# STOP Spillover

## Behavioral Risk Assessment Along Wildlife Value Chains in Dong Nai Province, Viet Nam:

## Principal Findings and Recommendations

Activity 1.2.6.1 | March 2023

# CONTENTS

# ACRONYMS

| | |
|---|---|
| DARD | Department of Agriculture and Rural Development |
| DoH | Department of Health |
| FGD | Focus Group Discussion |
| FPD | Forest Protection Department |
| KII | Key Informant Interview |
| NGO | Non-Governmental Organization |
| OH-DReaM | One Health Design Research and Mentoring |
| OH-DWG | One Health Design Research and Mentoring Working Group |
| PPC | Provincial Peoples' Council |
| PPE | Personal Protective Equipment |
| QA/QC | Quality Assessment/Quality Control |
| WLF | Wildlife farmer |

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## *STOP Spillover*

Strategies to Prevent Spillover (or "STOP Spillover") enhances global understanding of the complex causes of the spread of a selected group of zoonotic viruses from animals to humans. The project builds government and stakeholder capacity in priority Asian and African countries to identify, assess, and monitor risks associated with these viruses and develop and introduce proven and novel risk reduction measures. "Spillover" refers to an event in which an emerging zoonotic virus is transferred from a non-human animal host species (livestock or wildlife) to another, or to humans.

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# SECTION I: INTRODUCTION

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 (1) actors who are involved in the wildlife value chain (at the individual and household level); (2) social, economic, gender, cultural, environmental, and other drivers of spillover risk; and (3) 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.

Communes from two districts considered to be high-risk interfaces, Vinh Cuu and Tan Phu districts in Dong Nai province, were selected during the period of July to September 2022. A risk framework was developed based on observed practices in wildlife value chains at study sites. Actor groups from breeding facilities to production sites, intermediate stages, and consumers, were investigated by employing four main techniques. 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. 16 key informant interviews (KII) and 4 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.

This study applied a risk framework aligned with the Joint Risk Assessment Operational Tool (JRA OT), a multisectoral, One Health-based approach developed by Food and Agriculture Organization of the United Nations, World Organization for Animal Health and World Health Organization (WHO et al. 2020). This approach used problem formulation to frame activities across wildlife farms and actors, applied hazard identification and exposure assessment based both on previous research and findings by PREDICT, priority pathogens identified by STOPS Spillover, and likelihood of hazardous conditions arising across wildlife farming activities. Risk characterization was used to categorize risk factors and to inform targeted interventions.

Modified risk matrices were created to explore combinations of factors that could be used to classify the level of potential risks on each farm as Category A (low), Category B (medium) and Category C (high). The lower risk methods included composting, treating with probiotics, and biogas technology; the medium risk methods included collection of waste into a bag or cesspit

and applying to crops without composting; the higher risk methods included the application of wastewater and manure directly to crops and feeding waste directly to fish. One of the Trial of Improved Practices (TIPs) to be implemented is a comprehensive approach to improving waste management, handling, and processing on wildlife farms, which is directly supported by findings from our risk matrix on waste management. The majority of farms (188 farms, 76.8% of 245 total farms) employed some category B methods and no category C methods, comprising the medium risk group. There were 43 farms with some Category C methods for treating animal waste (17.5% of 245 farms) which placed them into the higher risk group.

Opportunities in using this risk matrix approach include the possibility to look at the multi-factorial context for biosafety and biosecurity at the wildlife farms. For example, this methodology allowed us to examine the intersection of factors of number of species, water sources, and disposal of animal waste on wildlife farms. We also did an integrative analysis of whether reported PPE use differed between genders and whether risk perception in terms of "worry about human and animal diseases" differed by gender.

# SECTION II: PRINCIPAL FINDINGS AND RECOMMENDATIONS

The principal findings and recommendations of the behavioral risk assessment are summarized in this section. The full methods and results are contained in a detailed report attached as Appendix A. Table 1 gives a summary of research findings and key information on the significance of the findings. This is followed by brief discussions of knowledge, attitudes and practices, opportunities and challenges, and general recommendations for spillover risk mitigation arising from the research.

The document then provides a list of opportunities for risk mitigation where adopted interventions would have important spillover risk mitigation impacts with a brief discussion of each. The last section provides a discussion that draws on the Behavior Risk Assessment (Activity 1.2.6.1) and the Biosecurity Assessment (Activity 1.3.1).1 to inform intervention design.

Table 1: Summary Research Findings and Why They Matter

| Actors/ Sectors | Activity | Gender AGE | PPE Risk Perception | Water/Waste Management Infrastructure | Value Chain | Health Care |
|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |
| **WILDLIFE FARMERS (WLF)** | | | | | | |
| **Wildlife Farmers (WLF)**<br><br>**Highlights** | Years involved in WLF (<1 to 35 years)<br>83.5% of respondents stated they raised at least one of the 4 high risk species targeted by the project (civets, bamboo rats, porcupine or sambar deer).<br>23.2 % of all respondents indicated that they raised only one of the 4 high risk species.<br>Of the 16.5% of respondents that indicated they raised a second wildlife species, 50% said they raised one of the 4 high-risk species. 75.5% of Wildlife farms had both | 267 respondents<br>17 communes<br>44.6 % women across farms<br>Mean age 48.7<br>(Range 18 to 88 year)<br>23.5% over 60 years<br>Significant differences in activities by gender—more men owned or managed WLF and handled dead animals | 46.3% of WLF expressed concern about the possibility of disease transmission affecting humans or animal health.<br>48.4% had no concern.<br>WLF indicated that they used PPE, but respondents were not frequently observed to have the specified PPE<br>Direct observation of PPE usage did not support the | Multiple sources of water were available to the WLF<br>38.4% of WLF used surface waters or uncovered reservoirs that were ranked as greater likelihood of impact<br>Multiple types of Waste management practices were noted across the WLF, including practices that were ranked as having a greater likelihood of impact (94.3% of farmers with medium to higher hazard methods in practice)<br>19.1% of WLF indicated that they would eat or sell dead wildlife | About 75% listed WLF as a primary source of income<br>Income impact varied widely (from 5 to 100% of family income)<br>Reasons for doing WLF was to increase income, family tradition/family labor, easy to raise | DVMs lack disease knowledge<br>Human respiratory effects linked with bamboo rat contact<br>Husbandry care interventions lacking<br>Breeding information could be useful and targeted at potential higher risk interface |

| Actors/ Sectors | Activity | Gender AGE | PPE Risk Perception | Water/Waste Management Infrastructure | Value Chain | Health Care |
|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |
| | wild and domestic species<br>Porcupines, civets and bamboo rats are primarily raised for breeding stock and meat, while sambar deer are mainly raised for antlers as a medicine<br>Coronavirus serology from existing evidence has identified positive cases in bamboo rats, porcupines and domestic pigs | | levels of PPE usage reported in surveys | | | |
| **Why it Matters** | Diversity of WLF by wildlife species, diversity and proximity of domestic farming indicates that both core as well as directed interventions are needed | Targets for gender-specific considerations include encouraging women as owners and managers<br>Ensuring that PPE is available | Biosafety/Biosecurity guidance and rationale for using PPE is needed<br>Specific targeted interventions would be indicated with | Variability across WLF in infrastructure not only support prioritized core interventions, but also support detailed targeted interventions under these broader infrastructural interventions<br>Significant decrease in spillover risks could be | Variability in reason and motivation suggests need for targeted interventions across examples | Improving health care has the potential to enhance several key intervention interfaces for both animals and humans<br>Targeting knowledge gaps for DVMs would be especially impactful and affect sustainability of message |

| Actors/ Sectors | Activity | Gender AGE | PPE Risk Perception | Water/Waste Management Infrastructure | Value Chain | Health Care |
|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |
| | | across activities and gender | some items such as clothing | averted by targeted interventions on how to handle and dispose of dead animals | | |
| **WILDLIFE TRADERS** | | | | | | |
| **Wildlife Traders**<br><br>**Highlights** | 60.5% traded both wildlife and domestic animals<br>79% traded multiple WL species.<br>21% traded 1 WL species.<br>17.1% raised pigs which may carry coronavirus<br>19.5 % raised poultry | 43 respondents<br>39.5% were female.<br>Mean age 43.4 years ranging from 25 to 64<br>Recruited from same area as WLF | Not discussed | There are no wildlife markets | For 58.1% a major source of income, adding 32.9% to household income<br>72.1% believed income from WL trading decreased by 13.1% over 3 years<br>WL purchased mainly for meat and breeding<br>Farmgate sales 89 to 100% depending on species<br>Wildlife products are unregulated from a health perspective. No inspection or processes to | DVMs lack disease knowledge<br>Human respiratory effects linked with bamboo rat contact<br>Husbandry care interventions lacking<br>Breeding information could be useful and targeted at potential higher risk interface |

| Actors/ Sectors | Activity | Gender AGE | PPE Risk Perception | Water/Waste Management Infrastructure | Value Chain | Health Care |
|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |
| | | | | | control disease spread or food safety in wildlife products | |
| **Why it Matters** | Multiple species increase probability of disease spillover | Women's involvement in wildlife trade is significant | Not discussed | N/A | Variability may affect strategy for interventions<br>Wildlife products are unregulated from a health perspective. No inspection or processes to control disease spread or food safety in wildlife products | Improving health care has the potential to enhance several key intervention interfaces for both animals and humans<br>Targeting knowledge gaps for DVMs would be especially impactful and affect sustainability of message |
| **WIILDLIFE NEIGHBORS** | | | | | | |
| **Wildlife Neighbors**<br><br>**Highlights** | 85% reported raising domestic animals<br>72% raised poultry.<br>24% raised pigs. | 103 respondents<br>Mean age 44 range 24 to 72<br>From same area as WLF | 50% concerned about disease in humans and animals<br>40% expressed no concern | 75% used covered drilled wells or water taps<br>15% used uncovered rainwater or pond/river water | | DVMs lack disease knowledge<br>Human respiratory effects linked with bamboo rat contact<br>Husbandry care interventions lacking |

| Actors/ Sectors | Activity | Gender AGE | PPE Risk Perception | Water/Waste Management Infrastructure | Value Chain | Health Care |
|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |
| | | 46% were women | | | | Breeding information could be useful and targeted at potential higher risk interface |
| **Why it Matters** | Livestock populations at risk of spillover from neighboring WLF | | Target for education about biosecurity and biosafety measurers | Water sources are important for disease spillover and targeted interventions for education of neighbors is needed | | Improving health care has the potential to enhance several key intervention interfaces for both animals and humans<br>Targeting knowledge gaps for DVMs would be especially impactful and affect sustainability of message |

## 2.1 Knowledge, Attitudes and Practices

Within the One Health (OH) agencies of government, there is limited capacity to provide the wildlife sector with services in zoonotic disease control, animal health management, and biosecurity and health surveillance. Veterinary services do not have the capacity and training to support wildlife farmers. Veterinary staff have limited experience treating and handling wild animals and little knowledge of wildlife diseases. In the human health sector, there are limited resources to monitor the specific health concerns and risks faced by wildlife farmers. Non-domestic species are excluded from the slaughter facilities used for livestock and are subject to no food safety inspection regime. The Forest Protection Department (FPD) is one of the key governmental agencies working on wildlife management from the provincial to the commune level, but FPD staff have limited capacity to address issues of captive wildlife farming or wildlife farmer health issues and risks.

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.

The study respondents believed the captive breeding models for wildlife farming were highly successful. When asked directly, many stated they saw no disease risk in their farms, either to themselves or their animals. On the other hand, 46.3% 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 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.

There are few formal marketing channels for wildlife products and no access to regulated slaughter facilities. There were 21 respondents (19.1% of 110) who reported they ate or shared wildlife that died on the farm with friends, family, or neighbors for the intent of consumption. Sale of deceased wildlife or wildlife products from deceased animals was reported in semi-structured interviews. Since wildlife products are excluded from the regulated slaughter facilities, there is no food safety inspection or pathogen surveillance, and unsafe products are able enter the value chain unimpeded and undetected.

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.

The human health sector currently monitors five common zoonotic diseases (Avian influenza; Rabies; Streptococcus suis (type 2); Anthrax; Leptospirosis) (MOH and MARD 2013), but these 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. The animal health agencies also lack knowledge on the recognition and treatment of common wildlife diseases and are therefore unable to educate farmers on the warning signs for which they should monitor or management steps they should take to improve the health of their herds. The environmental and food safety control agencies presently play no role in the management of wildlife farming or quality control of wildlife food products – these agencies currently focus solely on domestic animal farming quality control of products from livestock. As such, the captive wildlife value chain is uncontrolled and uninspected. There are no barriers to entry of unsafe products into the market and a weak ability to trace the source of unsafe products in the event of an outbreak or adverse event.

## 2.2 *Opportunities and Challenges*

Farmers are the central actors in the wildlife value chain, from breeding supply and production to processing, slaughter and sales, so future interventions should focus primarily on farmers. Given the apparent lack of overt disease detectable by farmers, the main incentives to improve the quality and safety of wildlife products will come from market forces. Biosecurity and risk reduction strategies that enhance the market value of a product have the potential to be adopted and sustained, depending on willingness to pay and perceived value. Exclusion of wildlife and wildlife products from livestock slaughter facilities and inspection processes, while safeguarding the safety of livestock products, results in an unregulated, high-risk value chain for wildlife products. This contributes to increased risk of disease transmission to humans and health problems in the farmed wildlife population going undetected for extended periods of time. In the absence of inspection and regulation, even the marketing of dead animals was reported.

There is a strong need for focused wildlife product value chain analysis to identify nodes of zoonotic spillover risk and opportunities to implement effective, achievable, and sustainable biosecurity and zoonotic disease prevention interventions. Wildlife farms have strong networks

of peer groups that include social media groups, but they lack sufficient knowledge on biosecurity or zoonotic disease prevention.

Furthermore, the Provincial People's Committee publishes a circular guiding the inter-sectoral coordination mechanism in zoonotic disease prevention that is intended to create favorable conditions to strengthen coordination among stakeholders tasked with preventing spillover. The role of the wildlife trader also needs to be evaluated in this context as described above since they potentially represent a critical control point for intervention in spillover risk.

## 2.3 General Recommendations

According to the study conducted by STOP Spillover, some of the general recommendations are summarized below:

- Strengthen 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;
- Identify control points, economic drivers and potential incentives from the perspective of the wildlife value chain to inform interventions and drive adoption of spillover risk mitigation measures;
- For farmer health, apply participatory and/or syndromic surveillance to monitor and detect zoonotic disease spillover on wildlife farms;
- Strengthen capacity of the public veterinary sector on zoonotic disease control, biosecurity, biosafety and quarantine in relation to wildlife farms;
- Strengthen and train community One Health workers working under professional supervision and peer networks on zoonotic disease and biosecurity.

## 2.4. Opportunities for Risk Mitigation

### 2.4.1 Improve treatment of animal waste on wildlife farms

Although 79 farmers (32.2% of 245 respondents) used some methods for handling waste that were ranked as low risk, there were 14 farmers (5.7% of 245) that only used low risk methods, and 162 farmers (66,1% of 245) that used a mixture of medium and higher risk waste management methods involving the use of untreated waste. There were 44 farmers (18.0% of 245) using higher risk options that are critical targets for interventions that mitigate spillover transmission risk in waste management. The lower risk methods included composting, treating with probiotics, and biogas technology; the medium risk methods included collection of waste into a bag or cesspit and applying to crops without composting; the higher risk methods

included the application of wastewater and manure directly to crops and feeding waste directly to fish.

### 2.4.2 Integrate wildlife farming into animal health institutions

The wildlife farms do not have access to wildlife health services as veterinarians do not currently have capacity in this area and wildlife products are excluded by law from livestock slaughter and inspection processes. Robust peer networks are the primary source of information on production and health care of wildlife. Slaughter and processing are mainly done by producers and consumers. Interventions targeted to increasing access to animal health services would enhance information flow (disease reporting) and reduce the risk of disease transmission within wildlife populations and spillover to humans. Interventions to introduce animal health monitoring and inspection of wildlife products would mitigate the risk of spillover.

### 2.4.3 Increase use of PPE

The results relative to the use of PPE were complex. Although moderate to high levels of use were reported in the biosecurity questionnaire surveys (Activity 1.3.1) and in cleaning and feeding activities in this study, observation indicated PPE was not widely used. In the risk assessment questionnaire, PPE was reported to be used only 20% to 40% of the time for the catching and handling of animals and about 10% of the time during slaughter. Women reported a greater use of PPE than men. The main drivers for PPE use appear to be injury prevention and cleanliness rather than prevention of infection. The use of PPE is one of the most direct methods to reduce exposure available and interventions to enhance PPE use that are based on a good understanding of social drivers and peer education networks could significantly mitigate the risk of spillover.

### 2.4.4 Reduce number of species on wildlife farms

There were 62 farmers (23.2% of 267) considered as low risk with a single species of wildlife and 67 farmers (25.0% of 267) considered as medium risk with two species (wildlife and domestic). There were 138 farmers (51.8% of 267) considered as high risk with three or more species who would be critical targets for the directed interventions.

Table 2: Cross Tabulation of Targeted Wildlife Species and Domestic Species on Farms

| | **Percent of Respondents (Number of Respondents)** | | | | | |
|---|---|---|---|---|---|---|
| Number of Wildlife Species | Number of Domestic Species | | | | | |
| | 0 | 1 | 2 | 3 | 4 | Total |
| **1** | 23.2 (62)* | 24.3 (65) | 33.3 (89) | 9.0 (24) | 3.0 (8) | 92.8 (248) |

| | Percent of Respondents (Number of Respondents) | | | | | |
|---|---|---|---|---|---|---|
| **2** | 0.7 (2) | 1.5 (4) | 1.9 (5) | 0.4 (1) | 1.5 (4) | 6.0 (16) |
| **3** | 0.4 (1) | | | 0.4 (1) | | 0.8 (2) |
| **4** | 0.4 (1) | | | | | 0.4 (1) |
| **Total** | 24.5 (66) | 25.8 (69) | 35.4 (94) | 9.8 (26) | 4.5 (12) | 100.0(267) |

* *Sambar Deer is the only wildlife species recorded on single species farms*

### 2.4.6 Improve water sources on wildlife farms

There were 157 farmers (61.6% of 255 respondents) that used low risk water sources for all types of water uses and 98 farmers (38.4% of 255) that used medium and high risk water sources. There were 43 farms (17.0% of 255) using higher risk options who would be critical targets for the interventions directed to the mitigation of water borne transmission risk. The lower risk group included covered drilled wells, water taps, and filtered water; the medium risk group included covered rainwater and covered dug wells; the higher risk group included uncovered dug wells, uncovered rainwater, and ponds or rivers.

### 2.4.7 Decrease overall risk based on combined evaluation of the three criteria of treatment of waste, number of species, and water sources to assess overall risk

There were 76 farmers (32.3% of 235 respondents) that used only low and medium risk methods (no high risk methods) for these three criteria, and only 2 farmers (0.8% of 235) that used only low risk methods for all three criteria. There were 159 farmers (67.7% of 235) using higher risk options that would be critical targets for an integrated intervention that targets waste treatment, water source and species composition of the farms.

## *2.5 Informing Trials of Improved Practices*

A key output from the Risk Assessment and Activity 1.3.1.1 is to inform intervention selection and design under Activity 2.2.2.1. In this section, evidence from the Risk Assessment Report (Activity 1.2.6.1) and the Rapid Assessment of Prior Biosafety Training (Activity 1.3.1.1) that is directly relevant to the TIP selection process is presented and discussed. It also highlights information that differs between the two studies and explains when and how these differences could affect the choice of interventions.

In Activity 1.3.1.1, the most important barriers to implementing biosafety and biosecurity measures as cited by wildlife farmers were: cost of measures, discomfort of wearing PPE, and

the lack of information on biosafety and biosecurity for wildlife. Of the 267 study participants interviewed in the risk assessment, 74.9% listed wildlife farming as one of their primary sources of income and the mean percentage of household income from wildlife farming was 64.8%. Participants were therefore economically dependent on wildlife farming and added expenses could be perceived as a threat to their livelihoods. Consequently, any new biosafety and biosecurity practices proposed must be cost-effective and presented such that they add economic value to the product or reduce unnecessary losses due to disease or other costs.

The data collected showed that approximately half of the wildlife farmers expressed biosafety concerns regarding the risk of personal illness resulting from their exposure to their wildlife holdings. However, when asked directly, many farmers answered that they had never seen any disease in farmed wild animals and were not concerned about this issue. Based on household observations, interviews and checking of medical records, some people had symptoms of respiratory disease at the bamboo rat farms. Yet, they did not believe there was a link between the illness in humans and disease in animals. These results taken together indicate that the community's knowledge and awareness of disease risk is a complex topic that cannot be easily categorized. It suggests that some wildlife farmers are aware of the potential for zoonotic spillover, but they view the topic as a sensitive subject and are sometimes reluctant to discuss the topic openly.

### 2.5.1 Improving waste management, handling, and processing on wildlife farms (for 4 species: civet, bamboo rat, porcupine, and sambar deer)

The findings of the Behavior Risk Assessment and Rapid Biosafety Assessment highlighted the risks and gaps in good biosafety and biosecurity practice for waste processing and the lack of PPE use in cleaning and waste processing. The Biosafety Assessment noted that most wildlife farms are not well designed and lack a waste disposal system.

Three levels of potential risk of waste treatment methods were identified: the lower risk methods included composting, treating with probiotics, and biogas technology; the medium risk methods included collection of waste into a bag or cesspit and applying to crops without any treatment; and the higher risk methods included directly applying waste to crops and feeding it to fish. The Behavioral Risk Assessment found that although 79 farmers (32.2% of 245 respondents) used some low risk methods for handling waste, there were only 14 farmers (5.7% of 245) that exclusively used lower risk methods, placing them into the low risk group. The other 65 farmers (26.5% of 245) also used some medium and higher risk methods for treating animal waste. The largest group of farmers (188 farmers, 76.8% of 245 respondents) employed some medium risk methods and no high risk methods, comprising the medium risk group. There were 43 farms with some higher risk methods for treating animal waste (17.5% of 245 farmers) which placed them into the high risk group. Together this identified 94.3 percent of farms in the medium to high risk categories based on their waste disposal infrastructure.

These issues with hygiene and waste handling were further supported by the 20 observational site visits conducted as part of the Behavioral Risk Assessment.

According to the Behavior Risk Assessment report, "many farmers had ideas for better treatment of wastewater and wildlife waste. They expressed interest in suitable probiotics (microbial additives) to treat manure, wastewater, and wildlife waste to limit odor and prevent environmental contamination. Some indicated that they are considering building a gutter to drain wastewater from barns to manure cellars or build biogas harvesting systems." This finding suggests that the wildlife farmers are interested in co-solutions and co-creation for waste infrastructure and indicates a receptive atmosphere for achieving successful SBC.

The Rapid Biosafety Assessment found that wildlife farmers do usually use PPE while cleaning and when they come into contact with waste. More detailed results from the Behavioral Risk Assessment indicated respondents reported that shoes or boots were commonly used when feeding (55%), cleaning cages (65%), and catching/touching animals directly (36%). Gloves are reportedly often used when cleaning the barn (66.7%) and catching/touching animals directly (42.7%). Masks were frequently used during feeding (70%), cleaning of cages (71.9%) and velveting (39.7%).

There are still a number of farmers who do not use any PPE in livestock production activities (accounting for 11-28%). During 20 visits to wildlife farms as part of Activity 1.2.6.1, a number of gaps in hygiene and biosecurity practices were observed - PPE use was observed to be limited or moderate on most farms and observation did not support the higher levels of use reported in questionnaires.

The Rapid Biosafety Assessment revealed that none of the wildlife farming households visited had adequate separation of wildlife from domestic animals and that waste from wildlife and domestic animal barns were drained into a pit without treatment (especially for civet and bamboo rats).

A risk matrix was created to rank the combined potential for risk of spillover based on waste disposal, water sources, and number of species kept on a farm. The combination of the three criteria shows that 60% are at the highest level of concern whereas 18% were at the highest potential for spread of disease based only on animal waste methods, , 52% were at the highest potential for spillover events based on the number of species, and 18% were at the highest risk for spread of disease based on water resources. These findings suggest a great amount of room for improvement and define the space that biosafety and biosecurity interventions will target.

In the Rapid Biosafety Assessment, the general attitude of farmers and consumers in terms of biosecurity is that wild animals are very clean, rarely get diseases, and carry a low risk of disease transmission. This does not align exactly with the Risk Assessment (RA). The RA report states "Regarding farmers' knowledge and practices regarding biosecurity and zoonotic diseases,

most farmers have not observed transmissible diseases in their captive wildlife, but are concerned about the risk of disease transmission from their holdings."

Despite the expressed observation that captive wildlife does not show diseases, there were 113 (46.3% of 244) respondents in the behavioral risk assessment survey that expressed concern about the possibility of animal or human disease transmission affecting human health. Among those respondents who were worried about diseases, 82 people (33.6% of 244) were worried about diseases in animals only; 31 people (12.7% of 244) worried about both animal and human diseases.

For neighbors of the wildlife farms, the study found "Many respondents (40.8% of 103) had no concerns about disease at the farm." A further 9.7% (of 103) indicated that they did not know. Among the respondents who had concerns about disease, 36.9% (of 103) worried about disease in animals; 12.6% (of 103) had concern about diseases in humans and animals. From the point of view of the risk of disease if exposed to live or recently slaughtered wildlife while having an open wound, 21.4% answered "No risk" (of 103), 27.2% answered "Yes" but were "unsure of what the risk is."

These results suggest that there is an important opportunity to mitigate risk in the processing of waste. The range in hazard levels associated with the different approaches used for treating waste indicate that positive examples exist within the wildlife producing community that could act as champions to drive change. The results on gaps in PPE use suggest that an intervention on waste processing should include appropriate attention to use of PPE.

### 2.5.2 Improving biosafety and biosecurity through disease control and monitoring

The risk assessment report quoted wildlife farmers as saying "They raise wildlife based on their experience in livestock husbandry. Selection of breeding stock, farming techniques and attempts to cure sick animals are learned from peers who are successful in raising the species in question. The strong wildlife producer peer networks in place are a positive opportunity for communication, surveillance and training."

The biosafety assessment found that there are currently no surveillance, monitoring or reporting systems for the management of disease transmission risks from captive wildlife to domestic animals or to humans. There is a lack of coordination among veterinary, human health and forest protection agencies in the management and prevention of zoonotic diseases to:

- Improve the health of captive wildlife.
- Decrease the risk of disease transmission from captive wildlife to humans.
- Increase disease reporting on wildlife farms.
- Increase coordination and communication between human health and captive wildlife health institutions and stakeholders.

The limited role of human health or environmental agencies was reported by the other sectors, though it is possible the informants were unaware of such roles. No health check or surveillance for farmers was in place and there is no food safety inspection of wildlife meat or meat products.

The risk assessment found that there is weak monitoring and evaluation of wildlife farms. Veterinary medicine is under DARD and exclusively focuses on domestic animals. Circular 07/2016/TT-BNNPTNT (MARD 2016) which describes agency policy does not include zoonotic diseases in wildlife. Veterinary officials stated "The issue of wildlife quarantine is very difficult, because the current regulations [does] not mention the list of wildlife quarantine diseases. I don't know what disease the civet has, what disease the porcupine has. In fact, in Tan Phu, the quarantine for wild animals has not been implemented for many years" (KII, Tan Phu VET)" and "From my experience, I only quarantined by observation without any tests. For example, pheasants quarantined against influenza H5N1 (KII, Provincial VET)."

The Risk Assessment report also states "Some farmers expressed a desire to apply cooling measures for farmed animals and to be instructed in reproductive techniques. There are no records of disease management, quarantine, and disease testing on animals and farmers are interested in improving this situation. Some farmers expressed an interest to be provided with suitable disinfectants and to disinfect their farms." Interviewees expressed their hopes of being trained on disease prevention, and safe and hygienic captive breeding techniques, and being guided by veterinary authorities on professional sanitation techniques. Some households desired support through labor protection equipment, disinfectants, and instructions on disease management standards.

Furthermore, our data revealed that breeding practices, farming techniques, and treatment of sick animals are learned from other wildlife farmers who are successful in rearing each respective species. This indicates that peers influence behavior, which can be leveraged for social and behavior change interventions. The significance of this peer network is echoed across the TIPs Report as peer-to-peer training and is foundational to many of the improvements the interventions are designed to implement.

In summary, the data from Activities 1.3.1.1 and 1.2.6.1 provided a robust risk and evidence basis for the next phase of intervention prioritization and design *. The absence of any wildlife health services linked to public or private veterinary practice is a major gap contributing to risk of disease spillover. Outbreaks of spillover disease pathogens in farmed wildlife populations could go undetected for prolonged periods and increase the likelihood of one or more spillover events. Present sharing of health information on captive wildlife is mainly through peer networks including social media groups. In all the TIPs, the project proposes to utilize peer educators who are members of existing producer peer networks at the community level as champions for uptake of mitigation measures. In this manner, TIPs will build on existing, self-sustaining mechanisms for knowledge transfer and introduce service provision elements. The

results indicate a strong need for appropriate wildlife health services where guidance on common production diseases of the major species could be used as an incentive to include measures addressing spillover risk and disease reporting.

** Note for Activity 1.2.6.1 (Behavioral Risk Assessment Report) 267 wildlife farmers were included from 17 communes in Tan Phu and Vinh Cuu. KAP assessments for Activity 1.3.1.1 were carried out in the Dinh Quan District on 66 wildlife farms.*