the context-specific knowledge, attitudes, beliefs, and practices of BGPs, their families, and neighboring households related to hygiene and infection prevention associated with exposure to bats and bat-borne pathogens. Data collection was carried out between February 28 to March 3, 2023. A total of 67 respondents (16 BGPs) were surveyed, which included three focus group discussions (FGDs) with BGPs and non-bat guano producers (NBGPs), and five key informant interviews (KIIs) with representatives of BGPs and NBGPs and local authorities in Khchau commune, Kang Meas district, Kampong Cham province.

Table 5. Summary of TIPs implementation in three districts focused on four captive farming wildlife species of civet, porcupine, bamboo rat and sambar deer.

Items		TIP 1 (VINH CUU)		TIP 2 (3 DISTRICTS)		TIP 3 (3 DISTRICTS)	
		Female	Male	Female	Male	Female	Male
1	Number of farmers joined for pilot	5	5	4	10	6	22
2	Number of farmers joined for pilot	2	8	0	6	1	4
3	Number of farmers joined for pilot	0		1	3	0	0
5	Number of farmers joined for pilot	7	13	4	16	7	26
	Total households/ farms	**20**		**20**		**30**	

= Female = Male

Below is a summary of key findings from the assessment:

- Surveyed households and communities are accustomed to "living with bats."
- There is little knowledge or awareness of zoonotic disease risks, or the potential spillover of zoonotic diseases from bats to humans.
- There are several potential zoonotic spillover risk pathways: (1) direct exposure by people collecting bat guano; (2) food and water contamination by bats flying over human living areas; (3) interactions between humans, domestic animals, wildlife, and bats; and (4) disposal of dead bats.
- Perceived health risks in communities (BGPs and NBGPs) are low, resulting in little to no usage of personal protective equipment (PPE).
- Women are the main participants in bat guano production, typically older women. Bat guano production is perceived as a household chore (activities commonly performed by women). As a result, women are more heavily exposed to any zoonotic spillover risks from bats.

Table 6. Risk Pathways, Target Groups, Risk Reduction Behaviors, and Illustrative Interventions

NO.	HIGH RISK PATHWAYS	TARGET GROUPS	RISK REDUCTION BEHAVIORS (ADAPTED ONCE LAB TEST RESULTS ARE AVAILABLE)	PROPOSED ILLUSTRATIVE INTERVENTIONS
BGP ONLY				
1	Guano harvesting (collecting, drying, and packing guano)	• Older women • Others involved in guano harvesting	Guano harvesters use PPE (Face mask, gloves, hats, long sleeves shirt and pants and shoes) when contacting guano at any step of the process. Guano harvesters change from & store PPE away from the house	• SBC Comms—Guidance & Reminders about proper PPE use • Develop context-specific guidelines: *Ways to have a safe bat guano business* • Guano producer WA/Line resource group • Support to ensure the supply of acceptable, affordable PPE • Installing private garment changing areas and tools/resources for PPE cleaning
2	Storing guano for use or sale	• Household members • Domestic animals	Guano farmers store packaged guano away from the house and in a manner that prevents contact with children and domestic animals.	Demarcation and/or provision of secure storage areas/ compartments for packed guano
3	Bat roost structure	• Household members • Domestic animals	Guano farmers elevate nets in which guano is collected and ensure that they are constructed to catch all droppings from the roost, particularly around the perimeter of the roosts.	Demarcation and/or provision of secure storage areas/ compartments for packed guano
COMMUNITY (BGPS AND NGBPs)				
5	Water sources	• Household members • Domestic animals	Household members cover all water containers, including water jars under house eaves, which are exposed to bat feces, urine, and dead bats. Household members move water storage containers as far from bat roosts and house eaves as possible.	• SBC Comms: Contextualize and *Living Safely with Bats* • Community engagement on protection of humans and protection of water and food sources from bats • Local solutions for water container covers
6	Dead bat disposal	• Household members • Domestic animals	Household members identify and bury dead bats immediately and away from homes and keep domestic animals away from dead bats. Household members use gloves during contact with live or dead bats.	• Community discusses disposal of dead bats and identifies proper areas for burial. • SBC Comms: Development of safe bat carcass disposal guidelines for bat guano farms
7	Bats entering the house	• Household members	Household members shutter windows and doors, particularly those in proximity to artificial roosts. Household members cover and store foods drying outside. Households with open kitchens protect food from bat contact.	• For open kitchens, test use of flags to keep bats away (shown effective in keeping bats out of fruit trees) • Appropriate cabinets/ cupboards for food (could be a local income generating activity for women's groups)

Trainers conduct simulation exercises using matrix scoring with OH-DReaM working group members in Cambodia.
Photo credit: Tetra Tech

Creating sentinel surveillance sites in guano communities in Cambodia at risk for zoonotic spillover.

Effective coordination and communication among interface-level stakeholders at the sub-national level is critical to ensure rapid response to zoonotic spillover events and to mitigate amplification and spread in the event of a spillover. Creating a sentinel surveillance system to pilot sub-national zoonosis surveillance at the community level in Kampong Cham province will enable rapid detection of and response to spillover at the bat-human interface and improve preparedness.

In early August 2023, STOP Spillover worked with sentinel sites in bat-guano-producing communities in Kampong Cham province to assess patient prevalence of severe acute respiratory illness (SARI), influenza-like illness (ILI), health-seeking behaviors, and to catalog the types of animal people keep around their homes to plan future sample collection. STOP Spillover One Health Design, Research and Mentoring (OH-DReaM) working group members conducted semi-structured interviews with 14 representatives from the human and animal health sectors. A focus group discussion (FGD) with 17 representatives of bat-guano-producing households (BGPHs) and non-bat-guano-producing households (NBGPHs) and a transect walk were conducted.

According to three local public health establishments in the target sentinel sites, there are 2-3 cases of SARI and 1-2 cases of ILI per month. Generally, BGPHs and NBGPHs seek more treatments with private clinics (60%) than with public health centers (40%) once they fall ill with SARI and ILI. Livestock (cattle, chickens, and ducks) and pets (dogs and cats) are kept by most BGPHs and NBGPHs. Each BGPH and NBGPH own approximately 15 – 16 animals, including both livestock and pets. Information generated through this exercise will help OH-DReaM members to monitor and analyze emerging virus spillover risks at the target interface and inform the design of the local syndromic and active surveillance system that STOP Spillover will support.

Coordination and capacity building of the sentinel surveillance team are ongoing. OH-DReaM WG members have strengthened their capacity for syndromic and active surveillance, and 15 completed didactic and practical participatory epidemiology training in September 2023. The surveillance system emerging from this participatory co-design process is unique and well-suited to present challenges in pandemic preparedness and response. STOP Spillover Cambodia looks forward to implementing this innovative system during project Year 4.

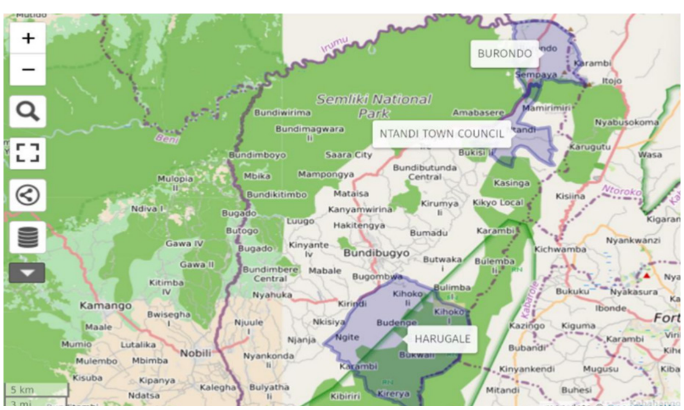
5. Interventions to reduce contacts with bats.

Developing and evaluating a community-based bat-human interface monitoring program for zoonotic spillover early warning and response in Uganda

Ebola Viral Disease (EVD) outbreaks have occurred with increasing frequency in recent years in Uganda, and the disease constitutes one of the largest current public health problems in Africa. Since 2002 Uganda has documented a total of six Ebola outbreaks. Additionally, three outbreaks of Marburg viral haemorrhagic fever have occurred in the country since 2007, including in Kabale district (2012), and Kween district (2017, traced to rock salt mining in a bat cave). While the viral reservoir for Ebola virus disease has not been definitively determined, Rousettus aegyptiacus has been identified as the reservoir for Marburg virus. . Zoonotic spillover has been associated with activities that increase human-bat contact. In project Year 3, STOP Spillover continued to work with stakeholders in Bundibugyo district to reduce the risks of viruses from bats spilling over to humans through the implementation of a participatory bat monitoring program centered around community-driven participatory mobile phone-based surveillance. The bat monitoring program has been operating since February 2023 in three sub-counties of Bundibugyo; Burondo, Harugale, and Ntandi town council. The goal of this program is to identify where humans are exposed to bats, and associated potential risk factors for viruses from bats, to identify the potential sources of risk and inform the design of risk reduction interventions.

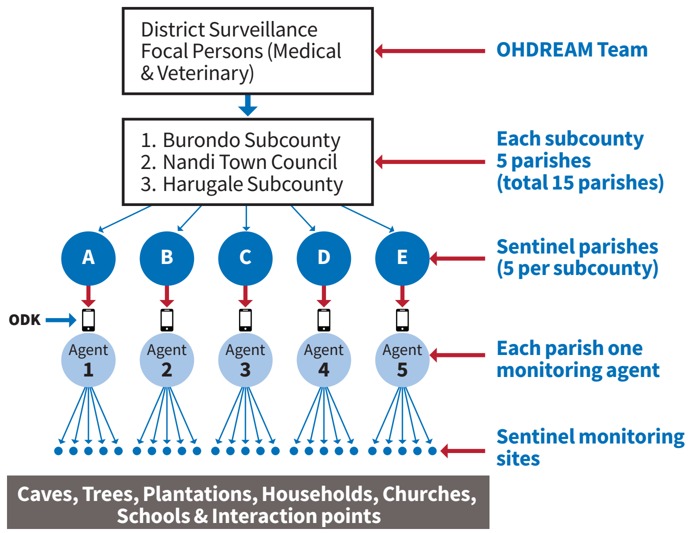
A key component of this activity is training and strengthening the capacity of local stakeholders to conduct surveillance using participatory epidemiology methods. A 10-day training was conducted in November 2022. Nineteen participants from a range of One Health disciplines appropriate to address the mitigation of spillover risk from bats to humans were

Figure 16. Map of Bundibugyo showing the 3 bat-human interface project areas of Burondo and Harugale sub county and Ntandi Town Council



selected to attend the 10-day training. Participants were drawn from local government officials at the interface district, OH-DReaM working groups, tour guides, park rangers, surveillance focal persons, Red Cross community surveillance volunteers, and parish administrators. Key outputs of this 10-day training included: (i) an initial list and map of sentinel surveillance sites; (ii) a list of bat monitoring agents across different parishes and villages; (iii) a list of key informants across the bat-human value chain to be engaged; and (iv) a draft bat monitoring framework to guide the community bat-human monitoring program.

Figure 17. Framework to guide participatory community-based bat-human interaction monitoring in Bundibugyo District



To standardize the monitoring process, a framework to guide participatory community-based bat-human interaction monitoring in Bundibugyo District was developed. The framework provided a detailed description of the planned community- based program for monitoring bat human interactions. Within each of the project sub-counties, five parishes were selected for monitoring, making a total of 15 parishes in the district. Each parish was provided with one bat monitoring agent (15 agents across all parishes) to monitor key human-bat interactions within their communities. Monitoring of bat roosts was done twice a month, once during the first week of the month (1st – 5th day of the month) and in the middle of the month (15th – 20th day of the month).

The bat monitoring exercise was carried out between February and March 2023. In total, 73 roosts were identified and mapped across the project sub-countries. There were variations in the number of roosts observed, specifically an increase of 17 to 24 new roosts between the end of February and beginning of March.

A reduction to only nine new roosts was observed at the end of March, attributed to the hot weather that led to migration of bats. Two main types of bats were observed: Emilima (big bats) and Keribo/kakolokombo (small bats). The number of observed bats increased from the start of February up to the start of March. This was mainly observed in roosts reported to have few observed bats (<5) at the time of roost mapping. However, the bat numbers started reducing from the start to the end of March. The majority (43%) of bat roosts were inside buildings, whereas the least number (9.7%) of bat roosts were observed in gardens.

While this bat monitoring activity was done for only two months, it offers insights into potential spillover points. For example, the greatest spillover risk was observed in household structures, especially those without ceilings, where household dwellers come in direct contact with guano, including via their drinking water and food. Therefore, interventions to reduce the bat-human interactions in households and protecting household drinking water and food from contamination are key to reducing the spillover risk. Notably, the majority of bat roosts were identified near national parks, and in some instances, bats appeared to have migrated back to the national parks. This calls for interventions targeting park encroachment, illegal tree cutting in parks or planting of trees to attract bats away from homesteads. However, we could not ascertain where the bat migrations had occurred for established roosts devoid of bats during the monitoring period. Therefore, studies tracking bat migrations over a wide distance could be beneficial in characterizing the spillover risk.

Engaging communities through an SBC intervention strategy to keep bats out of households, identify, and promote safe practices in Bundibugyo, Uganda

In Uganda, many households have bats living within their houses, usually in roofing materials. Opportunities for contacting bats occur on a daily basis, and are mainly driven by people's livelihoods, including economic, nutritional, and cultural needs. To achieve effective and sustainable preventive measures around bat contact in communities it is necessary to identify the risk factors that increase likelihood of exposure in order to prioritize possible interventions using defined criteria. In Year 3, STOP Spillover drafted an SBC strategy and plan for addressing practices, behaviors, and norms that put families and communities at risk, and promote sustainable, locally available ways to keep bats out of households, as well as safe practices around human interactions with bats. The strategy was developed based on findings from Uganda's study for addressing practices, behaviors, and norms that put families and communities at risk of viral spillover.

The strategy provides a roadmap outlining multiple prioritized interventions and channels at different levels to increase impacts, such as community dialogue, interactive radio programs, and interpersonal communication. It is intended to support and strengthen Uganda's intervention to promote safe practices for protecting food and water resources at the household and communal level. While it was not implemented by STOP Spillover due to the end of the project in Uganda, we recommend its adoption. The specific objectives of this intervention included.

Identifying and testing locally available and affordable materials to keep bats out of homes and community buildings.

Engaging local women, women's groups, and school clubs in testing out plants that repel bats due to their scent, such as mint and rosemary.

Improving community knowledge of, and increasing uptake of safety practices, by engaging VHTs, community leaders, religious leaders, community radio, and other influential channels in a multi-pronged SBC strategy and plan.

Determining the effectiveness and usability of available communication materials such as "living safely with bats", and determining the need to adapt, tailor/ format content to various audience segments, and /or develop additional materials.

Rolling out the SBC strategy: Between October 31 and November 9, STOP Spillover conducted a multi-day community engagement exercise, targeting communities from Harugale, Burondo, and Ntandi town council, in Bundibugyo. This activity was guided by the earlier consultative stakeholders' meeting and participatory assessments on human interactions with bats in Bundibugyo District with a focus on designing barriers and use of bat repelling plants to keep bats out of households and community buildings and promote practices to live safely with bats. Key outputs from this community engagement exercise included: identifying a list of households, schools, women's groups, and places of worship where barriers will be tested; identifying local artisans to support the design of barriers preventing entry of bats into buildings; identifying key social and cultural barriers and motivators for living safely with bats; identifying local influencers and channels of communication for SBC; and identifying bat repelling plants to potentially test.

In addition to the community engagement activity STOP Spillover conducted several other community meetings during this reporting period. In December 2022 , the STOP Spillover Uganda team visited individual households and community buildings with bats to understand the barriers, needs, availability of locally available materials and reliable sources and cost of bat repelling plants (rosemary and mint). In February 2023, STOP Spillover trained 120 women from Harugale, Burondo, and Ntandi on the planting and care of plants that repel bats.

The STOP Spillover team also pretested a community discussion guide on living safely with bats with local women and village health teams. The purpose of this pretest was to ensure that the illustrations and messages were acceptable and comprehensible and were contextualized properly to inform its adaptation for rolling-out to communities across Bundibugyo.

A post-test exercise for Living Safely with Bats at Burondo sub county. Photo credit: AFROHUN

Promoting protection of household and communal water resources and food safety.

One of the most common risk exposure pathways involves human contact with bat excreta through unprotected water collection and storage containers. Bats like to rest close to watering points. Bat roosts are often found in the roofs of houses, churches, and schools, and if water containers are left open, especially during the day when bats are at rest, bats can urinate and defecate in them. This also applies to communal water resources such as free-standing wells and surface water. Informed by findings from Uganda's study, STOP Spillover implemented an intervention that involved selecting practices designed to mitigate the risk of contamination of water and food by bat excreta. This intervention was designed to target mostly female household members, whose roles include collecting, storing, and protecting water and food; however, male household members were also included. The activity involved developing and testing simple, easy-to-use, and locally available tools using a TIPs approach.

STOP Spillover conducted a workshop to gather critical information to inform the design of the intervention. Specifically, the objectives of the workshop were: to identify current food and water safety practices among community members; to sensitize communities about the planned TIPs process and the importance of food and water safety practices; to select and codesign potential practices to test through the TIPs process; to identify motivators and barriers which influence food and water safety practices; and to identify households willing to participate in the TIPs process. A workshop was conducted in Bundibugyo, supplemented by three smaller workshops at the sub-country level (Burondo, Harugale, and Ntandi), involving 75 participants in total. Participants represented at least 12 households from each of the three targeted sub counties.

6. Development of an integrated App system to report poultry workers health status and mortality in poultry and wild bird in and around Live Bird Markets (LBMs) in Dhaka, Bangladesh

Early detection of zoonotic diseases allows for the implementation of response measures that may reduce the loss of human lives and economic disruption. Preparedness to identify and contain such emerging pathogens is a high priority for the global health agenda in Bangladesh. During a workshop in August 2021, the project proposed an activity using a mobile app to detect early signs of avian influenza in and around live bird markets in Dhaka city. The Institute of Epidemiology, Disease Control and Research (IEDCR) has been tracking health outcomes in humans and animals related to human cases since 2009. However, their surveillance system relies mostly on reports from the media, which can cause delays in investigating outbreaks. By using mobile phones for surveillance, it becomes possible to collect data from the community in near-real-time, even in remote and hard-to-reach areas. This helps minimize delays and reduce the amount of work needed. This intervention aims to generate data on poultry workers' health status, as well as unusual mortality in poultry and wild birds in and around live bird markets (LBMs). This intervention will also ensure real-time access and visualization of data submitted by app users via web-based platform, which can be used to trigger government response and disease mitigation in the event of an outbreak.

The key objectives of the intervention are:

1) to enable stakeholders to report unusual mortality among poultry and wild/pet birds around LBMs through a mobile phone app-based system.

2) to enable LBM workers to report illness with specific symptoms (fever and cough or conjunctivitis with or without fever), which may be a sign of influenza illness.

3) to test acceptability, feasibility, and efficiency of the app among different LBM stakeholders as proxy measures for sustainability following activity handover to the government.

To achieve these objectives, the requirements and technical specifications of the system were defined, and a local software development company with experience working with government institutions in Bangladesh was hired. The firm was also selected given their experience developing mobile applications for both Android and iOS operating systems, as well as web-based software solutions. The company has developed the Android version which will be in use for the pilot phase as most of the smartphone users in Bangladesh own Android phones. Users of the App will be able to select the Bangla language option. In order to ensure sufficient data monitoring and sharing, two distinct user groups were identified for the app application:

Live Bird Market (LBM) workers and customers: These serve as end users of the mobile application.

Strategic government stakeholders (data users): Stakeholders and data users assume a critical role in this intervention. This group possesses the authority to monitor, verify, and validate data shared through the web based application.

A mobile app has been developed for stakeholders to collect data in real time and the data being collected is being stored in a secure cloud-based storage system and featured in a web-based platform for data analysis and visualization.

7. Develop a holistic design for bio-secure LBM in Bangladesh

STOP Spillover is working to develop a bio-secure live bird market (LBM) design to reduce the risk of zoonotic spillover of avian influenza at the LBM interface in Bangladesh. STOP Spillover Bangladesh is adopting a holistic approach that considers:

- the **physical infrastructure** (e.g., improving poultry caging, ventilation, water supply, drainage, sanitation, and waste management).
- context-appropriate and easy-to-understand-and-implement **biosecurity and hygiene guidelines/SOPs** for various LBM actors.
- coordinated biosecurity **compliance monitoring plan** to be used by regulatory bodies internal and external to LBMs.
- coordinated **funding mechanism** shared among LBM stakeholders, local communities, and regulatory bodies to implement and sustain the interventions.
- comprehensive **social and behavior change (SBC) and advocacy strategy** to raise awareness and improve prioritization of LBM biosecurity among LBM workers, consumers, policymakers. and regulatory bodies.

Bangladesh proposed interventions to support LBM stakeholders of Dhaka city to develop and implement an LBM design with improved biosecurity and hygiene measures that reduce the risk of spillover. In addition to developing a bio-secure LBM design, biosecurity guidelines, and a compliance monitoring plan, this intervention aims to develop and implement a coordinated funding mechanism shared among LBM stakeholders, local communities, and regulatory bodies to ensure the sustainability of the intervention. A comprehensive social and behavior change (SBC) strategy and an advocacy component are also included in this intervention. Using the outcomes generated from Outcome Mapping (OM) and findings from two subsequent research activities, in collaboration with relevant stakeholders, the team designed the intervention for a bio-secure LBM, which will be implemented in a single poultry shop LBM in Dhaka North City Corporation (DNCC).

1. Design Infrastructure in Bangladesh LBMs

Live bird markets (LBMs) are considered hotspots of avian influenza virus and contamination as well as a significant source of foodborne pathogens, including Salmonella, enteropathogenic E. coli and Campylobacter. STOP Spillover Bangladesh conducted research to explore factors contributing to failures and success of previous interventions to improve biosecurity in the LBMs of Bangladesh and identified gaps in the LBM infrastructure interventions (See Objective 1, Bangladesh Activities 1.2.6.1 and 1.2.6.2). STOP Spillover Bangladesh team organized three consecutive workshops (April - May 2023) supported by Bangladesh Agricultural University and Mymesingh with other key stakeholders where expert members designed bio-secure LBM's tailored to Bangladesh context. Three designs were proposed as:

DESIGN 1	Design for renovation of existing single-shop LBMs
DESIGN 2	Design for renovation of existing multiple-shop LBMs (manual and semi-automated poultry processing systems)
DESIGN 3	Design for construction of new multiple-shop LBMs

The designs followed the biosecurity principles:

1. **A ventilation system** that ensures to prevent particle spillage out of the cages towards seller or buyer which reduces potential transmission.
2. **Floor:** Floor should be easy to clean. Tiling was found to be preferable for caging areas due to ease of cleaning.

3. **Cages:** Multi-layer metal cages should be used to contain live birds with a tray underneath each layer to collect waste.

4. **Drainage system:**
   a. Concealed drain should be situated under the floor with opening in the middle of each vendor area and should be connected to the central sewerage line of the market.
   b. Sloped floor for the selling platform and a drain line between the high platform and passage so that the wastewater from the selling area can easily pass through.

5. **Water supply:**
   a. Reserve tank with backup for sufficient water supply.
   b. system for hot water supply at the processing area.

Design 1 has been adopted. Renovation of the existing single-shop LBM.

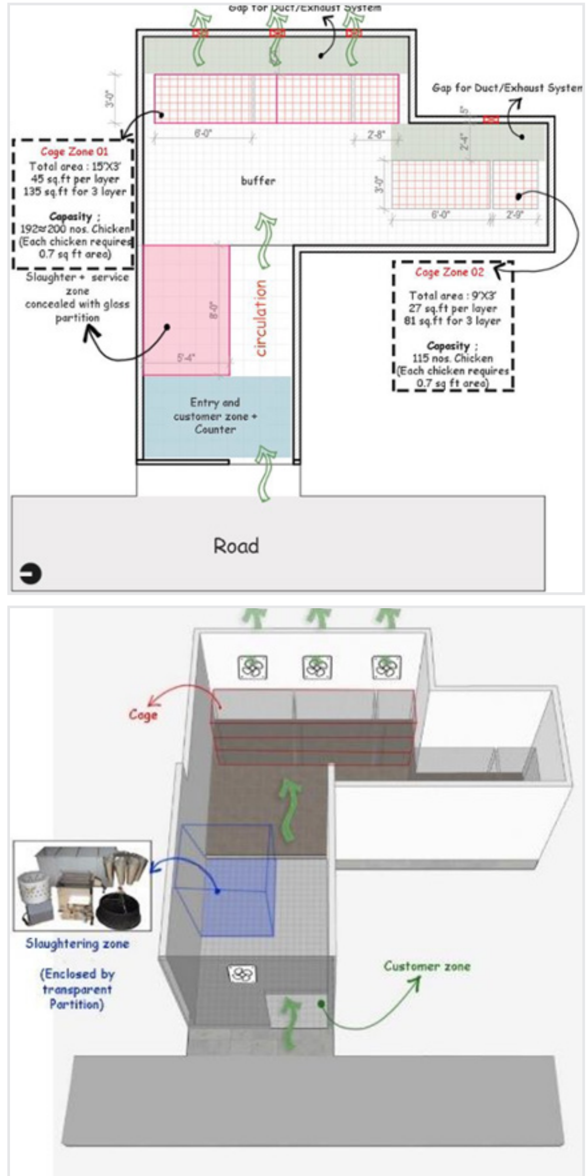
2. Biosecurity and Hygiene Guidelines in Bangladesh LBMs

In Bangladesh, the STOP Spillover country team has been working to develop the following context-appropriate biosecurity and biosafety recommendations and easy-to-understand and implement guidelines in response to the identified lack of bio-secure and hygiene guidelines. The guidelines are to be followed by different LBM actors, including shop owners, workers, and cleaners. These guidelines will be implemented during a pre-testing phase where feasibility, acceptability, and barriers to adoption will be assessed among different actors (market committee, shop owners, workers, cleaners, and transporters) and social and behavioral communication (SBC) experts. Following the pre-testing phase, SBC strategies will be implemented to support stakeholder adoption of the biosafety and hygiene guidelines.

Each section of the LBM will have specific guidelines. The areas include:

1. Purchase and sales area:
   - Personal hygiene for all personnel working in selling area
   - Equipment Cleaning and decontamination
   - Surface cleaning
2. Slaughtering and processing area:
   - Personal hygiene guidelines
   - Slaughtering, skinning, scalding, defeathering and evisceration processes
   - Equipment and cleaning decontamination- Knives, scissors, bone cutter
   - Slaughtering cone/barrel/drum and lid guidelines
   - Scalder
   - Defeathering/dressing machine and lid
   - Evisceration table
   - Blood bin
   - Surface cleaning and decontamination

Figure 18. Design 1: Layout of single unit solution-Plan View and 3D View.



3. Cleaning and disinfection of other areas:
   - General area
   - Unloading area
   - Poultry transportation vehicle cleaning and decontamination

3. Coordinated Biosecurity Compliance Monitoring Plan to be used by regulatory bodies internal and external to LBM's

A recent policy review by STOP Spillover Bangladesh identified that some policies to regulate LBMs are in place, but often those are not supported by explicit implementation strategy or plan of action. These policies are somewhat vague regarding the procedures that would guarantee their implementation, monitoring and assessment. The STOP Spillover country team identified a lack of systematic compliance with biosecurity practices, irregular inspection schedules, and little to no coordination of monitoring plans by regulatory authorities. Through STOP Spillover, the Bangladesh Country Team developed biosecurity compliance monitoring guidelines, described herein, for the regulatory bodies both internal (market committee, shop owners) and external (including City Corporation, Office of Deputy Commissioner, Bangladesh Food Safety Authority, and Consumers Association of Bangladesh) to LBMs. The biosecurity guidelines were developed in collaboration with national experts, government stakeholders, and development partners during a series of workshops aimed at improving biosecurity practices for multiple actors involved in the LBM continuum.

Monitoring, evaluation, and coordination of biosecurity efforts in LBMs are essential to assess the impact of implemented interventions. These indicators can be assessed in multiples ways: a) by pre-arranged or unannounced inspections using guidance documents and indicators developed by STOP Spillover and in coordination with regulatory authorities, and

Figure 19. Design 2: Layout of selling area (Plan and 3D)

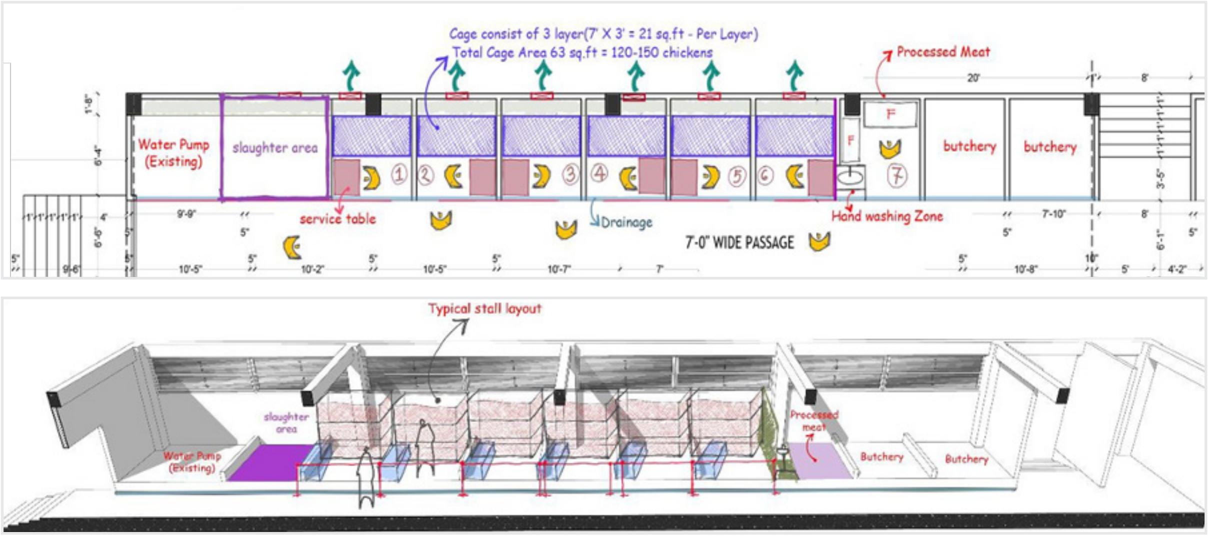
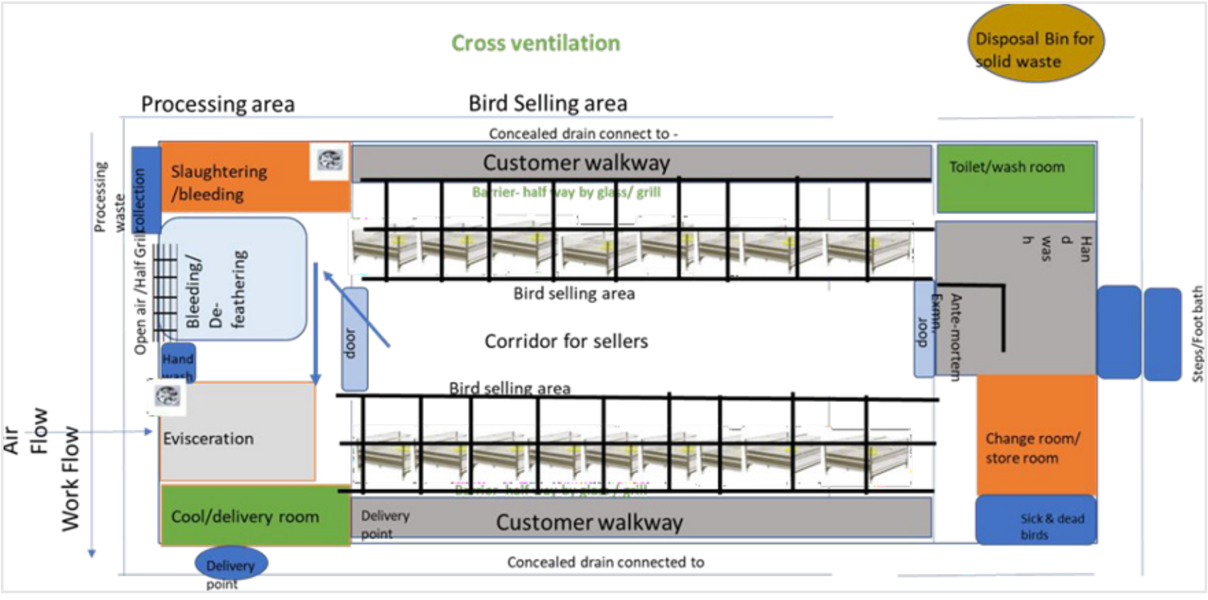


Figure 20. Design 3: Proposed layout for newly constructed LBMs



b) by evaluating the images/video footage from close-circuit television cameras (CCTV) installed in LBMs. Below are some examples of indicators for monitoring biosecurity compliance:

4. Coordinated funding mechanism shared among LBM stakeholders and actors

Implementation and maintenance of the infrastructural renovations require funding investment, which may not be affordable for the shop or LBM owners. Therefore, to identify a resource mobilization mechanism to implement and sustain the intervention, intervention, STOP Spillover Bangladesh intends to engage the private sector, in particular, poultry industry donors, through a sustainable business model for mutual benefit. This report describes the plan for a sustainable funding mechanism to support changes to improve biosecurity conditions and hygiene practices in LBMs. Several poultry industry donors have been approached and have agreed to partnering with STOP Spillover Bangladesh to fund the interventions. The industry donor will provide all necessary implements (refrigerator, weighing machine) and training the vendor to run the butchered meat shop, and also contribute to the infrastructural improvement costs of the LBM as part of their social responsibilities. This is meant to be a long-term arrangement until both parties disagree to be tied, or the government takes any initiative to change the system.

Table 7. Examples of indicators for biosecurity compliance

METHODS OF VERIFICATION	INDICATORS
On site observation of LBM workers' practices CCTV	1. % of LBM stakeholders (seller, processors, cleaners) routinely wear designated personal protective equipment (i.e. gloves, coat, face mask) 2. % of LBM stakeholders (seller, processors, cleaners) who wash hands with soap at a defined frequency (multiple times per day, once per day, daily, never)
On site observation of LBM environment CCTV	3. Market environment is routinely washed and sanitized. 4. % time during each day that market environment is free from fecal materials, offal, blood, feathers, dust, and dirt 5. % of daily visits where, necessary equipment used are found clean of organic matter (slaughtering tables, cages, cones, purchasing area) 6. % of daily visits where wastes are separated into designated bins
LBM workers' response by simple interview	% sectors of the LBM are enabled to practice targeted hygienic behaviors
Community/Consumers interviews	Majority of the consumers are satisfied with market environment

IMPLEMENTATION SPOTLIGHT

Wildlife Carcass Management and Community Engagement in Côte D'Ivoire

While the ecologies of Filoviruses (especially Ebolaviruses) are not fully understood, human contact with infected wildlife and consumption of infected wildlife carcasses have been linked to human outbreaks. Therefore, in situations where humans or other susceptible hosts may encounter potentially infectious wildlife carcasses, a safe method of disposing of these carcasses is required. In District des Montagnes, Côte D'Ivoire, Activity 2.2.1 focused on the development of district-level capacity for wildlife carcass identification, reporting, and safe disposal to prevent spillover of pathogens from wild animals to humans and to prevent contamination of the environment.

In August, 2023, a training of trainers (ToT) was held to reinforce the capacities of government partners from the Ministry of Animals and Halieutic Resources (MIRAH) and the Agency for Rural Development (ANADER) in District des Montagnes. The training focused on building capacities for appropriate wildlife carcass disposal techniques and biosecurity measures. The training focused on the following topics related to wildlife: (1) methods of carcass disposal (deep burial, open burning, shallow burial with carbon, and composting), (2) decision criteria for managing wildlife carcasses, (3) biosafety and biosecurity precautions during carcass disposal. These topics were reinforced through field demonstrations. Ultimately a protocol for wildlife carcass management was drafted.

In addition, the Gbêpleu community located in Man, District des Montagnes was sensitized to and engaged in carcass identification and reporting processes in collaboration with the local government. During the engagement, the Gbêpleu community committed to sensitizing their members to stop wildlife carcass consumption (a common practice in the community), due to risks involved with zoonotic disease transmission potential for infection. The wildlife carcass disposal training and the development of the protocols for carcass management are both firsts in Côte d'Ivoire.

As STOP Spillover looks forward, the ToT will be extended to additional local government personnel and the community, both equipped with appropriate skills, tools, and personal protective equipment (PPE) to engage in systematic and evidence-based carcass management activities. As an intervention to prevent spillover of zoonotic viruses from wildlife to humans, we will validate protocol adherence and feasibility and demonstrate how STOP Spillover's approach to carcass management reduces risks of exposure to dangerous pathogens.

Training workshop participants with consortium experts and local government authorities (left) and Field demonstrations on composting and shallow burial with carbon (right). Photo credit: AFROHUN

IMPLEMENTATION
SPOTLIGHT

Improving Biosecurity and Waste Management Practices on Wildlife Farms in Dong Nai Province, Vietnam

Following identification of risks associated with the farming of captive wildlife in Vietnam, the country team and cross-sectoral partners designed a series of interventions aimed at improving biosecurity and waste management practices in captive wildlife facilities. Using a modified Trials of Improved Practices (TIPs) methodology, a participatory formative research method that can be used to test and refine potential interventions on a small scale prior to broader implementation, three intervention points were developed (see below).

TIP-1: Enhance PPE use to reduce exposure to wildlife saliva, blood, urine, fees, respiratory droplets and aerosols.

TIP-2: A comprehensive approach to improving waste management, handling, and processing on wildlife farms (priority given to civet and bamboo rat farms).

TIP-3: Improved biosafety and biosecurity through health care, disease control and disease surveillance for farmed animals

In practice, the three TIPs have a close interrelation with each other with the objective of promoting sound wildlife husbandry practices. Waste treatment is an activity that necessitates use of proper PPE and farmers are now more aware of the need to prevent direct exposure to the risk of pathogens. In addition, we promote health monitoring in farmed wildlife to detect early changes in animals when abnormal signs are detected. Participants were instructed on how to track down the causes from internal sources (food, water, and barn cleaning) and external sources (people, tools and intermediate objects carrying pathogens from outside to the farm).

The good practice of applying three TIPs simultaneously on a wildlife farm is the basis for proposing the development of a set of biosafety criteria and progressing towards granting a biosafety certificate to wildlife farming households in the coming year. While the TIPs are still being evaluated, perspectives of implementing farmers demonstrate the promise of these interrelated interventions:

Uncle Truyen, Hieu Liem commune One Health worker, and chief of sambar deer cooperative, shared that:

"After participating in the practice of biosafety measures introduced by the project (3 TIPs), wildlife farming household are now aware of the prevention of the risk of disease transmission from wild animals to humans and vice versa. Household have self-invested in deer antler cutting equipment to reduce the risk that hiring people to cut antler will carry pathogens from one farm to another."

Uncle Tam, from a household raising 23 civets in Phu Hop B Village, Phu Binh commune, Tan Phu district, Dong Nai province said:

"Since applying waste treatment (feces and urine) to civets with fermented probiotic Balasa No I bedding, the bad odor from the civet's urine and feces has almost gone away. Moreover, I do not need to spray water to wash the floor of the barn every day, so the floor is always dry, reducing electricity and water cost. This treatment method is easy to apply, I had no difficulties from amking padding for waste treatment."

Mr. Cuong is a civet farmer in Phu Binh commune that suffered very heavy economic losses from the distemper diarrhea epidemic that occurred in his civet farm in March 2023 that killed 65 out of 75 civet animals. Currently, there are only 10 civets left after going through the epidemic. He said:

"If I had met the project staff earlier, my civets would not have died, my family wouldn't have suffered heavy damage during the recent epidemic. Meeting the project staff, talking with the district veterinary experts, made me more confident."

IMPLEMENTATION SPOTLIGHT

Investigating Behaviors and Practices that Increase Lassa Virus Exposure in Liberia

Rodent hunting is a popular activity in Liberia, primarily among young males aged 10 to 20 years, posing a potential risk of Lassa virus exposure. Exposure to rodents also occurs through the preparation, primarily by young girls and older women, and consumption of rodents by household members. Several other risk factors contribute to the transmission of the virus, including poor household sanitation (courtyards, kitchens, living spaces, and food and water storage), food preparation practices, and farmer practices.

Community leaders participating in a group discussion.
Photo credit: AFROHUN

To address these concerns, the Lassa virus risk behavior and exposure study (STOP Spillover Liberia activity 2.2.2.1) was designed to provide further evidence upon which to design and implement rodent proofing and social and behavior change (SBC) interventions to address identified risk factors. The study aimed to increase understanding of knowledge related to the Lassa virus, including the human-driven risks associated with farming and hunting activities, food and water storage practices, health-seeking behaviors, traditional practices, beliefs, and environmental and sanitation conditions at both household and community levels. The study covered 12 communities across three counties in Liberia, including 48 focus group discussions, 34 key informant interviews, 36 household observations, and 12 community observations were conducted across genders, age groups, and geographic locations to identify differential risks.

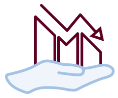
The study revealed differing knowledge of Lassa virus transmission among community members.

The risk behavior and exposure study results will inform the design of targeted interventions to mitigate the risk of Lassa virus transmission in Liberia, for instance “Eating rats and keeping the area dirty will make you get Lassa Fever” (Male, 10-15 years), and “This kind of sickness [is caused by] lizards, roaches, bats, and other mosquitoes” (Female, 25 years and above). Across all focus groups and interviews, participants accurately described common signs and symptoms of Lassa fever and hygiene practices to prevent infection, including proper food storage to prevent rodent infestation. Risks of exposure, including hunting of rodents, food preparation, and consumption of rodents, and contaminated food and grain storage was discussed.

Based on the findings provided, it is evident that the community is facing significant challenges with rat infestations, and many houses are in poor structural condition, making it easier for rats to gain access. To address these issues and prevent rodent infestations, STOP Spillover made the following recommendations, which will be addressed through future activities planned in an additional four communities in Year 4: a) promote safe food and water storage practices, b) promote proper hygiene, sanitation, and waste management practices, c) intervene with structural improvements in households to remove entry-points for rodent reservoirs of Lassa virus, and d) implement a comprehensive social behavior change campaign to increase awareness of the risks of Lassa virus.

Human, dog, crows: A candid moment, risking health in Bangladesh.
Photo credit: icddr,b

Activities & Accomplishments



OBJECTIVE 3

Recognizing that it will not be possible to prevent all spillover events from wildlife, Objective 3 focuses on assisting countries to limit the impact of spillover events should they occur. Minimizing the amplification and spread of zoonotic viruses within a human population, and containing the spillover event as much as possible, will limit the public health impact of such events. This section outlines STOP Spillover's achievements and accomplishments for Objective 3 during Project Year 3.

Media Capacity strengthening in Côte d'Ivoire, Sierra Leone, and Bangladesh

More than two years after COVID-19 became the biggest global news story, zoonotic diseases continue to be a source of debate, conflict, and misinformation worldwide, contributing to limited public awareness of the risks they pose. Accurate, informed reporting about zoonotic spillover can improve policies and outcomes, stimulate action and bring about change. Meanwhile, inaccurate or sensationalist reporting can fuel fear and misconceptions. To act, governments, policymakers, and communities need reliable, evidence-based, and robust information to inform decisions and push for change. During project Year 3, STOP Spillover made strides in strengthening journalists' capacity for risk communication. The capacity strengthening activities focused on improving the ability of local journalists and communicators to disseminate timely and accurate information about zoonotic spillover and how to prevent it.

STOP Spillover's partner Internews, an international media support NGO and a member of the STOP Spillover consortium during year 1 – 3, awarded three small grants for journalism capacity strengthening projects to local media organizations in Côte d'Ivoire and Sierra Leone. The selected local organizations trained a total of 120 journalists and other communicators on accurate coverage of zoonotic diseases and ways to prevent the spread of dangerous pathogens.

Côte d'Ivoire

In Côte d'Ivoire, Eburnie Today media organization, one of the Internews grant recipients, conducted two capacity-building workshops in Abidjan, involving 40 journalists from 18 media organizations.

The first training, held between June 21-23, 2023, targeted 20 participants: 16 professional journalists and 4 student journalists. The three-day training covered 1) Introduction to zoonotic disease and One Health; 2) How journalists can promote One Health and inform the audience about zoonotic diseases; and 3) How can scientific information about zoonotic diseases be turned into clear messages for the public. The second training, also held over three days in Abidjan (August 30-September 1. 2023), involved 20 journalists and radio producers, mainly students. The participants were exposed to content on zoonotic diseases and One Health including how a zoonotic viral spillover happens and the history behind One Health concept, and the relationship between environmental issues and health, the impact of global warming on health. They were also taught about resources to report on zoonotic disease and One Health, pitching a health story, choosing relevant sources, and how to identify and encounter health-related mis- and disinformation.

Sierra Leone

In Sierra Leone, Free Media Group (FMG), one of the two grant recipients, is the publisher of Politico SL, Sierra Leone's leading media outlet. Between August 28-30, 2023, FMG conducted a three-day training for journalists representing various national and regional media outlets of Sierra Leone.

Sixty journalists were trained during the workshop, which was organized in close collaboration with the STOP Spillover Sierra Leone team and under the mentorship of Internews. These included 25 professional journalists from all leading media outlets, including: Sierra Leone Broadcasting Corporation (SLBC); Radio Democracy 98.1FM; Freetown Television Network FTN; Expo Media; Sierra Leone Telegraph; Sierra Express Media; Politico; Concord Times; Nightwatch; and 35 student journalists from the Department of Mass Communications at Freetown University.

Like in CDI, this media workshop sought to strengthen and maintain the usefulness of the media in promoting community awareness about zoonotic disease in Sierra Leone. It also aimed to solidify journalists' reporting accuracy to harness community action groups.

The three-day workshop brought together professional and student journalists, and experts to discuss effective and responsible reporting of viral zoonotic diseases and prevention. The workshop also facilitated a visit to the Tacugama Chimpanzee sanctuary where journalists were given a special briefing on their various conservation activities and the threats faced by the chimpanzee population across Sierra Leone. Sanctuary officials presented the risks of zoonotic viral spillover due to continued hunting and illegal trade of Chimpanzees. The presentations also focused on the One Health approach to reduce these spillover risks by conserving the wild habitat of animals, stricter implementation of wildlife trade laws and advocating among local communities for alternative foods instead of game meats, including chimpanzees.

On the final day of the workshop, facilitators led a group exercise where journalists worked together to develop specific story ideas that were later pitched to a panel of senior journalists who gave input and advice on how to make them more gender-inclusive, culturally sensitive, and science-focused.


"Land encroachers are taking over" - Tacugama Sanctuary founder calls on Govt

Journalists trained on zoonotic diseases

Health Network-SL to observe World No Alcohol Day

To date, stories and posts have been published by journalists/ participants in the capacity building workshop.
Photo credit: Internews

Bangladesh

In Bangladesh, VOICE (Voices for Interactive Choice and Empowerment)—a rights-based training and advocacy organization based in Dhaka—was one of the three selected grant recipients. Their project aimed to strengthen the capacity of local journalists to report on zoonotic disease and the prevention of spillover in Bangladesh, and to deepen public understanding of the sources, risks, impacts, and solutions of zoonotic disease spillover prevention. VOICE organized a media training workshop on “Effective and Responsible Reporting on Viral Zoonotic Diseases and Prevention of their Spillover” for local journalists from media outlets in Dhaka from August 21-23, 2023. The media workshop aimed to strengthen the knowledge and reporting skills of Bangladeshi journalists on viral zoonotic diseases and prevention of spillover.

Local journalists from media outlets in Dhaka participated in a media capacity building workshop.
Photo credit: Internews

Outbreak Risk Management Workshop

1. Scenario development for practice of outbreak risk management in Cambodia

The STOP Spillover Cambodia Outbreak Risk Management Workshop was held in Kampong Cham province over two days in September 2023. Forty six stakeholders from international agencies, government ministries, academic institutions, NGOs, and local authorities participated in a tabletop exercise to discuss and revise the draft scenario. The overall objective of the workshop was to involve partners and stakeholders with an interest in the bat-human interface to test and exercise outbreak risk management coordination processes. The specific aims of the workshop were to 1) brief participants on the nature of bat-human interfaces, 2) conduct a tabletop exercise to revise and improve upon a draft outbreak risk management scenario, and 3) recommend next steps to enhance outbreak risk management.

Tabletop exercise on a scenario of bat-human interface outbreak risk management.
Photo credit: Tetra Tech.

The outbreak risk management scenario was revised to define clear roles and responsibilities of stakeholders, provide recommendations on workflow, and answer questions raised. A document was developed that focuses on multi-stakeholder interactions in the earliest phases of outbreak recognition and response—early action towards early control. It is meant to provide a common frame of reference for planning discussions or activities at the local level. This is not a guideline; it is meant to prompt questions among stakeholders. The scenario highlights where discussion of stakeholder interactions may be needed and does not seek to provide an answer. When used in individual planning events, it should be further tailored.

To better contextualize the conditions under which risk management must occur, workshop participants conducted field visits, divided into three groups. Each group visited one bat guano harvesting household to explore aspects of the bat guano commodity chain and relevant practices. After direct interaction with the guano harvesting households, each group discussed their experiences and addressed the three questions below:

1. Where is the potential risk and how are we part of the risk?
2. How do we know when we are doing something that increases the likelihood of a spillover?
3. What are the barriers and opportunities to prevent and mitigate such potential risk?

Field visit to a bat guano harvesting household in Kang Meas district, Cambodia.
Photo credit: Tetra Tech

2. Scenario development in Sierra Leone

In July 2023, the One Health Platform in Sierra Leone conducted a hands-on (non-computer based) tabletop simulation exercise in Joru community, Gaura Chiefdom, Kenema District, which was supported by STOP Spillover and One Health partners. The 3-day simulation workshop focused on strengthening interface-level readiness for a potential Lassa fever outbreak. The simulation assessed community and district-level responders' abilities to manage a Lassa fever epidemic. This was the first tabletop simulation exercise conducted at the community level in Sierra Leone. The simulation tested preparedness and response system efficiency, staff capabilities, and community readiness.

Participants for the simulation workshop were drawn from local communities and included all of the main actors in emergency outbreak response. They included traditional chiefs, religious leaders, youth leaders, CHWs, healthcare workers, traditional healers, commercial bike riders (transportation service providers), extension workers, sanitary officers, and women's leaders. District level participants from Kenema included staff from the District Health Management Team (DHMT), the Ministry of Agriculture and Food Security (MAFS), the Ministry of Environment and Climate Change (MECC), and the Office of National Security (ONS), all of which formed part of the scenario team. National level staff and partners formed part of the exercise's evaluation and management team.

Throughout the simulation exercise, the community's role in reporting and responding to a Lassa fever outbreak was clear. Community participants discussed existing community structures and task allocation practices that are important to successful event management, including clear rumor management steps. Community health workers (CHWs) and healthcare workers based in care facilities adeptly grasped alert protocols for swift detection including clear elucidation of the reporting and response process utilizing the Integrated Disease Surveillance and Response (IDSR) framework, which makes surveillance and laboratory data more usable and helps public health managers and decision-makers improve detection and response to leading causes of illness, death, and disability. Targeting community response structures in this simulation exercise and discussion allowed those on the frontline of outbreak events to share their insights. This exercise effectively refreshed interface-level responders' familiarity with outbreak alert and response protocols. Community contributions helped refine and inform the interlinkages, strategies, and mechanisms that bind district and community response structures.

Table 8. Results from field visit and group discussions during Cambodia outbreak risk management workshop

QUESTIONS	RESULTS
Where is the potential risk?	• Bat guano harvest, drying, packaging, and storage without the use of personal protective equipment (PPE) • Bat guano transportation without the use of protective materials • Proximity of dwellings and shops to bat roosts • Bad climate, especially rain, overflows bat guano into the environment • Spillover of bat guano from the plastic net onto the ground • Bat hunting without the use of PPE
How are we part of the risk?	• Pregnant women, kids, people/tourists traveling through bat guano villages during bat emergence time • Harvesters without proper biosafety practices in public areas (markets, pagodas, etc.) • Sellers and users of bat guano • Workers handling bags of bat guano • Transporters of bat guano • Tourists visiting places where bat guano is used • Medical doctors and staff at healthcare institutions (hospitals, health centers and private clinics)
How do we know when we are doing something that increases the likelihood of a spillover?	• Lack of biosafety practices in handling bat guano • Bat guano farming and harvesting without proper training and education • Free-roaming livestock and pets in bat guano harvesting communities • Improper practices of food, water, clothes, and other household materials • Touching dead bats directly with hands • Cooking and consuming bats • Bat roosts changing • Bat hunting for food • Improper uses of biosafety materials (reuse gloves, removal, washing) • Living close to bat roosts • Frequent exposure to bat guano, dead bats, and bat-laden materials without biosafety practices • Interaction with bat-human interface community members
What are the barriers to preventing and mitigating such a potential risk?	• Rain • Belief and behavior (e.g., harvesters do not use PPE) • Lack of knowledge of risk and biosafety measures • No guideline/standard operating procedure (SOP) on safe bat guano handling • Lack of education and training on infectious diseases from bats and prevention measure
What are opportunities to prevent and mitigate such a potential risk?	• Education and training from authorities and relevant organizations • Strategies to protect and prevent infectious diseases on time • Distribution of protective materials to bat guano harvesting community people • Encouraging biosafety and biosecurity practices • STOP Spillover in Cambodia • Creating and implementing guidelines/SOPs, policies, strategies • Patients reporting and recording (with symptoms of respiratory should inform the doctor in the area where they live) • Surveillance from the village veterinarian • Updating skills and knowledge of medical officers of zoonotic diseases

IMPLEMENTATION SPOTLIGHT

Convening One Health Platform Stakeholders in Sierra Leone to Conduct a Practical Simulation Workshop on Outbreak Risk Management

During Outcome Mapping in Sierra Leone, stakeholders at the interface level described lessons learned during the Ebola outbreak with regards to local leadership roles and responsibilities, and the drafting and implementation of local by-laws that helped mitigate continued Ebola amplification and spread. This clearly shows the importance of communities in outbreak risk management. They also highlighted the need for increased training programs and simulations to maintain these capacities at all levels, but particularly at the community level.

One Health partners, with support from the STOP Spillover Sierra Leone team, conducted a tabletop simulation exercise to test interface level preparedness and response to zoonotic disease (Lassa Fever) outbreaks. A tabletop simulation exercise—though less intense than a full-scale simulation—provides an opportunity to assess community readiness, structure functionality and staff ability to respond to an epidemic.

The simulation exercise provided valuable insights and opportunities for enhancing coordination among district and community response structures, ensuring timely and effective responses to emergencies.

The simulation exercise also identified the strength of the community in terms of alert, reporting and response to a Lassa Fever outbreak. Healthcare workers and community health workers clearly explained the reporting and response mechanism using the IDSR system.

Gaps were identified and recommendations made to address the gaps:

GAPS	RECOMMENDATIONS
Delay in sample collection, testing, turnaround time and patient referral and treatment	Propose RDT for Lassa Fever in selected CHC and establish structures to manage cases at CHC level in Lassa hotspot areas
The district team did not showcase more understanding of the Incident Management System	Incident Management training to be conducted for the district team
Limited coordination effort of community with all relevant stakeholders (OH) concerning rat control measures in addressing risk associated with harvest period	Engage community stakeholders on risk associated with harvest and involve OH stakeholders in community coordination

The knowledge gained from the simulation exercise is being used to develop interventions to address structural, coordination and technical weaknesses.

Lassa fever simulation exercise in Sierra Leone.
Photo credit: Tetra Tech

Conclusion

STOP Spillover promotes a multisectoral, One Health approach to address emerging zoonotic viruses before they pose an epidemic or pandemic threat. Throughout Year 3, the STOP Spillover team helped multisectoral local partners increase and institutionalize zoonotic spillover knowledge and capacity in existing local systems, adapt learning to their context, and continuously expand their expertise. In Year 4, STOP Spillover will continue to work to strengthen local capacity to develop, implement and validate interventions to reduce spillover risks of known zoonotic pathogens with pandemic potential, including Ebolaviruses, Marburg, Lassa, Nipah, animal-origin coronaviruses (including SARS-CoV, SARS-CoV-2, and MERS-CoV), and animal-origin zoonotic influenza viruses (avian influenza).

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