



Selling spillover: a qualitative study of wildlife trade and market practices in Southeast Asia

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Ethics

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Abstract

Southeast Asia faces increased risks of zoonotic spillover as a major driver of emerging infectious diseases and pandemics, due to unprecedented environmental change, biodiversity loss and wildlife trade. Within this context, wildlife markets are locations where zoonotic pathogen spillover risks are amplified. However, there is limited understanding of human operational dynamics, hygiene, and the regulatory environment in these markets.

We employed a formative qualitative study design at a cross-border wildlife market in Southeast Asia in January 2025 to explore risk behaviors and prevention opportunities. We used participatory and non-participatory observation, in-depth interviews and shared walks as data collection methods, and a deductive reflexive thematic approach for analysis. We classified the market and animal taxa traded following defined taxa risk categories.

The market was ranked as ‘very high risk’ for spillover due to the taxa traded. Observations revealed handling and hygiene practices that could increase pathogen transmission risk, such as direct contact with live and dead wildlife, inadequate waste disposal, and lack of protective measures. Cross-border trade and wildlife consumption was driven by local practices, food preferences, and economic and cultural factors. Operating procedures of the market shape risk behaviors but also provide opportunities for preventive measures.

This wildlife market operates at the intersection of restrictive trade laws, culturally embedded practices and high spillover risk. Spillover prevention strategies should integrate a holistic and culturally informed One Health approach that addresses immediate market risks while considering broader systemic drivers. A risk-informed regulatory framework may help mitigate future zoonotic spillover threats.

Keywords

Zoonotic spillover, emerging infectious diseases (EID), pandemics, wildlife trade, hygiene, market procedures, risk behaviors

Journal Pre-proof

1 Introduction

Zoonotic spillover, the inter-species transmission of pathogens, including from animals to humans, is a key driver of emerging infectious diseases (EID) worldwide (Ellwanger & Chies, 2021; Plowright et al., 2017). Wet markets trading wildlife (referred to here as wildlife markets) are considered important environments for such spillover events (Kreuder Johnson et al., 2015; Magouras et al., 2020; Sparaciari et al., 2025). These markets are part of a supply chain that involves hunting, trading, butchering, and the consumption of wildlife under conditions that amplify the risk of cross-species disease transmission (Kreuder Johnson et al., 2015; Magouras et al., 2020). Wildlife markets are often crowded, large-scale events bringing together vendors, customers, and animals from different locations. Stressed live animals housed in cramped conditions, combined with direct contact between humans, live and dead (domestic and wild) animals, butchering, and onsite consumption in an unhygienic environment create an ideal environment for zoonotic transmission and subsequent spread (Magouras et al., 2020; Naguib et al., 2021).

Different animal species pose varying levels of risks for disease transmission due to the viral, bacterial and parasitic pathogens they carry and shed, especially when they are stressed and ill (He et al., 2022; Meurens et al., 2021). Of particular interest are mammals, especially primates, bats, rodents, pangolins, civets and mustelids, as well as certain bird species as they can carry potentially harmful or easily transmittable viruses to humans, some of which are traded in wildlife markets (Meurens et al., 2021; Wikramanayake et al., 2021). Some of these mammals, such as pangolins and particular bat species, are also threatened with extinction (Turcios-Casco & Cazzolla Gatti, 2020). Their trade accelerates biodiversity loss, disrupts ecosystems, and undermines essential ecosystem services such as pollination or insect control (Chao et al., 2019; Lin et al., 2021; Turcios-Casco & Cazzolla Gatti, 2020), which in turn can create new pathways for zoonotic spillover (Food and Agriculture Organization [FAO], 2020; Winkler et al., 2025).

Southeast Asia is at growing risk for spillover events, owing to its biodiversity and the abundance of zoonotic hosts, potentially dangerous to human and animal health, and accelerated macroecological changes (Allen et al., 2017; Nguyen et al., 2024; Sánchez et al., 2022). Wildlife markets are widespread across Asia (Aguirre et al., 2020), and while often associated with heightened disease risks, these markets also hold cultural, social, and economic significance (Mele et al., 2015). Markets provide affordable, fresh and exotic (i.e. species without a history of domestication (Price, 1984)) foods, cater to medical or ceremonial purposes (Aguirre et al., 2020; Magouras et al., 2020), sustain livelihoods and nutritional needs, foster social exchange, drive local economic activity, and in some cases, serve as tourist attractions (Mele et al., 2015; Naguib et al., 2021; Roe et al., 2020; Sparaciari et al., 2025).

Despite legal frameworks prohibiting hunting or trading of exotic and endangered wildlife species in most Southeast Asian countries, enforcement remains inconsistent (Anagnostou & Doberstein, 2026; Chitov, 2019). Monitoring and surveillance of animal health in these markets is weak, particularly given the prominence of informal or illegal trade (Magouras et al., 2020; Rush et al., 2021; Watsa, 2020). Therefore, experts increasingly advocate not for blanket bans – which risk undermining livelihoods, surveillance and cultural practices – but more effective regulation: enforcing bans on endangered species, improving hygiene, and strengthening oversight of species traded (Nadimpalli & Pickering, 2020; Peros et al., 2021; Petrikova et al., 2020).

This study is guided by a One Health conceptual framework where health emerges from dynamic interactions between humans, animals, plants, and ecosystems across interconnected social, economic, political, and environmental systems (Winkler et al., 2025). The Lancet One Health Commission argues that understanding contemporary health challenges requires moving beyond linear models of disease transmission towards systems-based approaches that recognize interdependence, complexity, uncertainty, and processes operating across local, regional, and

global scales (Winkler et al., 2025). Wildlife trade and wildlife markets provide a particularly relevant setting in which to examine these interconnections, as they sit at the intersection of biodiversity, food systems, livelihoods, governance, consumer demand, and zoonotic disease emergence (Sparaciari et al., 2025). A One Health lens therefore provides a useful framework for understanding how spillover risks are shaped not only by biological interactions between species, but also by the broader socioecological systems in which those interactions occur (Winkler et al., 2025).

Limited understanding about market practices, hygiene measures and interactions in high-risk markets particularly in Asia and from an emic, qualitative, observational perspective impedes targeted and effective preventive action (Jenkins et al., 2024; Peros et al., 2021). This study describes the market setup, the products sold, the actors trading high-risk taxa and the hygiene practices in a wildlife market in mainland Southeast Asia. We contribute to a qualitative understanding of wildlife markets as high-risk interfaces for emerging infectious diseases (Peros et al., 2021). Informed by a One Health approach, these emic insights reveal how hygiene practices, operating procedures and characteristics of the market shape spillover risk. We discuss how the market as a microcosm of the animal- human- environment interface converges the macrocosm and the implications of this for spillover prevention and governance.

2 Methods

2.1 Study design and setting

We employed a qualitative case study design (Yin, 1994) using observational methods, semi-structured in-depth interviews (IDIs) and shared walks. This study was part of a larger One Health project aiming to understand spillover risk and to develop a spillover prevention intervention. We purposefully selected this market as an example of the intersection between wild animals, humans and the environment for its diversity of taxa, wildmeat, local and regional

reach, amount and origin of customers and cross-border trade. The market is located at the border between two Southeast Asian countries. Since this study reports illegal activities more detailed information cannot be displayed, to ensure full anonymity and safety of sensitive information of participants. The market is authorized by the local government and runs two days a week. Local vendors as well as vendors from the neighboring country sell goods, ranging from clothes, cooked food, vegetables and fruits, raw meat and fish to kitchen and hunting utensils.

2.2 Study population

In addition to participant and non-participant observations (Bryman, 2016), we conducted six IDIs and six shared walks with the market organizer, cleaner, and market vendors (see **Table 1** for participant characteristics). The participants were chosen according to their experience and expertise (purposive sampling) and their willingness to participate in an interview about their (illegal) trade (convenience sampling).

Table 1: IDI Participant characteristics (n = 6)

Characteristic	Number	% (rounded)
Total	6	100
Gender		
Female	5	83
Male	1	17
Age group		
18-29 Years	1	17
30-49 Years	4	67
50-69 Years	1	17
Religion		
Buddhist	6	100
Relationship Status		
Married	3	50
Widowed	1	17
Single	2	33
Number of children		
0	2	33

1-2	4	67
Highest Education Level		
Primary Education	2	33
Middle School	1	17
High School Education	2	33
Tertiary Education	1	17
Occupation (more than 1 possible)		
Garbage Collector	1	17
Vendor	4	67
Market Organizer	1	17
Origin country		
Neighboring country	4	67
In country	2	33

2.3 Data collection

The lead and last authors trained five research assistants (RAs), three women and two men, in qualitative data collection. Within this training, topics such as constructionism, reflexivity, research ethics, IDIs, observations and shared walks were introduced, discussed and practiced. During the training, RAs translated and familiarized themselves with interviews, shared walk and observation guides and refined translation and language use. All instruments were piloted in January a week before data collection began. Our piloting took place in a small market community outside study province to ensure there was no risk of biasing our sample population. The interview guides included open-ended questions regarding experiences in the market, occupation (vendors, garbage collector, organizer), perception of animal health and spillover risk and hygiene practices. Initial narrative building questions allowed for broad personal responses. Interviewers probed on topics that seemed of relevance to the participant or identified as significant themes via debriefings. Interviews were translated and transcribed after data collection.

RAs were fluent in English and their native language and educated to a graduate level at the University of Khon Kaen. They were supported by the research team consisting of two professors from Khon Kaen University (PL, TM), BS and MDCR. KL and KB led data collection. A scoping visit was conducted from the 24th to 29th of December 2024 to meet with provincial, district and subdistrict authorities and to understand if the market was an appropriate site for our work. We met with the market organizer during this visit and informed her about the study. She granted us permission to conduct the study in the market, meaning vendors were not pre-identified or contacted which avoided any pre-sensitization. The time of data collection was arranged with the market organizer a few days beforehand. Data were collected on the 17th, 18th, 24th and 25th of January 2025.

Qualitative observations consisted of both participatory observation and non-participatory approaches. During participatory observation, we actively engaged with the population in the market through informal conversations, participation in the buying process, and interactions with customers. RAs purchased products, asked questions, and posed as tourists to blend into market affairs. Vendors and customers were asked about prices, product use and origin, and engaged in discussions on quality, disease control, trading restrictions, and law enforcement. In contrast, non-participatory observation involved quietly observing market activities without direct engagement. This observation allowed RAs to focus on detailed notetaking regarding market setup, procedures, customers, and surroundings, supported by a structured checklist (Appendix 1). The checklist documented market characteristics such as the number of stalls, types of animals present, and customer volume. Written informed consent was obtained from the market organizer prior to all observations, and the market organizer informed vendors about our study.

In addition, RAs conducted and audio-recorded six semi-structured in-depth interviews and shared walks, in which participants could show RAs places of interest in the market. RAs used an interview guide (specific to the participant's main occupation) available in both the native

language and English (see Supplemental Material, S1). Cover sheets captured socio-demographic data (gender, age, employment status, children, relationship status, and religion) as well as reflexive and observational notes. RAs explained the purpose of the study, obtained written informed consent, and built rapport via informal conversations with participants prior to the interviews. Interviews were conducted in the market and lasted approximately 30- 45 minutes. Following each interview, participants and RAs undertook a shared walk around the marketplace, where participants - according to their preferences - led RAs through the market, nearby the warehouses, and the dumpsite. These shared walks were audio-recorded, and photographs were taken along the route. The RAs later drew maps of the routes and linked photographs to their corresponding locations. In cases where vendors declined audio-recording or photography, RAs instead produced detailed notes and drawings.

The lead author (KL), together with MDCR, BS, UK, and the senior author (KB), conducted daily debriefing sessions throughout data collection to discuss findings and refine the modes, duration, and timing of observations (McMahon & Winch, 2018). During the first days of fieldwork, RAs encountered challenges conducting both participatory and non-participatory observations. Their non-local accents, physical appearance, and prolonged presence in the market led vendors to perceive them as outsiders. These concerns were particularly pronounced among wildlife vendors, who appeared uneasy about being observed. This was exacerbated by relatively low customer traffic on the first day, making the RAs more conspicuous within the market environment.

To address these concerns, we asked the market organizer to reiterate the purpose of the study to wildlife vendors, emphasizing that the team were researchers conducting observations rather than government officials monitoring wildlife trade. Following this clarification, vendors appeared more at ease and continued to openly display and sell wildlife products. As fieldwork progressed, vendors became increasingly familiar with the RAs and no longer appeared

concerned that information about wildlife trading activities would be reported to authorities. Market activities subsequently proceeded without noticeable disruption.

These developments also prompted adaptations to the study design. The initial plan had been to interview only the market organizer and garbage collector while conducting observations of vendors and customers. However, as rapport developed, the research team recognized that wildlife vendors could provide valuable insights into wildlife sourcing, trade chains, slaughtering practices, and meat preparation. Consequently, the sampling strategy was expanded, and four wildlife vendors who agreed to participate were interviewed during the second week of fieldwork.

Although wildlife vendors were informed about the study, most other vendors and customers remained unaware of the researchers' role. To reduce disruption and improve the quality of observations, the RAs adapted their field practices after the first day. They alternated observation shifts, minimized visible note-taking by using smartphones and audio recordings, and avoided interacting with one another while in the market.

2.4 Data analysis

Notes from daily debriefing sessions, reflexive and observational notes, drawings, photographs, and interview transcripts were analyzed following the six stages of Reflexive Thematic Analysis, applied in a non-linear manner (Braun & Clarke, 2023; Terry & Hayfield, 2020). KL inductively coded the data using a mix of semantic and latent coding and then, through an iterative process including team discussions, re-reading and writing, created themes around the handling of wildlife products (including preparation, storage and selling), market procedures (including hygiene, controls, networks, transportation and setup, garbage and water management), and narratives around consuming and hunting wildlife. The range of data types collected provided a comprehensive understanding of the market and allowed us to build themes across data sources (Varpio et al., 2017), further enriched by our direct experiences and

impressions from the fieldwork. Data was managed using NVivo Pro 15 (Lumivero, 2025) to facilitate the management of the various data sources.

In April 2025, a weeklong data workshop was held with all RAs as a form of participatory analysis and co-creation of meaning (Varpio et al., 2017). During this workshop, the research team including the RAs presented their interpretations of ‘what mattered most’ to the group, reflected on created themes and narratives and discussed implications of the findings. The outputs of this workshop were used to further refine themes.

The data that we collected at the market was assessed in terms of risk for zoonotic disease outbreak using a rapid assessment tool for wildlife markets developed by Wikramanayake et al. (Wikramanayake et al., 2021) to underline the significance of the market in spillover risk. The tool combines a “market trade risk” (based on market size, crowding of wildlife that creates stressful situations, hygiene conditions, number and turnover of people through the market and customers’ origin) and “traded taxa risk” for categorized high-disease risk taxa (based on available knowledge on the numbers of taxonomic groups traded, derived from snapshot surveys, estimates or counts from several site visits, or expert assessments) in a risk matrix to assess disease risk in specific wildlife markets.

2.5 Ethics

All procedures were performed in compliance with relevant laws and institutional guidelines. This study was approved by [anonymized]. All interviewed participants received an information sheet and signed a written informed consent form before participation. Privacy rights of human subjects have been observed. Ethical concerns arose because the practices observed in the market include illegal wildlife trade. Although our results suggest that such practices are nationally and internationally known, the research team decided to censor all identifying data and withhold the specific market location to ensure anonymity, confidentiality, and to prevent potential consequences for vendors or officials. The observational methods also

raised ethical considerations, as not all participants (customers and other vendors observed in the market) were informed about the study and RAs had to act as customers without disclosing the true purpose of their presence. The research team intensively discussed this issue and concluded that while full disclosure would have been preferable, it was not feasible in this setting and could have substantially altered participant behaviour, thereby limiting the depth and authenticity of the data. We thus followed the Ethics Committee's approach that written informed consent obtained from the market organizer would suffice to allow observations within the market. We therefore ensure complete anonymity and confidentiality in the data presented.

2.6 Reflexivity

Our author team brings diverse disciplinary backgrounds, including medicine, social science, global health, and climate–environment research. While several team members have extensive experience working in Asia, South-East Asia and sub-Saharan Africa, others had not visited or worked in the study country prior to this project. During data collection, members of the team were present across all field sites, including visits to the market both in a research capacity and as ordinary customers. This mixture of familiarity and distance shaped our interactions, observations, and interpretations. As a team, we share a commitment to understanding how human-induced environmental changes — including climate change, biodiversity loss, and shifting ecological conditions — intersect with daily life, health, livelihoods, and social relations. Throughout the analysis, we aimed to present participants' accounts descriptively and respectfully, avoiding judgments about hygienic practices, trade behaviors, or activities related to spillover risk or wildlife use. Our interpretive approach is grounded in constructionist (Harré, 2002), culturally sensitive, human-centered (Reñosa et al., 2024), and decolonial principles (Thambinathan & Kinsella, 2021), recognizing that knowledge is socially constructed through interactions and that our own positionalities influence what we see and how we make sense of

it (Braun & Clarke, 2023). We were mindful not to reproduce narratives that criminalize or blame individuals in under-resourced settings for practices that may carry broader environmental or global implications. As a team, we believe that intervention efforts should prioritize participatory, empowering, and equity-oriented strategies that center the voices and agency of local communities, rather than imposing responsibility on those with the fewest resources to adapt or change (Winkler et al., 2025).

3 Results

We present qualitative findings from a wildlife market and describe the animals and wildlife that were present on the days of our data collection, including species that have been classified as high risk for zoonotic spillover. Hygiene practices in and around the market and insights into transport and preparation of animal products reveal a variety of risk contacts.

3.1 Descriptions of the market

3.1.1 Market setting

The market is located in a small village near a border of two Southeast Asian countries and operates every Friday afternoon (3:00-5:30 pm) and Saturday morning (6:00 am-1:00 pm). It covers an area of approximately 4,000-5,000 square meters and accommodates between 20 stalls on Fridays and up to 150 stalls on Saturdays. The stalls are arranged on a dedicated open market square with a dry, sandy floor, which in some areas were soaked with blood and wastewater. Visitor numbers were observed as averaging around 200, with peak attendance of approximately 400 during Saturday morning (8:00-9:00 am). The market is surrounded by grocery stores, restaurants, parking lots, a local government building, residential houses, warehouses, and a dumpsite (see **Figure 1**).

Figure 1: Schematic drawing of the market with type of stall



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Most of the wildlife stalls were set up on the floor on plastic mats with the products either presented on banana leaves, plastic bags or trays directly on the mat. Vendors often displayed their products on or inside foam boxes – used both for transportation and as tables for display – alongside plastic bags (**Figures 2 & 3**). Wildmeat was mostly not separated from other products such as cooked food or vegetables. Typically, meat pieces were packed in one banana leaf in a plastic bag and then stacked into the foam boxes with other products such as whole animals without additional packaging. RAs reported soiled containers, and that foam boxes were blood-stained and dirty. Stalls selling other goods (like cooked food, domestic meat, vegetables and fruits or clothes) by domestic agent vendors were mostly on tables. Some vendors used umbrellas for shade, though many goods remained exposed to sun, wind rain and open air.

Figure 2: Drawing by RA 4 of a typical wildlife market stall on the floor. Wildmeat was stored in foam boxes packed in plastic bags. Dead, whole-body bamboo rats were displayed openly. The vendor had a scale and a water bucket to wash her hands.

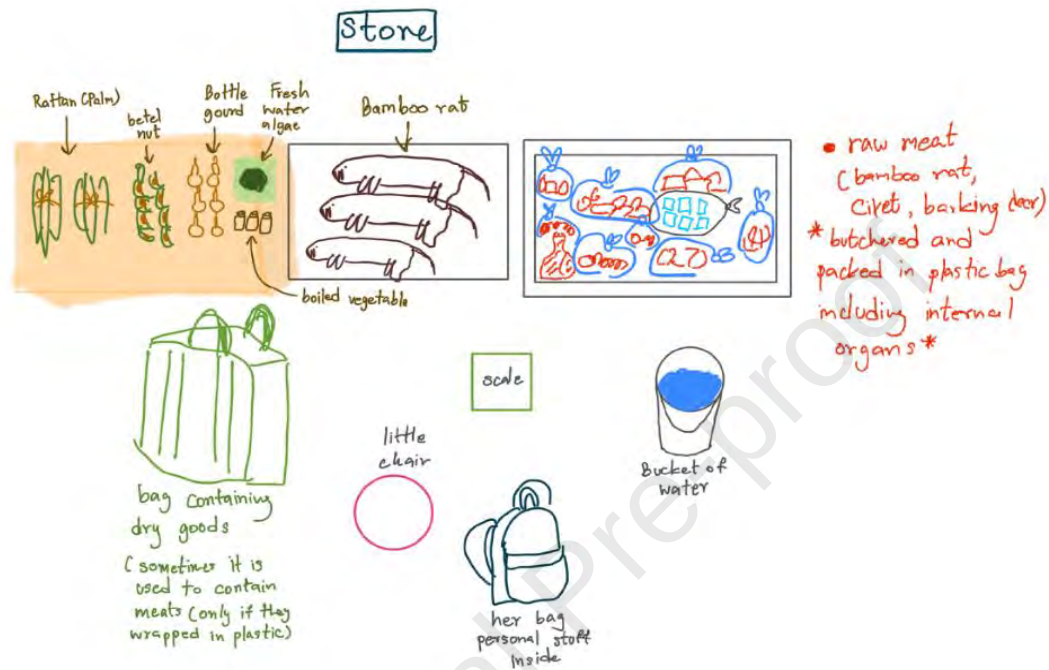


Figure 3a & b: Pictures of typical wildlife market stalls of agent vendors. Wildmeat was presented on Banana leaves next to other goods.





3.1.2 Products and transportation

The market offered a wide range of products including clothes, bags, cooked food, vegetables and fruits, meat and other animal products (both wildlife and domestic), fish, as well as kitchenware and hunting utensils. The market had four sections (see **Table 2**).

Table 2: Sections of the market with respective products sold and maximum number of stalls counted according to the checklist.

Section	Products	Number of stalls (max.)
1	Wild meat & vegetables (vendors from the neighboring country)*	74
2	Fruit, vegetables & domestic meat (vendors from resident country)	19
3	Cooked/ prepared food	26 + 5 - 7 restaurants
4	Other (traps, clothes, electronics)	24

* Most wildmeat stalls also sold vegetables and herbs, though some only sold wildmeat.

Wild and domestic animal meat, along with other animal products, were sold at the market and offered in multiple forms, including the whole body (with and without fur), chopped pieces, frozen, fresh, cooked, dried, or grilled (see **Table 3**). Wildmeat was exclusively sold by female vendors from the neighboring country. In addition to meat, animal by-products such as intestines, blood, bile, and gall of wild animals were extracted and stored in bottles or plastic

bags, often displayed alongside the corresponding animal meat (from which the by-products were extracted) (see **Figure 4** as an example). Porcupine spikes were also available for sale.

Figure 4: This is an example of a market stall selling wild meat and other animal products (mole rats, small deer and porcupine meat, as well as blood and bile in the bottles on the right) (by RA 5).



RAs overheard customer conversations and directly asked vendors about the intended use of wild meat. Most customers shared purchasing for personal consumption, typically cooked, grilled or steamed. While taste was the primary motivation for consumption, customers described wild meat (for example, porcupine meat) as having healing abilities or bringing luck.

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This [porcupine] can be used as medicine to cure because it only eats herbs.

(overheard conversation by RA 1)

It's herbal medicine. Like the porcupine, we don't throw away the stomach.

[...] We keep it. Some people dry it. For me, I dry it too, it takes a long time, about two weeks. Some people grill it and sell it because many people use it

to soak in alcohol or make medicine. [...] Herbal medicine. (Vendor, female, 29)

You can eat everything. For example, the civet, some people want it whole. They want the intestines. [...] They say the intestines are delicious. (Vendor, female, 29)

Table 3: Animals present at the market, observed time at the market stall until sale, price per kilogram (kg) and amount of the product. Amount that is estimated is marked (~) and estimated conservatively. Taxa are colored according to their zoonoses risk following the Taxonomic Risk categories by Wikramanayake et al. (Wikramanayake et al., 2021) (red = high risk, orange = medium risk, yellow = low risk). According to their tool for rapid assessment of wildlife markets, the market ranks as ‘very high risk’ based on the traded taxa observed in the market (Appendix 2). Domestic animal meat is listed at the bottom.

Animals (Order): (Family, Genus, Species) if known	Alive	Raw meat	Cooked	Time until sale	Price per kg (if not specified differently) (in USD, rounded)	Number (Estimated, max.)
Bats		+ (dead body)		1-2 hr.	3 bats 3.2	6
Rodents (Rodentia): Rat, Bamboo rat (Family Spalacidae, probably Cannomys badius)	+ (bamboo rat)	+	+ (grilled, dried)	1-2 hr.	bamboo rat 9.7, rats 2.3-3.9	
Civets (Paradoxurus): several kinds, common palm civet (Paradoxurus hermaphroditus)		+	+ (grilled)			~ 10
Pangolin (Manis spp.)		+			19.3 (whole body)	~10
Birds: Greater coucal (Centropus sinensis), sparrow, pheasant (Family: Phasianidae), junglefowl (Genus: Gallus)		+		15-20 min.		
Tiny birds		+ (dead body)		Not sold		~10
Kloss's mole (Euroscaptor klossi)	+	+				
Deer: Barking deer/ Muntjac (Muntiacus genus (Cervus muntjak)), Mouse deer (Chevrotain)		+ (mouse deer, barking deer)		Barking deer 5-10 min. (rare and famous), mouse deer 1 day	Barking deer 14.5-16.1, Mouse deer 14.5	Mouse deer 2
Wild boar (Sus scrofa)		+				
Porcupine (probably Hystrix brachyura)		+		30 min.	12.9-14.5	~10
Squirrels (Sciuridae): Giant squirrel (Ratufa)		+				~5
Fish	+	+	+ (grilled)			30
Water snails & other seafood (squid, prawn)	+	+	+			>100
Crabs	+					
Frogs (Anura): (probably Hoplobatrachus chinensis), toads	+	+				50

Insects	+	+	+			>100
Bamboo worms (<i>Omphisa fuscidentalis</i>) (pupae and caterpillars)		+	+			>100
Cattle/ cow		+ (cow's placenta)	+			
Buffalo		+	+ (dried, boiled skin)			
Pig		+	+			
Poultry		+	+			

Although not very common, we observed some live animals at the market. These included a wild chicken in a bamboo cage, field crabs and fish in bamboo cages or in plastic bags with air tubes, insects wrapped in banana leaves, snails in foam boxes with water, baby moles in a basket, bamboo rats in a trap box, and frogs in plastic bottles with air holes.

During non-participant observation, one RA noted and photographed a customer interacting with live bamboo rats in a cage. The customer was bitten, and the bamboo rats fought among themselves, leaving blood around their mouths. The vendor told the RAs that live mammals could also be kept as pets.

The vendors allowed customers to handle them [bamboo rats] and even recommended keeping them as pets. Yet, one customer remarked that this particular mole rat could not be kept as a pet because its pale-yellow front teeth were broken, making it unlikely to survive in captivity. I also observed the cages in which the vendors kept these animals, which were old and crowded enclosures that forced the animals into cramped conditions. In addition, I encountered an elderly lady selling baby moles who invited me to feel it; indeed, it was very soft. When I asked if I could keep it as a pet, she replied that it could be kept just like any other pet. (RA 7)

The housing conditions of the live animals were poor, with cages being too small and unhygienic:

The catfish flailed and were pressed against one another, many with visible wounds, swimming in murky water that reeked of a thick, fishy slime. (RA 7)

The market organizer shared some reflections on live animals, which are mostly brought when no control officers are announced:

Yes, if there's no officers coming, they do [bring live animals]. Like rabbits, rats, and bamboo rats. In cages. They also bring crabs. [...] More dead ones. Live animals are fewer. (Market official)

RAs also observed small numbers of stray cats and dogs moving around the market, some of which were scavenging for food at the nearby dumpsite.

Wildmeat typically arrived with vendors crossing the border from the neighboring country. RAs observed that when the neighboring border opened at 8:00 am, vendors quickly traversed the no-man's-land buffer zone, arriving at the local checkpoint on motorcycles or in trucks. Their goods – packed in colored plastic bags or foam boxes –were promptly unloaded. Once the barriers lifted, vendors rushed through the checkpoint on foot to the other side, where local carriers with motorcycles and sidecars were waiting. The products were rapidly transferred to the carriers, who then transported them to the marketplace. Vendors later located these carriers in the market to pay for their services. Vendors with fewer products carried their goods directly.

The border was guarded by police officers with dogs and crossing of the border and exchanges (between vendor and carrier) were executed quickly. This way, most vendors avoided thorough inspections. We observed several superficial checks, where officers would briefly look into the bags before allowing vendors to pass. RAs noted that the police dogs did not trigger alarms. Domestic meat vendors from the local area were also observed bringing their products in pickup trucks. The market organizer provided insights into border controls and ways around them, such as by hiding the meat underneath other products (see **Figure 5a & b**):

RA 5: Is this considered a relaxed checkpoint?

Market official: It's considered an international border.

RA 5: But it allows for special cases?

Market official: It's like a custom, something that's allowed but done discreetly for economic reasons.

RA 5: When they bring goods through, do customs check?

Market official: If they're in a hurry, they don't check. And if they see someone attractive, they might not check.

RA 5: As I see, when they put wild animals in a vegetable bag.

Market official: They hide the animals in pine wood or in vegetable bags. They have their ways of hiding things.

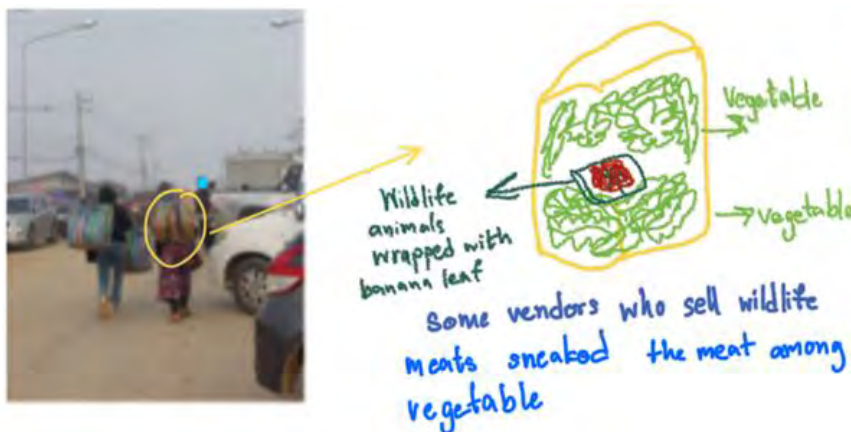
RA 5: So, even though it's known that they're selling these things, they don't do it openly?

Market official: Yes, they try to be discreet.

RA 5: They can't just openly carry around a rat.

Market official: No, some put them in sacks, some in bags of sesame seeds, but they have to be careful about the smell of blood. They have to pack it well.

Figure 5a & b: Observation of vendors hiding meat inside vegetable bags (RA drawing).





There were no controls observed in the opposite direction at the domestic border, and vendors could freely cross the border with whatever they did not sell.

3.1.3 *Vendors*

Wildmeat vendors were predominantly women, operating either as private vendors and/or semi-professional vendors from the neighboring country. Private vendors typically sourced their meat from (mostly male) family members who hunted small game (a term referring to hunting of non-domesticated birds and small mammals), such as rats and birds. These women butchered and prepared the meat themselves, arriving on Saturday mornings. In addition to wild meats, they also sold home-grown vegetables and used big plastic bags for transportation.

Semi-professional vendors, by contrast, purchased their meat – often of big animals – through middlemen who obtained it directly from hunters. They usually arrived on Friday afternoon and stayed overnight in nearby warehouses rented collectively with other vendors to continue their stall on the next day. Between three and ten vendors shared each room (size around 4x4 meters), and products were stored either in the same room or in a separate space. The warehouses lacked basic facilities such as showers or toilets, so vendors relied on the market facilities.

At the market, vendors prepared and sold a variety of wild animal species, some of which vendors described as "rare" or particularly desirable. All vendors were observed wearing normal, everyday clothing rather than protective gear. In contrast, vendors of non-animal products were mainly local, professional vendors selling products such as clothes.

Wild meat vendors described how they deliberately came to sell at this market, since they could get good prices for their wild meat. As wild meat trading is illegal in their country (and also in the country of the market, but tolerated), it provided a special opportunity for them.

3.1.4 Customers

Customers appeared to be tourists and locals. Among them were domestic tourists from other provinces, as well as tourists from neighboring Southeast Asian countries, many of whom reportedly came specifically for wild meat. The customer car park contained vehicles with license plates from across the country and bordering countries. Within the market, wild meat was regarded as an exotic delicacy.

If we bring food, some people come from [capital]. They're traveling and stop by, and they ask for it [...] They're people from far away. Some are from abroad, visiting relatives. Some live in [city nearby] or [capital]. Some are locals from [...] or around here, but they work in [capital] or elsewhere. When they come back, they come up and buy. (Vendor, female, 29)

Local customers primarily purchased fruits, vegetables, or domestic meat. Some local villagers advised against buying food from the market, as it was considered unclean. Tourist customers were observed to receive and discuss wild meat orders through their phone. One vendor shared that some tourist customers even stayed overnight to secure the best products available early in the morning. While some vendors reported having regular customers who placed advance orders of wild meat, others reported that tourists tended to buy opportunistically, choosing meat that looked most appealing at the time. Overall, customers of wild meat were predominantly middle-aged, non-local men. Most customers arrived via car or motorbike at the market and parked in the nearby parking lot.

3.2 Hygiene

Systems that support a hygienic environment were insufficient in the market. A single water source served the whole market, and no draining systems were in place, except for a small section in front of the warehouse where vendors washed meat. RAs reported an overpowering smell of blood, combined with smoke from the nearby dumpsite, and observed a large number of flies surrounding the meat. Dust stirred up by passing traffic further contaminated the ground and stalls.

3.2.1 Practices in and around the market

3.2.1.1 Selling process.

The sale of meat largely involved direct handling of meat and byproducts, including blood, with bare hands, by both vendors and customers (**Figure 6**). While some vendors wore gloves, these were not changed between handling wild meat and other products. Others used improvised practices such as wiping their bare hands with a small cloth or tissue paper – sometimes offering the same cloth to customers – or rubbing their blood-stained hands on foam boxes. Others rinsed their hands in buckets of water kept behind their stalls. In some cases, plastic bags were used as alternatives for gloves when touching and selling the meat.

Hygiene practices were inconsistent, and some vendors ate their food with unwashed hands after handling wild meat. Money was also routinely exchanged without cleaning hands, and one vendor was observed slapping money directly onto the meat as a ritual of good fortune, leaving bloodstains on the bills. Tools such as knives and weighing scales were used repeatedly with raw wild meat and were observed to not be cleaned between products and customers.

Figure 6 a & b: Selling raw wild meat with bare hands, touched by vendors and customers using a blood-stained scale.



One vendor shared that she does not allow customers to touch the meat, as she felt this was inappropriate for the final buyer or interfered with the display of the products.

They [customers] don't [wear gloves]. Mostly, they don't touch [the meat]. I ask them what they want, and I'll show them. [...] I don't want them to touch. Sometimes, when I haven't finished setting up the shop, they come and touch, and I would tell them, "If you're not buying, don't touch." Sometimes they touch and mess up the arrangement. I don't want them to touch. [...] Sometimes it's fresh meat. Who knows what they've touched with their hands?

[...]with meat, deer meat, and other meats, before I put them in bags, I'll show them first. Because I don't want them to touch. But inside, we put things like bones, different parts. There are bones, innards, "[traditional dish]" meat sets [...]. We put everything in. If they ask, we tell them the truth, that there are bones, meat, innards. If they don't want it, that's okay. But some older people, they don't know, they touch and poke around and then don't buy. [...] When we arrange them, we make them look nice. We [...] make them look appetizing. Some people poke around and mess up the arrangement. I don't want them to do that. (Vendor, female, 29)

This vendor was observed to apply stricter hygiene rules than the others. She elaborated further on why she liked to wear gloves when selling meat:

It's like when we touch things. Personally, I like to cook, and because of that when I touch things, I want to wear gloves. If I don't wear gloves, it feels weird. Like something will stick to my hands. Like washing alone isn't clean enough. So, I wear them all the time. I used to cook and sell food; I had a restaurant. I like cooking, so I always wear gloves. (Vendor, female, 29)

Another vendor was observed to use a plastic bag as a cover on her weighing scale. One vendor provided insights on how the hygiene practices differed at home where she prepared the meat for the market:

Yes, I wear gloves [when I pack the meat]. [...] I don't wear them when we're selling. [Country] people don't seem to like it. [...] When we sell, we touch it, but we have to wash our hands. I put tap water in a bucket. [...] I don't use it [soap or alcohol or wet wipes] here. If I'm at home, I use it. Mostly there's

no water. We have to carry it from far away. We have to ask the [market official]. That's what they say. (Vendor, female, 38)

Customers were not observed to follow hygiene practices when handling meat. They frequently touched different pieces of wild meat with bare hands before deciding which one to purchase. One RA described that this appeared to be a routine, almost unconscious practice. Some customers wiped their hands with paper cloth afterwards, but such practices were inconsistent. Customers rarely wore face masks.

3.2.1.2 Meat preparation and storage.

Wildmeat was usually prepared at the vendor's home, though some preparation also took place directly in the market. Once animals were received from hunters, middlemen, or family members, vendors used different preparation strategies depending on the species. For example, some animals needed to appear freshly killed – such as barking deer, which vendors covered in blood to show freshness – while others required processing, such as rats, whose fur needed removal by boiling or burning. One vendor described in detail the steps in receiving and preparing animals for specific purposes:

The animals, I have to get them from the outer areas, from places that are far from the city. And there are middlemen who buy them. [...] They live outside [the city], and I have them find meat for me. When they get meat, they would ask me if I want it. [...] Once I get it, if people want the whole animal, like civet, deer, barking deer, things they get fresh, like they just shot it, not butchered yet, once they get it, they freeze it to keep it fresh. [...] They put it in the freezer to keep it fresh and then send it to me. [...] After I get it, I butcher it. Some customers want the whole animal. So, I sell it whole. Some

people want it for making "[traditional minced meat dish]", so I have to butcher it into pieces. [...] It's wild animals, they have to hunt and shoot it, so it's already dead. (Vendor, female, 29)

Vendors reported that they used different spaces for meat preparation than for their usual household cooking and used separate knives and cutting boards. Some vendors also mentioned wearing gloves or washing their hands thoroughly after handling wild meat. One vendor explained she did not allow her child to be in the room while preparing the meat. Animal waste was generally disposed of by burying.

Rubber gloves. When I sell, when I handle meat or anything, I have to wear gloves. Because I don't want to touch the meat, the smell will stick. [...] I do it at home because I have a drain. The drain is for tap water. And when I do it, I have an open space. I spread out clothes or something. I have things prepared specifically for doing this. (Vendor, female, 29)

Vendors described using various strategies to assess meat quality. The appearance and colour of the meat were key signals, with red meat considered healthy and fresh compared to dark shades. Smell and texture were also important cues. As one vendor shared, wild animals were generally believed to be healthy because their meat was not considered not carry a strong odor reflecting a belief that animals living in nature were seen less likely to be diseased:

Usually, wild animals are healthy. They live in nature. When we butcher them, they don't have a smell. The meat looks good, red. [...] If it has a disease, they won't sell it. (Vendor, female, 38)

One RA summarized her observations and insights from the IDI with a vendor applying stricter hygiene practices:

She (the vendor) described her butchering process at home, stating that she always wore gloves, buried unsellable animal parts, and drained wastewater into a greywater sewer. I decided to observe her practices at the market and noticed that she wore gloves when handling animals. To maintain meat quality, she placed products on ice. She also mentioned that when she received poor-quality meat, she would take a photo and request a replacement from her supplier, the middlemen who she bought animals to resell in the market. (RA 5)

Wild meat was stored in the fridge and on the day of the market transported and stored in foam boxes with or without ice or in plastic bags, usually not separated from other goods. The vendors that stayed overnight on Friday repacked the leftover meat in plastic bags and put it back into the foam boxes. A local vendor sold bags of ice cubes which were added to the boxes to keep meat fresh for the next day. The boxes were then stored in an uncooled warehouse or left outside in the market square. Vendors staying overnight said they exchanged plastic bags for new bags over the two days, to make the meat look cleaner.

3.2.2 Regulation at the market

No clear hygiene regulations appeared to be in place at the market. While signs encouraged garbage separation (see ‘Cleaning of the market’), these rules were not enforced. The spillover risk at the market was recognized by some people. One RA conversed with a disease control officer at the market and presents his assessment of the officer’s powers and outbreak preparation:

He said that it [disease outbreak] couldn't be helped. All he could do is to notice any symptoms for disease: anthrax, flu, influenza, monkey pox. Personally, I feel like there's no preparation for any outbreaks in the market because you can't do anything with the animals because they are illegal so

the officers aren't able to properly check the quality of the meats (even putting meats on the stalls is "impossible"). I believe if an outbreak actually happened again the only thing, they could do is just to close the market for a while (just like how they did when COVID- 19 spread). (RA 1)

The market organizer also shared that she perceives the market as a potential risk event for spillover:

There's a possibility, because humans can transmit diseases through saliva. And with animals, we don't know if their blood can carry diseases to humans. And when we eat them, we don't know the level of risk. I think there could be some risk. [...] Yes, it [market] can [contribute to the spread of diseases] because people come here to buy and sell things. (Market official)

However, vendors and customers did not seem to be aware of spillover risk and the vendors who participated in interviews reported to not or rarely have seen zoonotic disease transmission.

3.2.3 Cleaning of the market and leftovers

After the market closed the vendors packed up their stalls. Leftovers after the second day were few and brought back home in the same boxes or sold for cheaper prices to agents, as described by an RA:

Some vendors [from the neighboring country] took bushmeat back to [their country], while others sold bushmeat through telephone orders at a discounted price to [country] customers who call to order bushmeat during market closure. (RA 3)

The market official explained why meat leftovers are scarce:

There's usually not much animal waste because every part of the animal is valuable. Wastes are from some rotten fruits or vegetables. They butcher the animals at home, so there's almost nothing left. Everything is valuable.

(Market official)

Leftovers were taken back to the vendors' country of origin and were often sold there, as most vendors reported not consuming wildmeats themselves, except for small game such as rats. For some, larger animals like pangolins were too expensive, while others cited taste preferences or the fact that such meat was simply not part of their cultural diet. Larger species, such as pangolins and porcupines, appeared to be hunted primarily for sale to tourists at the market.

Foam boxes used to store meat were cleaned on-site. At the end of the day, blood and other liquids collected in the boxes were poured onto the market floor, after which the boxes were rinsed with water before the leftovers were repacked inside (**Figure 7**). Vendors also exchanged plastic bags containing meat leftovers.

Figure 7: Blood, tissues and meat liquids on the ground after washing out foam boxes.



Waste was disposed of in bins and bags without prior sorting and transported to a landfill located behind the market, where it was subsequently burned. Although recyclable waste was meant to be collected separately, this practice was inconsistently applied and rarely enforced. Some vendors managed their own waste disposal, but overall responsibility fell to a designated garbage collector who picked up trash by hand and burned the accumulated waste at the landfill. The collector relied on a motorcycle to transport garbage bags and was equipped only with a face mask and latex gloves. The market itself was not cleaned with water, and thus no wastewater was generated. However, because the site lacked a drainage system and the market's water was pumped directly from a nearby reservoir (**Figure 8**), potential concerns may arise during the rainy season, as one RA observed:

Water used for tap water for people living in border areas is pumped from the reservoir lower than the landfill and market. The market cleaner said that during the rainy season, the market area where [foreign] vendors sell their products is in terrible condition due to the stagnant rainwater. From the environment of the market, it can be seen that the market is not far from the garbage dump and the reservoir used for making tap water. The market is at a higher level than the garbage dump and the reservoir. From observing the market, it was found that during the closing time, all [foreign] vendors who sell bushmeat wash the blood in their foam boxes with water and dump it onto the ground at their stalls. Therefore, during the rainy season, the water flowing from the market and the garbage dump will flow into the reservoir that is used for making tap water. (RA 3)

Figure 8 a & b: Water management and infrastructure of the market. Figure 8a shows an illustrated map of the market infrastructure, which is accompanied by Figure 8b with original photographs. The water is pumped from a reservoir to a tank and from there to a tap in the marketplace.



4 Discussion

We present qualitative accounts of a wildlife, describing the products sold, hygiene practices, operating procedures, and the movement of illegal products across an international border into the market. We observed that the market traded taxa ranked high-risk for spillover, such as bats, pangolins and rodents, whereas live animals that pose higher risks of transmission and ‘mixing’ viruses were less. Female vendors from the neighboring country smuggled wild meat across the border and set up their stalls on the floor on plastic mats. Customers were primarily urban residents and international visitors. Raw wild meat was stored in foam boxes or on banana leaves and touched with bare hands and tools without proper washing or sanitization afterwards. Cleaning and waste disposal was insufficient due to lacking infrastructure and hygiene regulation was non-existent. These conditions and practices contribute to a high risk for zoonotic disease transmission and spread (Magouras et al., 2020; Naguib et al., 2021; Sparaciari et al., 2025).

4.1 *Limited spillover and hygiene awareness*

Our observations demonstrate that awareness about zoonoses and spillover risk associated with the hunting, handling and selling of wildlife was limited or not prioritized in the market. While some participants such as the market organizer admitted that there could be a risk, it was downplayed, ignored or vendors and customers seemed to be unaware, and no structural preventive measures, such as animal health control, proper sanitation facilities, waste(water) management or even hygienic storage and display of products were in place (Jenkins et al., 2024; Peros et al., 2021). We did not observe customers following established preventative hygiene practices and wildlife meat was preferred over packed meat for its freshness, naturality and believed medicinal benefits (Aguirre et al., 2020; Magouras et al., 2020). While hygiene was insufficient in terms of spillover prevention, some vendors demonstrated established

practices for cleanliness and neatness. Vendors reported checking the animals for disease by judging their freshness by appearance, smell and texture, and refrained from selling sick animals as this would give them a bad reputation at the market. They were eager to present their products neatly, on clean fresh banana leaves or in clean, renewed plastic bags. Vendors seemed sophisticated in deciding which meat they would buy for trade, how to prepare and store it and practiced stricter hygiene at home than in the market.

4.2 Tensions between disease surveillance and regulations in illegal wildlife trade shape spillover risk

While some authors have called for the closure of wildlife markets to reduce spillover risk (Turcios-Casco & Cazzolla Gatti, 2020), others argue that blanket bans are not an effective solution (Magouras et al., 2020; Roe et al., 2020). As with the market we describe, the existing bans on wildlife trade are often not enforced (Anagnostou & Doberstein, 2026; Rosen & Smith, 2010), and trading law can inadvertently hinder disease surveillance and the monitoring and response to hygiene practices that may increase spillover (Bonwitt et al., 2018; Magouras et al., 2020). This is because laws prohibiting wildlife trade make it difficult for officials to assess the wild meat that is entering the market, and to assess animal health or meat quality (Aguirre et al., 2020). Furthermore, even though weakly enforced, the restrictive legal environment surrounding the market facilitated unhygienic practices that would otherwise be unnecessary and may increase pathogen transmission risk. For instance, hiding meat within vegetables increased the risk of cross-contamination, while the need to smuggle and sell meat covertly made adherence to basic hygiene more difficult (Jenkins et al., 2024). Criminalization may thus drive the trade underground into clack markets or to be hidden to avoid national or local public health monitoring and standards, thereby exacerbating the very risks such bans aim to mitigate by impeding safety controls for spillover risk and facilitating unhygienic conditions (Bonwitt et al., 2018; L  m et al., 2024; Stephen, 2021). Additionally, bans have shown not to be feasible

in the face of contradicting traditional and local practices, as we see trading exotic wildlife without hygiene guidelines as normalized (Bonwitt et al., 2018). While it is unlikely that loosening trade laws would directly lead to improved hygiene and disease monitoring, decriminalization of traditional wildlife consumption could facilitate more effective surveillance, education, and implementation of zoonotic risk prevention strategies. Evidence suggests that decriminalizing the wild meat trade and transitioning from punitive bans to licensing schemes may result in safer and more transparent practices (Lâm et al., 2024). While direct empirical evidence from South-East Asian contexts on unintended consequences for health risk prevention of wildlife-trade regulation appears limited, with the existing literature focusing more on implementation gaps of regulative law (Jiao et al., 2021), evidence from other criminalized contexts such as sex work and prostitution reveal positive health-related outcomes when decriminalizing schemes are implemented (Macioti et al., 2023). Legal regulation can facilitate improvements in market infrastructure and sanitation, enable formal inspection and oversight mechanisms, and introduce biosecurity protocols to reduce zoonotic risk (Sparaciari et al., 2025). In Ghana, programs supported by conservation and public health NGOs have worked with wildmeat traders' associations to formalize trade through licensing schemes (Cowlshaw et al., 2005). Traders who registered and complied with basic hygiene standards—such as displaying meat off the ground, using gloves, and maintaining clean workspaces—were granted access to improved market stalls, refrigeration equipment, and priority placement within legal markets. These material incentives not only encouraged compliance and the adoption of hygienic practices but were also considered to have built more trust and cooperation between traders and regulators. On the other hand, Wikramanayake et al. explain that “*no matter how clean the cages and knives are, dangerous viruses can spillover to humans in trade chains that include high disease-risk taxa*”, such as pangolins and bats (Wikramanayake et al., 2021, p. 2). The observations from this market raise questions about the extent to which spillover risk is driven by unhygienic practices versus the trade of wildlife itself. While poor

hygiene may amplify opportunities for pathogen transmission, the handling and sale of certain wildlife taxa remain high-risk activities even under improved sanitary conditions. Overall, this persistent trade risk and the unintended consequences and lacking feasibility and effectiveness of bans demand caution in designing spillover interventions to avoid shifting rather than eliminating risk, including practices of concealment and adaptations that alter how wildlife is sourced, transported, and sold.

4.3 Commercial interests appear to drive contemporary wildlife trade more than traditional practices

While both commercial interests and traditional practices contribute to wildlife consumption and trade (Paudel et al., 2025), our findings suggest that contemporary wildlife trade within the study setting was mainly driven by commercial demand rather than subsistence-oriented or culturally embedded practices. Recognizing that many communities rely on wildlife as a vital source of food and income, scholars emphasize the need for a nuanced understanding of wild meat consumption, noting that it is not inherently the source of zoonotic spillover (Milbank & Vira, 2022). They also highlight how the debate has often been shaped by culturally insensitive and racialized distinctions between so-called ‘good’ and ‘bad’ consumption practices (Milbank & Vira, 2022). We recommend a nuanced perspective that differentiates between traditional, local, national and global wildlife consumption and trade and considers preventive measures beyond bans (Magouras et al., 2020; Roe et al., 2020; Volpato et al., 2020). Our observations and interviews suggest that traditional and local wildlife consumption has primarily focused on small game - such as rats - typically hunted by farmers as pest control and by villagers for personal consumption or small-scale trade within their communities. However, rising interest in wildlife as a status symbol by urban and high-income consumers has led to maximization of wildlife harvesting to respond to the market pressure (Volpato et al., 2020). The involvement of vendors, hunters, middlemen, and market networks has expanded, elevating the scale and

complexity of the trade (‘t Sas-Rolfes et al., 2019). Animals circulating in these markets tend to be considered ‘special,’ or of medical use and are often endangered, such as the pangolin (Volpato et al., 2020). In traditional, subsistence-oriented practices, the hunting and consumption of these species is regulated through cultural beliefs and knowledge, if practiced at all (Volpato et al., 2020). A once sustainable and relatively low-risk practice of living with and utilizing natural environments has been transformed into an unsustainable and high spillover risk system due to unprecedented resource extraction and land use change—both in terms of the species being traded and the expanded potential for zoonotic spillover. While our focus is on spillover prevention, it is important to highlight that many of the taxa traded in these markets, such as pangolins, are endangered or critically vulnerable to extinction (Lin et al., 2021). These species play a crucial role in maintaining ecosystem stability (Chao et al., 2019; Turcios-Casco & Cazzolla Gatti, 2020), which in turn underpins human health. Disrupting these ecosystems is believed to increase the risk of zoonotic spillover (FAO, 2020).

4.4 One Health approaches point to a microcosm of the One Health macrocosm

These considerations encourage viewing the market through a One Health and political ecology lens. Similarly to how Massé and Gladkova reframe spillover as a structure rather than an event through a political ecology perspective (Massé & Gladkova, 2025), wildlife markets should be framed as a structure rather than an event, highlighting that they are manifestations of broader socioecological systems shaped by uneven power relations, environmental transformation, infrastructural and social determinants and economic dependency (Duffy et al., 2025; Winkler et al., 2025) rather than sites where spillover risk can be reduced to zoonotic pathogen circulation or individual behaviors. In Southeast Asia, deforestation, agricultural expansion, and growing demand for wildlife products as ecological processes are shaped by political-economic forces that restructure human–animal–environment relationships, drive encroachment into wildlife habitats, and determine which species and quantities of them are

traded (FAO, 2020). Wildlife trade, biodiversity loss, and spillover risk thus emerge not as separate phenomena but as interconnected outcomes of wider land-use, development, and market dynamics. From this perspective, the market infrastructure observed in this study reflects more than local sanitary conditions. The assemblage of wildlife products, international traders and customers, poor waste and water management, and water systems susceptible to contamination illustrates how environmental governance becomes embedded within everyday practices of trade, creating conditions through which zoonotic and environmental hazards can produce public health risks (Jenkins et al., 2024).

A political ecology perspective further highlights how the benefits and burdens of wildlife trade are distributed unevenly (Duffy et al., 2025). Wildlife trading and consumption support the livelihoods of communities facing biodiversity loss, climate-related disruptions, land-use change, food insecurity and economic dependencies (Naguib et al., 2021; Roe et al., 2020), while disproportionately exposing them to the consequences associated with wildlife trade, namely increased eco-system disruption and resulting food scarcity or health risks (Booth et al., 2021; FAO, 2020; Robinson et al., 2018). Our findings also reveal gendered dimensions of this vulnerability, with women overly involved in butchering, processing, transporting, and selling wildlife and therefore bearing heightened occupational exposure risks (Jenkins et al., 2024; Kusumaningrum et al., 2022). The criminalization of subsistence-based wildlife trade and resulting rise of difficult to surveille and regulate black markets does not only threaten already precarious livelihoods, but leaves powerful actors situated higher in the supply chain largely insulated from enforcement pressures (Duffy et al., 2025; Paudel et al., 2020). As a result, risk, accountability, and visibility become unevenly distributed across the trade network. The regulatory landscape reflects political-economic structures that determine not only who becomes the focus of surveillance but also who benefits from the opacity created by prohibition, which in turn obstructs appropriate public health assessment and reinforces gendered and

classed inequities across the trade (Duffy et al., 2025). When viewed through the One Health ethos and equity paradigm (Winkler et al., 2025), these dynamics reveal persistent gaps in fairness, accountability, and participation, and collectively undermine the trust and cooperation necessary for effective zoonotic risk mitigation (Osorio & Bernaz, 2024). Thus, rather than emerging solely from contact between humans and wildlife, spillover vulnerability must be understood as stemming from contested territorial and economic relations shaped by uneven enforcement, livelihood precarity, and asymmetrical cross-border governance. Following this line of argument, we term the market here as an example of where the One Health macrocosm – comprising wider animal- human- environment interactions – is converged into a microcosm – the market and on-site trade – shaped and enacted by the described underlying drivers.

4.5 Recommendations

Understanding the market as a microcosm of the One Health macrocosm implies that zoonotic prevention interventions must target different levels. On the micro and local level, the lack of sufficient infrastructure to support hygiene practices can be addressed by improved sanitary infrastructure, regulations for waste management and hygiene practices in the market (Bardosh et al., 2023; Jenkins et al., 2024; Nadimpalli & Pickering, 2020; Naguib et al., 2021). On the meso level, vendors' and customers' behaviors could be attended to through educational interventions. Female food vendors are considered to demonstrate more hygienic behavior and have shown more adherence to hygiene practices in markets (Salamandane et al., 2020). As described above and in other markets, vendors reveal understandings, knowledge and practices related to hygiene when it comes to meat quality checking, cleanliness and neat display of products (Bardosh et al., 2023; Wallace et al., 2022). Educational interventions could empower those vendors vulnerable to transmission by using culturally mediated messaging that builds on these existing understandings. Interventions targeting female vendors could also have a wider effect, translating food hygiene practices to the household. Educational interventions on the

customer demand side could help decrease trade volume (Challender et al., 2015). Whilst decreasing wildlife consumption might be one of the most sustainable in terms of preserving ecosystems and therefore pandemic prevention in the long run, the economic consequences for wildlife traders must be taken into account and alternative income sources, e.g., through preserving incentives must be created (Challender et al., 2015).

On the macro level, the regulatory and political landscape shaped practices in the market and poses challenges when applied in local contexts, e.g., due to lack of enforcement, and discrepancies of cultural practices and law. Although upstream interventions, including conservation and environmental protection policies, are essential for addressing the structural drivers of zoonotic spillover, their implementation is often challenged by complex trade systems and globally interconnected economic interests. Consequently, they should be complemented by more immediate and pragmatic measures capable of reducing spillover risk in the short term.

While many scholars have argued for streamlining regulations, globalizing trade laws and strengthening enforcement (Aguirre et al., 2021), our example shows how economic interests undermine regulations and how regulations in turn complicate hygiene practices. As surveillance in illegal settings is often hampered and not sufficiently considered in illegal wildlife trade (Aguirre et al., 2021), for zoonotic disease surveillance, it may be more effective to separate trade regulation from animal health monitoring. By enabling animal health and disease control officials to operate - even within informal or illegal settings - they could monitor risks of zoonoses and source dynamics, promote preventive measures, and educate vendors confidentially. Like healthcare workers, these professionals could play a unique role in safeguarding both animal and human health by supporting existing practices with targeted hygiene education and ground surveillance. Rather than focusing exclusively on eliminating risk-generating activities, a more feasible approach may be to reduce the likelihood of disease

transmission through targeted education for individuals in contact with wildlife and through surveillance and control systems capable of detecting emerging pathogens, including within informal or illegal trade networks (Rush et al., 2021; Watsa, 2020).

We support the considerations by Naguib et al. who advocate for holistic approaches such as One Health or Planetary Health to assess and protect the health of the human species (Naguib et al., 2021). As we have displayed above, societal and economic factors such as globalization of trade chains, change in traditional lifestyles to farming and climate change greatly influence our example market for wildlife trade and therefore have to be considered in developing useful and fair pandemic prevention systems. The difference between the global trade of high-risk, endangered and exotic species by high-income, urban consumers versus a traditional, subsistence-oriented and sustainable use of wildlife by remote communities should be considered both in (de)criminalizing wild meat consumption and pandemic prevention. Given the complexity and multifactorial nature of zoonotic emergence, prevention cannot rely solely on biomedical or ecological perspectives. While the One Health framework offers a robust integrative lens by integrating human, animal, and environmental health, its effectiveness depends on incorporating economic, cultural, and socio-political contexts, as well as the livelihood realities of local communities. Such a holistic approach to the prevention of zoonotic spillover is critical to ensuring the feasibility, sustainability, equity and overall effectiveness of preventive measures.

4.6 Limitations

Our study focuses on observations and interviews at a wildlife market at a specific time as an example of a potential spillover hotspot. While we gain insights into trade chains, hunting and preparation of the meat through the participants, a more detailed picture of all involved in the trade chain would be useful to understand how the risk at the market is eventually shaped. Ethical issues in our observations concerning the fact that wildlife trade is illegal might have

influenced the behavior of those aware of our study towards socially desirable answers and practices. We tried to eliminate this by extended engagement in the field over four days, so that vendors got used to the research team and a multitude of unaware customers could be observed. We highlight that though the market acts as an example of a high-risk interface, it is recognized as a special market particularly trading exotic wildlife, which does not apply to many wildlife markets in the region.

5 Conclusion

We provide qualitative insights from a Southeast Asian wildlife market trading high-risk and endangered species. Consumption was driven largely by taste preferences and perceived health benefits, while the market's layout, trading practices, and hygiene conditions offered limited protection against zoonotic spillover. Preventive measures should account for the cultural and economic drivers of wildlife use, support livelihoods that depend on these practices, and ensure that local communities are meaningfully involved in shaping risk-reduction strategies.

6 Declaration of Competing Interests

The authors declare they have no competing interests.

7 References

- 't Sas-Rolfes, M., Challender, D. W., Hinsley, A., Veríssimo, D., & Milner-Gulland, E. J. (2019). Illegal Wildlife Trade: Scale, Processes, and Governance. *Annual Review of Environment and Resources*, 44(1), 201–228. <https://doi.org/10.1146/annurev-environ-101718-033253>
- Aguirre, A. A., Catherina, R., Frye, H., & Shelley, L. (2020). Illicit Wildlife Trade, Wet Markets, and COVID-19: Preventing Future Pandemics. *World Medical & Health Policy*, 12(3), 256–265. <https://doi.org/10.1002/wmh3.348>

- Allen, T., Murray, K. A., Zambrana-Torrel, C., Morse, S. S., Rondinini, C., Di Marco, M., Breit, N., Olival, K. J., & Daszak, P. (2017). Global hotspots and correlates of emerging zoonotic diseases. *Nature Communications*, 8(1), 1124.
<https://doi.org/10.1038/s41467-017-00923-8>
- Anagnostou, M., & Doberstein, B. (2026). Countering organised wildlife trafficking: insights from law enforcement personnel on challenges and opportunities. *Trends in Organized Crime*. Advance online publication. <https://doi.org/10.1007/s12117-026-09588-6>
- Bonwitt, J., Dawson, M., Kandeh, M., Ansumana, R., Sahr, F., Brown, H., & Kelly, A. H. (2018). Unintended consequences of the 'bushmeat ban' in West Africa during the 2013-2016 Ebola virus disease epidemic. *Social Science & Medicine (1982)*, 200, 166–173. <https://doi.org/10.1016/j.socscimed.2017.12.028>
- Booth, H., Arias, M., Brittain, S., Challender, D. W. S., Khanyari, M., Kuiper, T., Li, Y., Olmedo, A., Oyanedel, R., Pienkowski, T., & Milner-Gulland, E. J. (2021). “Saving Lives, Protecting Livelihoods, and Safeguarding Nature”: Risk-Based Wildlife Trade Policy for Sustainable Development Outcomes Post-COVID-19. *Frontiers in Ecology and Evolution*, 9, Article 639216. <https://doi.org/10.3389/fevo.2021.639216>
- Braun, V., & Clarke, V. (2023). Toward good practice in thematic analysis: Avoiding common problems and becoming a knowing researcher. *International Journal of Transgender Health*, 24(1), 1–6. <https://doi.org/10.1080/26895269.2022.2129597>
- Bryman, A. (2016). *Social Research Methods*. Oxford University Press.
<https://books.google.de/books?id=N2zQCgAAQBAJ>
- Challender, D. W., Harrop, S. R., & MacMillan, D. C. (2015). Towards informed and multi-faceted wildlife trade interventions. *Global Ecology and Conservation*, 3, 129–148.
<https://doi.org/10.1016/j.gecco.2014.11.010>
- Chao, J.-T., Li, H.-F., & Lin, C.-C. (2019). The role of pangolins in ecosystems, 43–48.
<https://doi.org/10.1016/B978-0-12-815507-3.00003-4>

- Chitov, A. (2019). International law and criminalizing illegal trade in endangered species (from the Far Eastern perspective). *Asia Pacific Journal of Environmental Law*, 22(2), 207–227. <https://doi.org/10.4337/apjel.2019.02.02>
- Cowlishaw, G. U., Mendelson, S., & Rowcliffe, J. M. (2005). Evidence for post-depletion sustainability in a mature bushmeat market. *Journal of Applied Ecology*, 42(3), 460–468. <https://doi.org/10.1111/j.1365-2664.2005.01046.x>
- Duffy, R., Hutchinson, A., Iordachescu, G., & Lappe-Osthege, T. (2025). A harms-based political ecology: Understanding harms through the wildlife trade. *Journal of Political Ecology*, 32(1). <https://doi.org/10.2458/jpe.6226>
- Ellwanger, J. H., & Chies, J. A. B. (2021). Zoonotic spillover: Understanding basic aspects for better prevention. *Genetics and Molecular Biology*, 44(1 Suppl 1), e20200355. <https://doi.org/10.1590/1678-4685-GMB-2020-0355>
- Food and Agriculture Organization. (2020). *Global emergence of infectious diseases: links with wild meat consumption, ecosystem disruption, habitat degradation and biodiversity loss*. <https://doi.org/10.4060/ca9456en>
- Harré, R. (2002). Public Sources of the Personal Mind: Social Constructionism in Context. *Theory & Psychology*, 12(5), 611–623. <https://doi.org/10.1177/0959354302012005895>
- He, W.-T., Hou, X., Zhao, J., Sun, J., He, H., Si, W., Wang, J., Jiang, Z., Yan, Z., Xing, G., Lu, M., Suchard, M. A., Ji, X., Gong, W., He, B., Li, J., Lemey, P., Guo, D., Tu, C., . . . Su, S. (2022). Virome characterization of game animals in China reveals a spectrum of emerging pathogens. *Cell*, 185(7), 1117–1129.e8. <https://doi.org/10.1016/j.cell.2022.02.014>
- Jenkins, J., Lawundeh, W., Hanson, T., & Brown, H. (2024). Human-animal entanglements in bushmeat trading in Sierra Leone: An ethnographic assessment of a potential zoonotic interface. *PloS One*, 19(3), e0298929. <https://doi.org/10.1371/journal.pone.0298929>

- Jiao, Y., Yeophantong, P., & Lee, T. M. (2021). Strengthening International Legal Cooperation to Combat the Illegal Wildlife Trade Between Southeast Asia and China. *Frontiers in Ecology and Evolution*, 9, Article 645427. <https://doi.org/10.3389/fevo.2021.645427>
- Kreuder Johnson, C., Hitchens, P. L., Smiley Evans, T., Goldstein, T., Thomas, K., Clements, A., Joly, D. O., Wolfe, N. D., Daszak, P., Karesh, W. B., & Mazet, J. K. (2015). Spillover and pandemic properties of zoonotic viruses with high host plasticity. *Scientific Reports*, 5, 14830. <https://doi.org/10.1038/srep14830>
- Lâm, S., Masudi, S. P., Nguyen, H. T. T., & Grace, D. (2024). Preventing mpox at its source: Using food safety and One Health strategies to address bushmeat practices. *BMC Global and Public Health*, 2(1), 69. <https://doi.org/10.1186/s44263-024-00100-2>
- Lin, B., Dietrich, M. L., Senior, R. A., & Wilcove, D. S. (2021). A better classification of wet markets is key to safeguarding human health and biodiversity. *The Lancet. Planetary Health*, 5(6), e386-e394. [https://doi.org/10.1016/S2542-5196\(21\)00112-1](https://doi.org/10.1016/S2542-5196(21)00112-1)
- Lumivero. (2025). *NVivo (Version 15)* [Computer software]. Lumivero. www.lumivero.com
- Maciotti, P. G., Power, J., & Bourne, A. (2023). The Health and Well-being of Sex Workers in Decriminalised Contexts: A Scoping Review. *Sexuality Research and Social Policy*, 20(3), 1013–1031. <https://doi.org/10.1007/s13178-022-00779-8>
- Magouras, I., Brookes, V. J., Jori, F., Martin, A., Pfeiffer, D. U [Dirk Udo], & Dürr, S. (2020). Emerging Zoonotic Diseases: Should We Rethink the Animal-Human Interface? *Frontiers in Veterinary Science*, 7, 582743. <https://doi.org/10.3389/fvets.2020.582743>
- Massé, F., & Gladkova, E. (2025). Spatializing zoonotic disease dynamics from a political ecology perspective: Reconceptualizing spillover as structure. *Journal of Political Ecology*, 32(1). <https://doi.org/10.2458/jpe.5810>

- McMahon, S. A., & Winch, P. J. (2018). Systematic debriefing after qualitative encounters: An essential analysis step in applied qualitative research. *BMJ Global Health*, 3(5), e000837. <https://doi.org/10.1136/bmjgh-2018-000837>
- Mele, C., Ng, M., & Chim, M. B. (2015). Urban markets as a ‘corrective’ to advanced urbanism: The social space of wet markets in contemporary Singapore. *Urban Studies*, 52(1), 103–120. <https://doi.org/10.1177/0042098014524613>
- Meurens, F., Dunoyer, C., Fourichon, C., Gerdt, V., Haddad, N., Kortekaas, J., Lewandowska, M., Monchatre-Leroy, E., Summerfield, A., Wichgers Schreur, P. J., van der Poel, W. H. M., & Zhu, J. (2021). Animal board invited review: Risks of zoonotic disease emergence at the interface of wildlife and livestock systems. *Animal : An International Journal of Animal Bioscience*, 15(6), 100241. <https://doi.org/10.1016/j.animal.2021.100241>
- Milbank, C., & Vira, B. (2022). Wildmeat consumption and zoonotic spillover: Contextualising disease emergence and policy responses. *The Lancet. Planetary Health*, 6(5), e439-e448. [https://doi.org/10.1016/S2542-5196\(22\)00064-X](https://doi.org/10.1016/S2542-5196(22)00064-X)
- Nadimpalli, M. L., & Pickering, A. J. (2020). A call for global monitoring of WASH in wet markets. *The Lancet. Planetary Health*, 4(10), e439-e440. [https://doi.org/10.1016/S2542-5196\(20\)30204-7](https://doi.org/10.1016/S2542-5196(20)30204-7)
- Naguib, M. M., Li, R., Ling, J., Grace, D., Nguyen-Viet, H., & Lindahl, J. F. (2021). Live and Wet Markets: Food Access versus the Risk of Disease Emergence. *Trends in Microbiology*, 29(7), 573–581. <https://doi.org/10.1016/j.tim.2021.02.007>
- Nguyen, T. T., Mai, T. N., Dang-Xuan, S., Nguyen-Viet, H., Unger, F., & Lee, H. S. (2024). Emerging zoonotic diseases in Southeast Asia in the period 2011-2022: A systematic literature review. *The Veterinary Quarterly*, 44(1), 1–15. <https://doi.org/10.1080/01652176.2023.2300965>

- Paudel, P. K., Shrestha, D., & Deshar, R. (2025). Global patterns and drivers of wildlife hunting and trade: A review. *Ecological Frontiers*, 45(5), 1147–1156.
<https://doi.org/10.1016/j.ecofro.2025.06.005>
- Peros, C. S., Dasgupta, R., Kumar, P., & Johnson, B. A. (2021). Bushmeat, wet markets, and the risks of pandemics: Exploring the nexus through systematic review of scientific disclosures. *Environmental Science & Policy*, 124, 1–11.
<https://doi.org/10.1016/j.envsci.2021.05.025>
- Petrikova, I., Cole, J., & Farlow, A. (2020). Covid-19, wet markets, and planetary health. *The Lancet. Planetary Health*, 4(6), e213–e214. [https://doi.org/10.1016/S2542-5196\(20\)30122-4](https://doi.org/10.1016/S2542-5196(20)30122-4)
- Plowright, R. K., Parrish, C. R., McCallum, H., Hudson, P. J., Ko, A. I., Graham, A. L., & Lloyd-Smith, J. O. (2017). Pathways to zoonotic spillover. *Nature Reviews. Microbiology*, 15(8), 502–510. <https://doi.org/10.1038/nrmicro.2017.45>
- Price, E. O. (1984). Behavioral Aspects of Animal Domestication. *The Quarterly Review of Biology*, 59(1), 1–32. <https://doi.org/10.1086/413673>
- Reñosa, M. D. C., Bärnighausen, K., Wachinger, J., Endoma, V., Landicho, J., Aligato, M. F., Landicho-Guevarra, J., Bravo, T. A., Scott, K., Bärnighausen, T., & McMahon, S. A. (2024). Messy but worth it: Human-centred design as applied within a successful vaccine-promotive campaign. *BMJ Global Health*, 9(7).
<https://doi.org/10.1136/bmjgh-2023-014870>
- Robinson, J. E., Griffiths, R. A., Fraser, I. M., Raharimalala, J., Roberts, D. L., & St. John, F. A. V. (2018). Supplying the wildlife trade as a livelihood strategy in a biodiversity hotspot. *Ecology and Society*, 23(1). <https://doi.org/10.5751/ES-09821-230113>

- Roe, D., Dickman, A., Kock, R., Milner-Gulland, E. J., Rihoy, E., & Sas-Rolfes, M. 't (2020). Beyond banning wildlife trade: Covid-19, conservation and development. *World Development*, 136, 105121. <https://doi.org/10.1016/j.worlddev.2020.105121>
- Rosen, G. E., & Smith, K. F. (2010). Summarizing the evidence on the international trade in illegal wildlife. *EcoHealth*, 7(1), 24–32. <https://doi.org/10.1007/s10393-010-0317-y>
- Rush, E. R., Dale, E., & Aguirre, A. A. (2021). Illegal Wildlife Trade and Emerging Infectious Diseases: Pervasive Impacts to Species, Ecosystems and Human Health. *Animals : An Open Access Journal from MDPI*, 11(6). <https://doi.org/10.3390/ani11061821>
- Sánchez, C. A., Li, H., Phelps, K. L., Zambrana-Torrel, C., Wang, L.-F., Zhou, P., Shi, Z.-L., Olival, K. J., & Daszak, P. (2022). A strategy to assess spillover risk of bat SARS-related coronaviruses in Southeast Asia. *Nature Communications*, 13(1), 4380. <https://doi.org/10.1038/s41467-022-31860-w>
- Sparaciari, F. E., Firth, C., Karlsson, E. A., & Horwood, P. F. (2025). Zoonotic disease risk at traditional food markets. *Journal of Virology*, 99(8), e0071825. <https://doi.org/10.1128/jvi.00718-25>
- Terry, G., & Hayfield, N. (2020). Chapter 38: Reflexive thematic analysis. In M. Ward & S. Delamont (Eds.), *Social and Political Science 2020. Handbook of Qualitative Research in Education* (pp. 430–441). Edward Elgar Publishing. <https://doi.org/10.4337/9781788977159.00049>
- Thambinathan, V., & Kinsella, E. A. (2021). Decolonizing Methodologies in Qualitative Research: Creating Spaces for Transformative Praxis. *International Journal of Qualitative Methods*, 20, 1-9. <https://doi.org/10.1177/16094069211014766>
- Turcios-Casco, M. A., & Cazzolla Gatti, R. (2020). Do not blame bats and pangolins! Global consequences for wildlife conservation after the SARS-CoV-2 pandemic. *Biodiversity and Conservation*, 29(13), 3829–3833. <https://doi.org/10.1007/s10531-020-02053-y>

- Varpio, L., Ajjawi, R., Monrouxe, L. V., O'Brien, B. C., & Rees, C. E. (2017). Shedding the cobra effect: Problematising thematic emergence, triangulation, saturation and member checking. *Medical Education*, 51(1), 40–50.
<https://doi.org/10.1111/medu.13124>
- Volpato, G., Fontefrancesco, M. F., Gruppuso, P., Zocchi, D. M., & Pieroni, A. (2020). Baby pangolins on my plate: Possible lessons to learn from the COVID-19 pandemic. *Journal of Ethnobiology and Ethnomedicine*, 16(1), 19.
<https://doi.org/10.1186/s13002-020-00366-4>
- Watsa, M. (2020). Rigorous wildlife disease surveillance. *Science (New York, N.Y.)*, 369(6500), 145–147. <https://doi.org/10.1126/science.abc0017>
- Wikramanayake, E., Pfeiffer, D. U [Dirk U.], Magouras, I., Conan, A., Ziegler, S., Bonebrake, T. C., & Olson, D. (2021). A tool for rapid assessment of wildlife markets in the Asia-Pacific Region for risk of future zoonotic disease outbreaks. *One Health (Amsterdam, Netherlands)*, 13, 100279. <https://doi.org/10.1016/j.onehlt.2021.100279>
- Winkler, A. S., Brux, C. M., Carabin, H., das Neves, C. G., Häsler, B., Zinsstag, J., Fèvre, E. M., Okello, A., Laing, G., Harrison, W. E., Pöntinen, A. K., Huber, A., Ruckert, A., Natterson-Horowitz, B., Abela, B., Aenishaenslin, C., Heymann, D. L., Rødland, E. K., Berthe, F. C. J., . . . Amuasi, J. H. (2025). The Lancet One Health Commission: Harnessing our interconnectedness for equitable, sustainable, and healthy socioecological systems. *Lancet (London, England)*, 406(10502), 501–570.
[https://doi.org/10.1016/S0140-6736\(25\)00627-0](https://doi.org/10.1016/S0140-6736(25)00627-0)
- Yin, R. K. (1994). *Case Study Research: Design and Methods* (2nd). Thousand Oaks, CA: SAGE.

Highlights

- Wildlife markets can be a platform for zoonotic spillover risk in Southeast Asia
- Poor hygiene practices, infrastructure and illegal trade amplify risk
- Regulative law, traditions, consumerism and environmental change shape market trade
- Understanding market practices creates opportunities for risk prevention

Ethics declaration

Informed consent and patient details

Written informed consent to take part in the study and to publish the article has been obtained from all participants or their legal representatives. The privacy rights of participants have been observed.

Studies in Human

This study was performed in compliance with relevant laws, regulatory frameworks and guidelines where the research took place.

This study was approved by the Ethics Committee of the Medical School of Heidelberg University.

(Approval No. S-686/2024)

Declaration of Interest Statement

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The author is an Editorial Board Member/Editor-in-Chief/Associate Editor/Guest Editor for this journal and was not involved in the editorial review or the decision to publish this article.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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