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Final report

project

Reducing disease risks and improving food safety in smallholder pig value chains in Vietnam

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Abbreviations and acronyms

ACIAR	Australian Centre for International Agricultural Research
GAHP	Good Animal Husbandry Practices
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHP	Good Hygienic Practices
HUPH	Hanoi University of Public Health
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
LIFSAP	Livestock Competitiveness and Food Safety Project
QMRA	Quantitative Microbial Risk Assessment
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USD	United States dollars
VietGAHP	Vietnam Good Animal Husbandry Practices
VNUA	Vietnam National University of Agriculture
WHO	World Health Organization

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1 Acknowledgements

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2 Executive summary

Food safety is a key concern in Vietnam. Pork is the most popular meat in the country and is essential for nutrition and farmer livelihoods. Pork is produced mainly by smallholders and sold fresh in traditional (wet) markets. In a country where one in four children are stunted, animal-source foods can help in tackling under-nutrition and as demand for pork grows, supporting the smallholder pig value chain can provide pathways out of poverty for farmers and others. The project *Reducing disease risks and improving food safety in smallholder pig value chains in Vietnam* (PigRisk) was implemented by the Hanoi University of Public Health (HUPH), the Vietnam National University of Agriculture (VNUA) and the International Livestock Research Institute (ILRI) from June 2012 to September 2017 in Hung Yen and Nghe An provinces. It improved the livelihoods of smallholder pig farmers by enabling market access through addressing food safety in the pork value chain. It built on strong national partnerships to address questions of consequence: Is pork in Vietnam safe? Are the risks serious? How best can these risks be managed? Key achievements are highlighted below, by objective.

Objective 1: To assess impacts of pork-borne diseases on human health and the livestock sector and identify critical points/opportunities for risk management

- We generated rigorous epidemiological evidence on *Salmonella*, a bacterial pathogen which pigs host. We detected *Salmonella* in 44% of marketed pork.
- The first quantitative microbial risk assessment (QMRA) in Vietnam found that 1–2 in 10 pork consumers are at risk of *Salmonella* poisoning annually.
- An economic assessment put the costs per treatment and per day of hospitalization for foodborne diarrhoea at USD 107 and USD 34, respectively.

Objective 2: To develop and test incentive-based innovations to improve management of human and animal health risks in smallholder pig value chains

- Evaluation of Vietnam Good Animal Husbandry Practices (VietGAHP) helped identify issues preventing large-scale adoption. It allowed us to identify a smaller set of simpler guidelines which may be more feasible and confirmed that without incentives, adoption is limited.
- A light-touch intervention at a slaughterhouse (off-the-ground slaughtering rack) improved pork safety but would not be used unless incentives could be introduced.
- Evaluation of a participatory video intervention from a previous ACIAR-funded project provided evidence for sustainable benefits and identified the factors that led to these.

Objective 3: To sustainably improve capacity to assess and manage risks in smallholder pig value chains by engaging stakeholders and co-generating evidence

- We built the capacity of researchers and students on risk assessment, risk communication, One Health and value chain assessment. Over 100 students obtained higher level degrees. Eleven posters and 21 presentations were presented at 22 international fora. A national taskforce on food safety risk assessment was set up and a national food safety working group supported. Tools for risk assessment and management were developed and used. Ten peer-reviewed journal articles were published; they informed the approach and priorities of a landmark report by the World Bank on food safety risk assessment which has been adopted by the Government of Vietnam.

Based on provided evidence in PigRisk a follow-on project Safe Pork (LS/2016/143) to develop, test and promote light-touch, incentive-based food safety interventions with a new component on behavioural economics (nudges) and private sector engagement has been launched in October 2018.

3 Background

The PigRisk project built on a previous ILRI-led project funded by ACIAR (LPS/2006/063) which comprehensively characterized the smallholder pig sector in Vietnam. The study concluded that the small-scale household pig production systems were highly competitive because of their use of home-produced feed and household labour. Smallholder pig production generates sufficient return to household labour and retains value within traditional value chains with large numbers of poor women and men involved in transport, slaughtering, processing and retail. Pork is the most consumed meat in Vietnam and its production delivers substantial benefits to the smallholders who supply 84% of the market. -Studies by ILRI have estimated that the share of the small-scale pig sector in Vietnam will remain almost unchanged over the coming years (Lapar et al. 2012).

Pork can contain high levels of pathogens and there is growing concern among the public and policymakers to manage food safety and animal disease in pork value chains. The profitability and functioning of those chains are extremely vulnerable to breakdowns in food safety.

The PigRisk project was developed based on growing concerns about food safety in Vietnam. Policymakers favour industrial systems based on perceptions that industrialization will not only improve food safety but also productivity. Food safety concerns continued to increase during the implementation of the project. A nationally representative survey funded by the United States Agency for International Development (USAID) found that food safety was one of the two most pressing issues for people in Vietnam, more than education, healthcare or governance (USAID 2015). A large survey in 2010 found that respondents were pessimistic about the food safety situation in Vietnam; 43% of interviewees felt that food safety had worsened in the previous 10 years while only 22% felt otherwise (Jabbar et al. 2010).

Pork in wet markets is perceived to be riskier than that sold in supermarkets, but several ILRI studies suggested it actually has lower levels of pathogens. The low risk associated with wet-market pork is related to short value chains, the short period between slaughter and consumption, and risk-reducing handling and consumption practices. The higher contamination in supermarket pork is related to longer storage time, intermittent cold chain due to power cuts and plastic packaging that keeps meat moist, favouring microbial growth. There may also be systematic differences in disease between large and small farms, but this has not been studied.

The Government of Vietnam has made addressing food safety a major strategic priority. In 2010, Prime Minister Nguyen Tan Dung approved a national food safety strategy which aims to have most actors complying with food safety regulations.

While Vietnamese policymakers currently favour industrial pork production systems based on perceptions that industrialization will improve productivity, profitability and food safety, there is strong interest in better understanding food safety and the health of producers in smallholder pig value chains and developing, testing and promoting incentive-based risk management approaches that are pro-poor.

Taking advantage of this opportunity, the PigRisk project addressed three research questions:

1. What are the human health risks and economic costs of pork-borne diseases in smallholder pig value chains in Vietnam and what are the critical points or opportunities for risk management?
2. What is the added utility of *risk-based approaches* to food safety and pork-borne disease (that focus on human health impacts) compared with current *hazard-based approaches* (based on the presence of pathogens in pork)?

3. What is the most appropriate role for incentive-based innovations in improving the management of human and animal health risks in these smallholder pig value chains?

By generating evidence that leads to more successful and pro-poor management of the risks to human and animal health currently hampering the pig sector in Vietnam, the project aimed to improve participation in and incomes from smallholder pig value chains.

4 Objectives

The goal of the project was to improve the livelihoods of rural and urban poor in Vietnam through improved opportunities and incomes from pig value chains as a result of reduced risks associated with pork-borne diseases. It addressed this goal through three objectives.

Objective 1: To assess impacts of pork-borne diseases on human health and the livestock sector and identify critical points/opportunities for risk management

This objective was met. We conducted Vietnam's first ever quantitative risk assessment of the health impact of salmonellosis, an important pork-borne disease. We conducted other evaluations on the health impacts of chemical hazards and selected pathogens. We also conducted the first cost of illness estimate for pork-borne disease. The findings were both novel and important. We found a much larger burden of disease from biological hazards than most stakeholders anticipated and a much smaller burden from chemical hazards. The results were published in peer-reviewed journals and disseminated to stakeholders via multiple pathways. They informed the approach and priorities of a landmark report by the World Bank on food safety which has been taken up by the Government of Vietnam (World Bank 2017).

Objective 2: To develop and test incentive-based innovations to improve management of human and animal health risks in smallholder pig value chains

This objective was only partially met, because of a longer than anticipated assessment phase. However, we developed some interventions and tested them to a limited extent.

- We evaluated the Good Agricultural Practices (GAP)/Good Hygienic Practices (GHP) scheme promoted by a major initiative. This enabled us to identify issues preventing large-scale adoption and safer pork, allowed us to identify a smaller set of simpler GAP/GHP which may be more feasible, and confirmed that without incentives, adoption is limited.
- We tested the use of an off-the-ground slaughtering rack in a slaughterhouse. We found that this light-touch intervention improved pork hygiene but was not attractive, in the absence of additional incentives for adoption due to an perceived slowdown of slaughter process. A follow up visit under Safe Pork (end 2018) revealed that the owner consequently adopted and even expanding our intervention responding to a demand for more hygienic slaughter by the private Samsung canteen which provided sufficient incentive for adoption.
- Participatory video, a media in which community members were asked to create their own film on the benefits of an intervention, was used to evaluate a previous ACIAR-funded project. Evidence was found on sustainable benefits and the factors that led to these.

Objective 3: To sustainably improve capacity to assess and manage risks in smallholder pig value chains by engaging stakeholders and co-generating evidence

This objective was largely met with substantive capacity building activities. These included training of more than 100 students who obtained higher level degrees in risk assessment, risk communication, One Health, system dynamics modelling and value chain analysis. Twelve MSc and two PhD students finalized or submitted their theses. Results were presented at more than 20 international conferences; this included 11 posters and 21 presentations. A national taskforce on food safety risk assessment was established and capacity built. In addition, policy and research briefs targeting central and provincial policymakers and researchers were developed through participatory processes.

5 Methodology

Site selection

Study sites were selected through a participatory process involving workshops and consultations with local and national authorities.

Selection of provinces

The project targeted two provinces in northern and central Vietnam. The provinces were chosen to be representative of two patterns of pork sector development detected by a previous ACIAR-funded project.

Hung Yen province is close to Hanoi and represents a scenario of rapid, unplanned, demand-driven development due to its proximity to urban markets. It has a population of 1.1 million people, a literacy rate of 95.8% and per capita Gross Domestic Product (GDP) of USD 1,986 (UNDP 2011).

Nghe An province is situated approximately 250 km south of Hanoi and is the largest province on the north-central coast. It represents a more traditional pig system with different possible trajectories of development. It has a population of 3 million people, a literacy rate of 94% and per capita GDP of USD 1,692 (UNDP 2011).

Selection of districts and communes

In each province, three districts were selected for detailed assessment of the risks and costs associated with diseases in the pork value chain. The districts were chosen based on six criteria developed by the CGIAR Research Program on Livestock for use in analysis of its value chains:

a. pig movement representing three different value chains of interest: rural to rural, rural to urban and peri-urban to urban;

b. pig density (low, medium or high);

c. pig production system and diversity of breeds;

d. location of districts (related to disease outbreak);

e. Livestock Competitiveness and Food Safety Project (LIFSAP) site; and

f. soft criteria about the cooperation of the local government.

In Hung Yen province, the selected districts were Khoai Chau, Van Giang and Tien Lu. In Nghe An province, the selected districts were Do Luong, Dien Chau and Hung Nguyen.

In each district, three communes were selected based on pig density, chosen randomly after excluding those dominated by large pig farms (confirmed by the local Department of Agriculture and Rural Development).

Figure 1 illustrates the maps of the selected provinces, districts and communes. Figure 2 shows a schematic diagram of the selected provinces, districts and communes and the value chains.

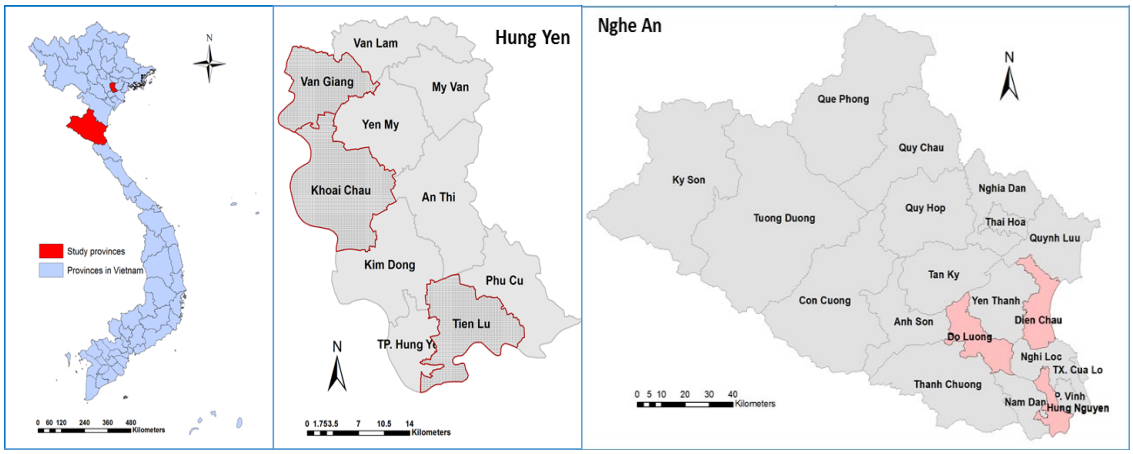

Figure 1: Maps of the selected provinces, districts and communes.

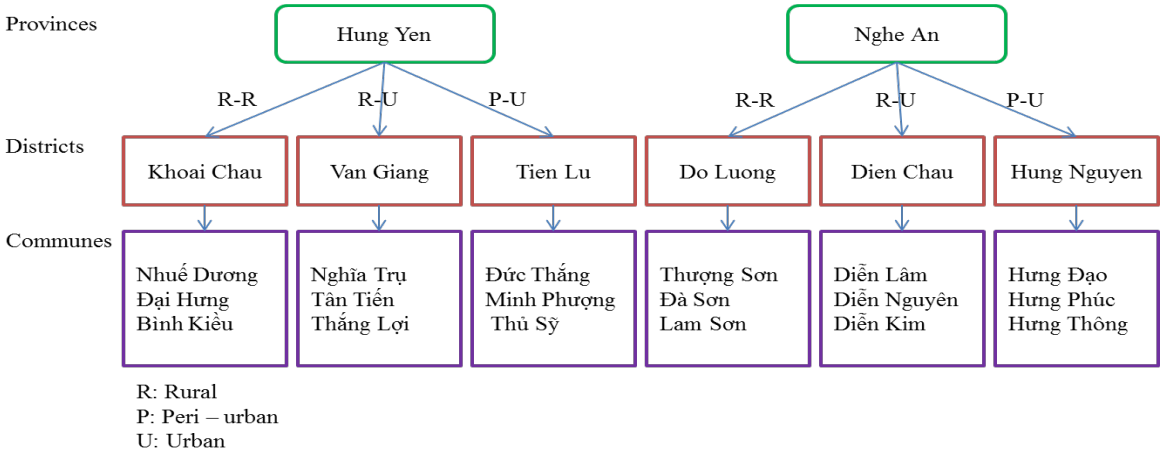

Figure 2: Schematic diagram of the selected provinces, districts and communes and the value chains.

Project framework

The project used a One Health approach to food safety research, bringing together a multi-disciplinary research team comprising veterinarians, medical doctors, environmental health experts and economists working with local stakeholders in pig production, slaughtering, processing, retail and consumers (farm to fork).

The expertise of the team members supported specific activities which included economic and health assessment related to pork-borne diseases, exploring and piloting potential interventions, capacity building and dissemination. The overall project framework with key activities by objective is presented in Figure 3.

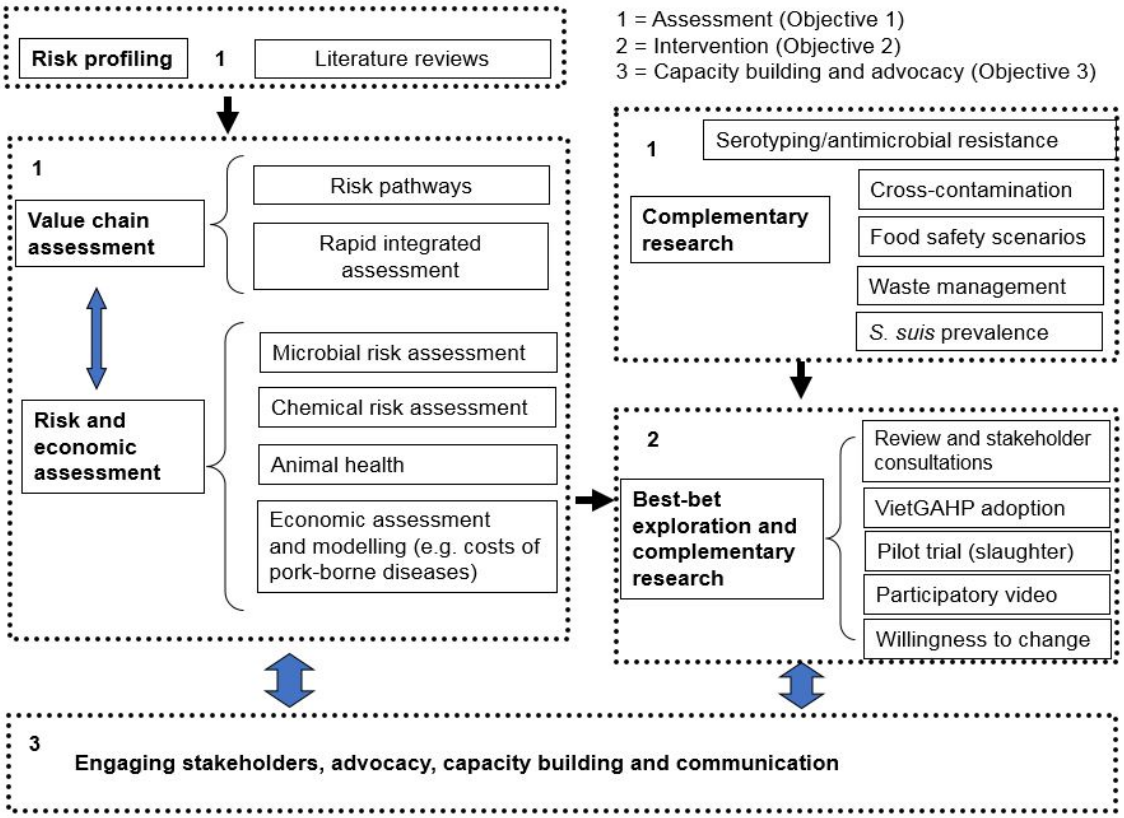

Figure 3: Project framework with key activities and supported objectives.

Objective 1: To assess impacts of pork-borne diseases on human health and the livestock sector and identify critical points/opportunities for risk management

This was achieved through desk studies, consultations with stakeholders and field surveys of hundreds of value chain actors in the two provinces.

Risk profiling and priority hazard identification following Codex Alimentarius guidelines were used to describe a food safety problem and its context in terms of hazards or risks relevant to risk management decisions. The aim was to identify which of the several hundred pathogens were most relevant to be studied. The tools used were systematic literature reviews, expert consultations and rapid value chain assessments.

Three systematic literature reviews were conducted to gain information on occurrence and impact of foodborne pathogens, chemical hazards and animal health constraints related to pig and pork production in Vietnam. The reviews covered the years 1990 to 2013 and involved a systematic search of PubMed, ScienceDirect, ISI Web of Science and SCOPUS databases using predefined key words. Vietnamese publications from educational institutions were also screened. Another review covering the years 1999 to 2013 was done on pig health constraints in Vietnam and focused on six production diseases and selected zoonoses.

Rapid value chain assessments in both provinces provided information on the flow and distribution of pork and identified factors that could influence adoption and effectiveness of potential interventions. The tools used were focus group discussions, participatory appraisals, semi-structured interviews and key informant interviews (Table 1). Only one commune/district was selected for the rapid value chain assessment.

Table 1: Tools used, groups included, and information collected in the rapid value chain assessments

Tool	Actor/group	Information collected
Focus group discussion and participatory appraisal	Various value chain actors	Linkages between and among them, and their perceptions of constraints and advice for solutions
Focus group discussion	Mothers and pregnant women consumer groups	Consumer behaviour including criteria for choosing animal-source foods
Participatory mapping	Communes	Basic infrastructure (main roads) and location of pork markets and vendors' points in the communes (where pork is sold)
Semi-structured interviews	Input suppliers, pig collectors, retailers, butchers and processors	Information on their roles, constraints and advice on solutions
Key informant interviews	Veterinary staff and others*	Animal health constraints, pig marketing, pig movement

*Chair of agricultural cooperative; village heads; chairs of women's unions or farmer groups; Department of Agriculture and Rural Development

Risk pathways were developed to assess health risks to people and pigs and support the identification of potential nodes for risk-reduction interventions. These included risk pathways for porcine reproductive and respiratory syndrome, identified from risk profiling as a priority pig production disease. Risk pathways were developed based on available literature and consultations with experts on pig production and health. They were also developed as part of the QMRA for a priority foodborne pathogen, *Salmonella* spp.

Risk and economic assessment was by baseline and longitudinal (repeated) surveys. The baseline survey was conducted in 2013 using a cross-sectional study design with individual questionnaires and covered 416 randomly selected households (208 in each province), 51 butchers/slaughterhouses and 74 retailers. Data were collected on pig production performance, animal health and food safety. For the repeated (nested longitudinal) surveys, a randomly selected subset of producers and urban consumers in each province was followed over 12 months and three different surveys were carried out between March 2014 and February 2015:

- Producer survey to quantify pig production parameters, constraints and cost of production over time. Data were recorded weekly using book-keeping by farmers.
- On-farm survey to quantify pig diseases and health parameters including biological sampling for pig parasites. Farm visits were done fortnightly and biological sampling monthly.
- Urban consumer survey of 32 households in both provinces. Records were taken on food purchasing and expenditures, and types of pork preparation and cooking during the study period. Information on frequency of eating pork (at home and outside) and self-reported foodborne illness symptoms was also recorded.

A cost-of-illness study used a bottom-up approach to estimate the cost of selected pork-borne diseases, namely acute gastroenteritis caused by *Salmonella* and meningitis and sepsis caused by *Streptococcus suis*. Data were collected by public health professionals from August to November 2013. This included a review of hospital records and interviews of patients suffering from pork-borne diseases (Hoang Van Minh et al. 2015).

Qualitative and quantitative risk assessment comprised (i) QMRA for *Salmonella* (identified by the risk profiling as a priority microbial hazard) (ii) chemical risk assessment for chemical hazards and (iii) risk communication. The QMRA covered hazard

identification, hazard characterization, exposure assessment and risk characterization to estimate the health burden for pork consumers (Figure 4). Chemical risk assessment involved qualitative and quantitative analysis of 514 pooled samples of pig feed, kidney, liver and pork for tetracyclines, fluoroquinolones, sulphonamide, chloramphenicol, beta-agonists and heavy metals. Risk communication was based on the evidence of the risk assessment. Opportunities and challenges of risk communication were reviewed.

Figure 4: The Codex Alimentarius risk analysis framework.

Complementary studies involved an experiment to determine the rate and risk of cross-contamination of boiled pork at household level; prevalence surveys for *Streptococcus suis*; serotyping and possible antimicrobial resistance of *Salmonella* in the pork value chain; food safety improvement scenarios; and analysis of wastewater and pig pen floor swabs for contamination with *Salmonella*, *Escherichia coli* and coliforms.

Objective 2: To develop and test incentive-based innovations to improve management of human and animal health risks in smallholder pig value chains

Following a recommendation from the mid-term review of the project, activities under this objective were revised because of a longer than anticipated assessment phase which included a set of complementary co-funded activities and because this research suggested the large planned randomized control trials was premature given our limited understanding of intervention effectiveness, efficiency and incentives for uptake. Randomized control trials were postponed in favour of a focus on identifying promising evidence-based interventions. Tools and information used included a desk study (literature review) of successful tested interventions in Vietnam, the Southeast Asia region and elsewhere; results of the QMRA including food safety improvement scenarios; and workshops and expert/stakeholder consultations. A list of potential interventions was developed.

Complementary studies involved a pilot trial at a slaughterhouse to assess the reduction of bacterial contamination (total bacterial count, *E. coli* and coliform load) on pig carcasses through the use of an off-the-ground iron slaughtering rack to avoid floor slaughter; gendered evaluation of uptake of VietGAHP by farmers; focus group discussions and key informant interviews among producers, butchers, retailers and consumers to assess willingness to change and pay for improved food safety in the smallholder pork value chain; and focus group discussions with farmer groups to study the

potential of participatory video as a best-bet intervention for long-term impact in Vietnam's smallholder pig value chain.

Objective 3: To sustainably improve capacity to assess and manage risks in smallholder pig value chains by engaging stakeholders and co-generating evidence

Engaging with stakeholders at local and national levels ensured the relevance and acceptability of research and helped identify strategies by which research outputs could lead to concrete impacts. The inception workshop was held in Hanoi on 12–14 August 2012 and a mid-term review workshop in March 2016.

Outcome Mapping (replaced by Outcome Harvesting in 2015) provided a framework to articulate the project's impact, identify actors whose behaviour should change for impact to occur, develop strategies to influence behaviour change and document processes and results. Focus group discussions and key informant interviews were held with policymakers in Hung Yen and Nghe An and with the research team.

Policy communication and advocacy activities by the project team members were used to disseminate the evidence generated by the project:

- Feedback workshops with various stakeholders and groups in both provinces
- Food safety and risk assessment support by the national taskforce on food safety risk assessment (since 2013)
- Roundtable discussion on food safety and risk management in Vietnam (January 2016)
- Food safety and value chain intervention workshop in Hanoi (May 2016)
- Contribution to the World Bank technical report, *Food safety risk management in Vietnam: challenges and opportunities* (World Bank 2017) and regular attendance at food safety working group meetings in Hanoi
- Production and dissemination of communication products tailored for targeted audiences, e.g. research and policy briefs, press releases, conference presentations, peer-reviewed journal articles in Vietnamese and English; project website and related web links on partner websites.

6 Achievements against activities and outputs/milestones

Objective 1: To assess impacts of pork-borne diseases on human health and the livestock sector and identify critical points/opportunities for risk management

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Risk profiling and priority hazard identification			
	Systematic literature reviews	Report (literature review: animal health and food safety)	2013	Publication for the food safety/zoonoses review in preparation (write shop, November 2017)
1.2	Rapid value chain assessment			Co-funded, rapid integrated assessment
	Mapping of value chain	Map of typical pork value chain in the study sites	2014	
	Risk pathway development	Report on risk pathway of pig diseases and foodborne diseases	2015	Zoonoses been replaced by salmonellosis (foodborne disease) and a major production disease (porcine reproductive and respiratory syndrome). Risk pathways (*Salmonella*) are part of the risk factor manuscript currently being finalized (see 1.4).
	Rapid integrated assessment	Report of rapid integrated assessment Summary of animal health and production constraints	2014	Paper published in Jan 2019 in special edition on leveraging value chains for health
1.3	Risk and economic assessment			
	Estimates on animal health and production constraints (baseline survey, repeated survey, community veterinary reports)	Baseline survey report Household pork consumption behaviour Biosecurity and disease control MSc thesis PhD thesis and paper (Asian Society for Agricultural Economics)	2015 2015 2017 2017	Quantitative estimates of animal health constraints by specific diseases challenging due to low compliance of producers in sharing specific disease information Community veterinary reports, faced some data gaps Publication on factors contributing to animal health risks (write shop, November 2017)
	Estimate of costs of pig diseases at farm level (baseline survey and veterinary reports)	Dataset Achieved, by age class and major diseases and symptoms Part of baseline survey report National publication, MSc thesis	2014, 2015	Community veterinary reports, faced some data gaps

	Estimate of costs of pork-borne diseases in consumers	Report and peer-reviewed international publication. First ever for Vietnam	2015	
	Estimate of costs of pork-borne diseases along the pork value chain	Part of baseline report National publication	2015	Not for specific disease but overall
	QMRA including risk factor analysis	Health burden for *Salmonella* estimated; first ever for Vietnam Two peer-reviewed international publications	2017	PhD thesis completed in February 2018 Paper published in 2017
	Qualitative chemical risk assessment	One peer-reviewed international publication	2017	Paper published in 2017
1.4	Complementary activities			
	Prevalence study on second foodborne pathogen	Report on *Streptococcus suis*	2015	
	Serotyping and antimicrobial resistance pattern for *Salmonella* isolates	Analysis started Report	September 2017 November 2017*	Paper expected in 2019
	Food safety improvement scenarios	Model developed and tested	September 2017	Paper expected in 2019
	Cross-contamination for *Salmonella* (household level)	Report	2016	Paper published in 2018

*After completion of project

Objective 2: To develop and test incentive-based innovations to improve management of human and animal health risks in smallholder pig value chains

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1	Literature review of incentive-based interventions for pig and human health risk mitigation	List of potential incentive-based approaches for mitigating (report) Examples of interventions, summary (included in Safe Pork proposal) Food safety and risk management in Vietnam roundtable discussion Food safety and value chain interventions workshop	2017 2017 January 2016 May 2016	
2.2	Experiments (randomized control trials) on willingness to adopt and willingness to pay for incentive-based risk mitigating interventions by various actors in the pork value chain	Pilot trial to test improved hygiene during slaughter process done and analysed Concepts for experiments have been developed (see 2.4) Global Food Security adoption manuscript currently finalized (see 2.3)	2016 2016 2017	Randomized control trials cancelled due to prolonged assessment phase. Interventions will be specifically addressed as per the Safe Pork project proposal
	Participatory video	Report Abstract accepted for Participatory Epidemiology Network for Animal and Public Health	2015 January 2018	
	VietGAHP adoption and impact survey	Report Global Food Security: Adoption manuscript submitted Asian Society for Agricultural Economics	February 2017 October 2017 2017	
	Willingness to change for improved food safety	Pilot to explore willingness to change of value chain actors to improved food safety Database	June 2017	

Objective 3: To sustainably improve capacity to assess and manage risks in smallholder pig value chains by engaging stakeholders and co-generating evidence

No.	Activity	Outputs/ Milestones	Completion date	Comments
3.1	Project inception and stakeholder consultation workshop		2012	
3.2	Outcome Mapping framework and implementation work plan Outcome Mapping monitoring with boundary partners	Workshop held and vision, mission, boundary partners and process markers identified and developed Report and brief	2013 2016	Outcome Mapping was replaced by Outcome Harvesting due to limited availability of Outcome Mapping expert (only until December 2013)
3.3	Mid-term review	Report	March 2016	
3.4	Policy communication and advocacy	Feedback workshops in Hung Yen and Nghe An, report, media release HUPH and ILRI blog post Policy dialogue initiated; policy brief National food safety taskforce for risk assessment	2017 Aug 2017 2017 Since 2013	Additional activity (co-funded) led by the World Bank with substantial inputs from PigRisk scientists National food safety risk assessment taskforce increasingly recognised as capacity building resource for food safety-related work in Vietnam (by government and international organizations)
3.5	Final workshop	Report Media releases	Sep 2017	Combined with inception workshop for the Safe Pork project

7 Key results and discussion

Objective 1: To assess the impact of pork-borne diseases on human health and the livestock sector and identify critical points/opportunities for risk management

Risk profiling and priority hazard identification

Risk profiling identified *Salmonella*, an important foodborne pathogen in Vietnam and one strongly associated with pork, as the priority for health impact assessment.

Review of foodborne hazards in the pork value chain

We retrieved 169 publications covering a wide range of pork-borne zoonotic hazards in Vietnam. Foodborne or zoonotic hazards were relatively under-represented (28 papers). Hazards considered were mainly bacterial pathogens including *Salmonella*, *E. coli*, *Streptococcus suis*, *Staphylococcus aureus* and *Leptospira* spp. Just three of these are included in the World Health Organization (WHO) assessment of the global burden of foodborne disease (Havelaar et al. 2015). *Streptococcus suis* is a hazard of local importance but *Staphylococcus aureus* and *Leptospira* are potentially important causes of foodborne disease; other potentially important hazards have not been investigated in Vietnam. Among these, *Salmonella* has been widely described as an important foodborne pathogen in Vietnam. This corresponds well with the WHO assessment. For 14 of the 28 selected hazards, no information has been found. A recent metadata review by Grace et al. (2012b) also found *Salmonella* to be an important foodborne hazard in Vietnam.

Review of pig diseases in the pork value chain

Based on a review of 91 publications and surveillance data for 2012 from the Department of Animal Health, foot-and-mouth disease, porcine reproductive and respiratory syndrome, classical swine fever, pasteurellosis, Paratyphoid suum disease and oedema are considered as the most important diseases in pig production in Vietnam. Among potential zoonoses, cysticercosis and trichinellosis are most important.

Rapid value chain assessment

The value chain actors and pig flows were similar in both provinces (Figure 5). The observed difference was mainly in the scale of operation, producers' behaviour and linkages among actors. More than half of the pigs in both provinces are slaughtered and processed locally and only a few (1–6%) are slaughtered at the farm level.

Producers: Pig production contributes 50–70% of total farm household income in Hung Yen and about 30% in Nghe An. Farmers in Hung Yen raise more pigs (15–20 pigs per cycle) than those in Nghe An (7–9 pigs per cycle). Pig production in Hung Yen is more specialized and commercial than in Nghe An. Feeding systems differ between both provinces with more industrial feed used in Hung Yen which gives comparative advantages to Nghe An farmers in responding to market price fluctuations as they can increase or reduce the amount of locally produced feed.

Veterinary service suppliers: Each commune has 4–6 veterinarians and several veterinary drug shops. Veterinarians usually work within 5–7 km.

Piglet collectors/brokers: In Hung Yen, there are approximately two collectors per commune who buy and sell piglets weighing 7–12 kg from within and outside their communes. On average, they buy and sell 200–250 piglets each month. Collectors in Nghe An collect pigs weighing 25–40 kg and sell them to collectors from other regions.

Slaughterhouse: Slaughtering pigs is the main economic activity of butchers. They function as collectors, slaughterers and pork retailers.

Retailers and processors: In each commune, there are both permanent and temporary markets where pork is sold. Retailers may also be processors. There are also processors who only process pork and sell processed products such as spring rolls and meat loaf.

Consumers: The average age of pork consumers was 45–50 years old and most were females. Women are usually responsible for purchasing pork for their families. Most of them are also farmers cultivating crops and producing pigs.

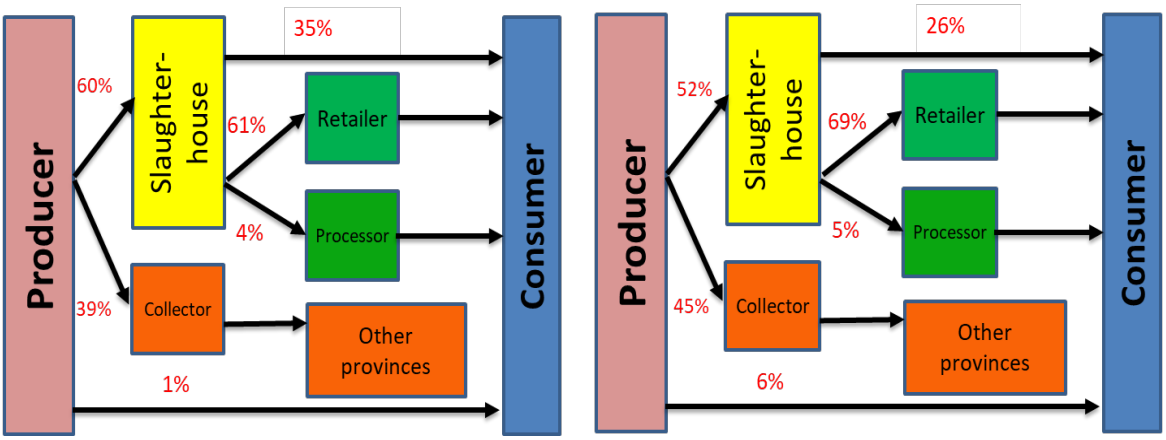

Figure 5: Overview of the pig value chain in Hung Yen (left) and Nghe An (right).

Risk pathways for porcine reproductive and respiratory syndrome

A prioritized list of risk pathways and risk factors contributing to the introduction of porcine reproductive and respiratory syndrome to a farm was developed:

- Farm visitors, particularly animal health professionals, with poor hygienic practices
- Direct contact with infected pigs via buying and selling of animals and live boar mating
- Infected vehicles and transport infrastructure (e.g. cages)
- Density of pig farms in the local area
- Proximity of pig farms to local slaughterhouses and main roads

Some of the mitigation and control measures proposed were training of farmers to improve their knowledge on disease prevention and control and biosecurity, and enforcement of hygiene and biosecurity procedures by animal health professionals.

Baseline survey

Economic performance of the pig value chain

On average, a smallholder farmer produced about 14 fattening pigs per cycle and 2–4 cycles per year (depending on slaughter age), supplying 2.5–5 tons of live pigs to market annually. Productivity did not vary among the value chain gradients but increased with scale of production, with monthly weight gain of 17.4 kg, 19.5 kg and 21.2 kg for small, medium and large scale of production, respectively. The total income generated by the pig value chain was USD 68–82 per 100 kg of pig live weight, of which 44–50% was for farmers. However, among chain actors, labour income was lowest for farmers.

The average cost of production was estimated at USD 1.74 per kg live weight, of which feed accounted for 78%. The cost of production was not statistically different among production scales and systems but differed among value chain gradients with the highest cost in the peri-urban to urban value chain.

Animal health

Farmers used rudimentary disease prevention measures with deficits in biosecurity and piglet management. Only half of farmers used and maintained disinfection mattresses. Majority of farmers did not limit access of visitors to their farms. While water was provided to pigs *ad libitum* by farmers in Hung Yen, this was the exception in Nghe An.

Farmers were the value chain actors most affected by pig disease risks. The most prevalent pig diseases or symptoms observed were diarrhoea, classical swine fever and swine enzootic pneumonia. Highly contagious diseases such as foot-and-mouth disease and porcine reproductive and respiratory syndrome were better managed at larger production scales.

Pig mortality was reported by more than one-third of farm households and the economic loss estimated at USD 77 per one-pig household, taking away 13–16% of total income from pig production. However, farmers did not consider pig diseases a priority.

Almost half of the slaughterhouses reported buying sick pigs unknowingly although the associated income losses were low (about 0.5% of total income from the chain activity). None of the retailers reported losses associated with pig diseases.

All slaughterhouses (owned and managed by men) were small scale, slaughtering 1–2 pigs per day on average. Slaughterhouses did not meet the requirements of the Ministry of Agriculture and Rural Development with respect to location, physical set-up, water supply and waste treatment and most were in residential areas thus likely to pose risks to human and animal health.

Pork retailers (mostly women) operated in wet markets or on streets and village corners. Their business volumes were low, varying from 20–60 kg per day. Apart from upgraded markets (e.g. by LIFSAP), observed hygienic conditions were poor.

Factors influencing pig mortality suggest that farmer practices rather than farmer and farm socio-demographics are key risk factors, for example, the use of preventive and curative practices (more does not guarantee lower mortality), disinfection (regular, more frequent use of disinfectants will likely reduce mortality), how dead pigs are disposed of (risky practices will likely lead to higher mortality) and sourcing of pig stocks from external outlets (will likely increase mortality).

The economic burden of pig disease was highest in piglets. Piglets with perceived higher breeding value have lower risk of disease exposure and farmers applying the farrow-to-finish production system were more productive.

Food safety concerns of value chain actors

Farmers believed that pork sold at local markets was safe because local butchers aimed to buy healthy pigs from local farmers. The rapid appraisal showed that there is a possibility that sick pigs are sold in local markets, but farmers were unaware of this.

Collectors did not pay much attention to the spread of pig diseases and indicated that quality control through inspection may not be effective in local areas.

Butchers reported that waste water was discharged directly into pools, rivers and the drainage system.

Consumers in both provinces perceived pork from pigs fed on industrial feed to be less tasty and those in Nghe An also perceived it to be unsafe. Consumers were concerned about food safety and expressed willingness to pay more for safe pork but had low trust in official certification.

Misperceptions around pork safety were common. Consumers were more concerned about chemical hazards in meat, ignoring biological hazards. This may be one reason why slaughterhouses and retailers have little incentives to upgrade.

Pork is easily available to consumers in each commune. The average per capita pork consumption is 24 kg per year, a bit lower than the national average (29.1 kg). Most buyers of meat for home consumption were female and preferred fresh and safe meat. They expressed very low trust in the certification or stamps on pork and opted to buy from meat sellers that they trusted.

Longitudinal (repeated) survey

Producer survey

There was high variability in the numbers of piglets and fattener pigs kept over time while sow numbers were constant. Market prices for pigs varied significantly throughout the year, ranging from 30,000 to 50,000 Vietnam Dong per kilogram, reflecting the seasonal nature of market demand for pigs and pork. There was no significant variation in the price of pig feed through the year; this was stated as a concern by farmers in the baseline survey. Farmers in Hung Yen spent more money on vaccines than those in Nghe An.

On-farm survey

No mortality in pigs was observed, perhaps because of low compliance of farmers in disease reporting due to fear of negative consequences by animal health authorities. The burden of intestinal parasites was high; 75% of faecal samples had at least one type of intestinal parasite and over 20% had at least two different parasites.

Urban consumer survey

Households tended to spend more money on food in the first quarter of the year due to traditional holidays and festivals. Pork for household consumption was mainly bought from central wet markets (68.4%) and village markets (29.2%) and rarely from supermarkets (0.2%) or street vendors (0.4%). The frequency of eating outside by household members fluctuated over the year and was relatively lower for women (46.9%) compared to men (53.1%). Fermented pork, intestines and blood pudding dishes were usually consumed when eating outside the home (at restaurants or parties).

System dynamics model

The system dynamics model simulated the potential effects of improved productivity at the farm level due to reduced piglet mortality from improved production practices, translating to increased supply with associated dampening of market prices for pigs, but also lower prices for pork and overall improved returns to pig producers due to higher volumes sold.

Econometric probabilistic model

The econometric probabilistic model estimated the likelihood of mortality and morbidity arising from practices and socio-demographic factors. Farmers who only practised disinfection and cleaning after a disease outbreak experienced higher mortality and morbidity. Farmers who sourced their pigs from external sources experienced higher mortality and morbidity. Farmers who responded to pig deaths with risky behaviour such as improper carcass disposal were more likely to experience greater mortality and

morbidity. Farmers whose pigs were treated by veterinarians were more likely to experience high mortality and morbidity (this finding is perhaps confounded with disease severity or due to biosecurity lapses).

Cost of illness study

The cost of illness of acute gastroenteritis caused by *Salmonella* was estimated at USD 2.5–7.6 million annually, accounting for 0.005% of GDP. On average, the costs per treatment episode and per hospitalization day for foodborne diarrhoea cases were USD 106.9 and USD 33.6, respectively. Indirect costs to patients and their relatives made up the largest share (51.3%). Direct medical costs accounted for 33.8%; direct non-medical costs to patients and their relatives represented 14.9%. This study provides the first ever estimate for the cost of illness of *Salmonella*-caused foodborne disease in humans in Vietnam. It also provides valuable information when linked to results of the QMRA on the health burden for consumers. See Hoang Van Minh et al. (2015) for details of the study.

QMRA for *Salmonella*

Risk pathways

Table 2 summarizes the risk pathways for the presence of *Salmonella* along the smallholder pig value chain.

Table 2: Risk pathways for *Salmonella* at different nodes of the value chain

Node	Risk pathway
Farm	Breeding source, contaminated feed and/or drinking water
Slaughterhouse	Pigs introduced to slaughterhouse; people working in slaughterhouse; insects; vehicles; rinse water sources
Retailer	Contaminated meat and processing equipment
Household (consumer)	Contaminated meat and processing equipment

Risk factor analysis

Salmonella prevalence was 36.1% (26/72), 38.9% (58/149) and 44.7% (97/217) on pig pen floors, pig carcasses in slaughterhouses and cut pork in pork shops, respectively. Table 3 shows the identified risk factors for *Salmonella* contamination along the value chain. The importance of slaughter hygiene and *Salmonella* contamination has been documented by others, though in the context of developed countries (Hald et al. 2003; Arguello et al. 2013; De Busser et al. 2013).

Table 3: Risk factors for *Salmonella* contamination at different nodes of the value chain

Node	Risk factor
Farm (pen floor contaminated with *Salmonella*)	Pig pen located next to household (p = 0.055) Free access to farm by visitors (p = 0.061)
Slaughterhouse (carcass contamination)	Slaughter area close to lairage without hygienic measures (p = 0.031)
Retailer (meat contamination)	For pork shops, presence of flies or insects on pork (p = 0.021) Use of a cloth at pork shops (p = 0.023)

Hazard identification and characterization

Non-typhoidal *Salmonella* spp. are one of the most important causes of foodborne disease. Previous studies in Vietnam found 37–69% prevalence of *Salmonella* in cut pork at market. To characterize the hazard, *Salmonella* growth and dose–response relationship models were obtained from the literature by the Beta–Poisson model.

Exposure assessment

Information from focus group discussions and non-parametric bootstrapping showed that each person consumed an average of 74 g (range: 20–200 g) of boiled pork per meal. The amount of boiled pork consumed per meal varied by age and gender group; 37 g for children, 100 g for adult males, 87 g for adult females and 73 g for elderly persons. The frequency of eating boiled pork was 117 times a year (range: 50–205 times).

Risk characterization

The QMRA model was developed and applied to estimate the impact of salmonellosis on pork consumers. The model combined quantitative and qualitative information from the assessment phase such as prevalence and counts of *Salmonella* in pork at market, levels of cross-contamination at households and frequency of pork consumption. The results of the QMRA provided daily and annual incidence risks of salmonellosis which were further stratified by age, gender and area (urban, peri-urban and rural).

The overall annual incidence of salmonellosis was 17.7% for the study areas. This means that 1–2 in 10 consumers are at risk of a *Salmonella*-related infection annually. Our estimates are higher than the WHO global estimate for the annual incidence of foodborne salmonellosis in the Asian region, including Vietnam (range 0.2–7%) but approaches differed significantly, and authors argued that estimates are likely considerable under-estimates (Havelaar et al. 2015).

Chemical risk assessment

We assessed the risk of exposure to hazardous chemical residues in samples of pork from wet markets in Hung Yen and Nghe An provinces. Legal antibiotics were common in feed. Tetracycline and fluoroquinolones were not present in pork but 11% of samples were positive for sulfamethazine above Maximum Residue Limits; 11% of packaged feed and 4% of pooled pork samples were positive for chloramphenicol, a banned substance; two feed samples, two liver samples and one pork sample tested positive for beta-antagonist but did not exceed Maximum Residue Limits; 28% of pooled samples had lead but all were below Maximum Residue Limits; and all samples were negative for cadmium and arsenic.

This is in line with government records from monitoring and inspection from early 2015 to February 2016 which found elevated levels of prohibited veterinary drugs and antibiotics in approximately 2% of 5,433 meat samples analysed (Van Duen and Nguyen Huong 2016).

Risk communication

Risk communication is key to managing food scares and building trust in the food system, but, as in many countries, there has been little attention to this in Vietnam. There are also many misperceptions about food safety, not only among the public but also among academics and the government. A common example was that almost all groups perceived the risk of foodborne chemical hazards to be higher than that of microbiological hazards, yet our results showed the opposite. See Hung Nguyen-Viet et al. (2017) for details.

Complementary studies

Cross-contamination of boiled pork at household level

This survey was designed to model potential *Salmonella* cross-contamination when handling pork in the household. Most people (71%) used the same knife and cutting board for both raw and boiled pork, and almost all people washed hands and equipment in between handling raw and boiled pork.

Simulation experiments indicated that hands, wash-water, knives and cutting boards exposed to raw contaminated pork were the main sources of spread to boiled pork. There was a high risk of cross-contamination to boiled pork when the same hands, knives and cutting boards were used for raw and boiled pork (78% of boiled pork samples were contaminated with *Salmonella*). Using the same cutting board resulted in 67% of boiled pork samples becoming contaminated with *Salmonella*.

Prevalence surveys for *Streptococcus suis*

Out of 147 samples of pig blood, 33.3% tested positive for *Streptococcus suis* but only two (1.4%) were positive for *Streptococcus suis* serotype 2, the serotype most frequently associated with severe human infections. Sixteen of 406 people interviewed (3.9%) reported eating raw blood pudding, whereas this rate was significantly higher among slaughterhouse workers (43.1%; 22 of 51).

Serotyping and possible antimicrobial resistance of *Salmonella* in the pork value chain

From *Salmonella* strains in pork samples, 17 *Salmonella* serovars were isolated. *S.* Typhimurium was found in 37.1% of the isolated *Salmonella*, followed by *S*. Derby (23.7%) and *S.* London (6.2%) and 15 other serotypes ranged from 1.0% to 4.1%. Isolated *Salmonella* strains were resistant to ampicillin (19.8%), trimethoprim (17.6%), chloramphenicol (16.5%), cefotaxime (16.5%) and colistin (12.1%). *S.* Typhimurium and *S.* Derby had higher rate of resistance to ampicillin, chloramphenicol, cefotaxime and colistin than other serovars. Resistance to chloramphenicol was also critical since this substance was prohibited for use in livestock.

Food safety improvement scenarios

The QMRA model provided different scenarios of *Salmonella* prevalence after hypothetical reductions at various points in the value chain. Given reduction scenarios of 10%, 25%, 50% and 75% of the original *Salmonella* prevalence (34.7%) on pork sold at market, the median annual salmonellosis incidence reduced from 14.9% (original model) to 10.9%, 8.5%, 4.7% and 0.69%, respectively.

Results from other scenarios of improving hygienic practice by using separate cutting boards and knives to handle pork in consumer kitchens showed that the median annual salmonellosis incidence in Hung Yen urban and rural reduced from 14.9% (Hung Yen urban) and 12.9% (Hung Yen rural) to less than 10.6 cases per year.

Interventions that could lead to a considerable reduction of *Salmonella* at market include the use of chlorinated water to clean cutting boards or used knives, as tested in a study on pork retailers in Uganda although results are still being analysed.

Other scenarios to link slaughterhouses and farm interventions are being developed and simulated. However, preliminary results show that the interventions at farms and slaughterhouses can lead to a marked decrease in the overall incidence of *Salmonella* at consumer level. A 10% reduction in *Salmonella* on slaughterhouse carcasses leads to annual incidence dropping from 14.8% to 11.8%.

The outcome of the simulated scenarios, including the use, strengths and limitations of the QMRA model, will be discussed with stakeholder groups and contribute to formulating interventions at most critical points along the pork chain and likely further addressed in the follow-on Safe Pork project.

Analysis of wastewater and pig pen floor swabs

In pig farms, the prevalence of *Salmonella* on pen floors and in wastewater was 36.1% and 38.9%, respectively. The high prevalence of *Salmonella* in farm wastewater which is frequently discharged untreated to the environment or community could pose health risks to people through agricultural activities and vegetable food chains.

Objective 2: To develop and test incentive-based innovations to improve management of human and animal health risks in smallholder pig value chains

Stakeholders in the smallholder pork value chain face significant cost and time constraints. Therefore, risk mitigation interventions must be based on robust evidence. Interventions must also account for the informal and dynamic nature of the smallholder pork value chain and be realistic in their ability to provide sustainable results. In this context, the lack of clear incentives for uptake of good practices means that food safety interventions at the farm level are not immediately practical and feasible.

Results show marked increases of microbial contamination from farm to slaughterhouse and further to retailers, mainly related to poor hygienic practices. These results are supported by evidence from the literature. Therefore, slaughterhouses and retailers are the key value chain actors for specific food safety interventions.

Results from the simulated scenarios have shown that markets and households can be a critical point for mitigating the risk of *Salmonella* to the consumer. The food safety interventions planned for the Safe Pork project will centre around increased knowledge and improved practices of value chain actors and consumers on hygienic handling of carcasses and pork in slaughterhouses, markets and household kitchens.

List of potential interventions

An initial list of potential best-bet interventions has been developed. These include the use of chlorinated water at farms, slaughterhouses and markets and the use of an off-the-floor slaughtering rack the latter also tested in a pilot trial in PigRisk (see below). The criteria for their evaluation have also been identified, i.e. expected adoption, investment costs, expected reduction of hazards among others discussed with stakeholders. These interventions will be tested by the follow-on Safe Pork project.

Desk study (literature review) of interventions tried in other regions

Over the last 15 years, ILRI has experimented with a range of light-touch, incentive-based interventions with varying success. Four of these are summarized in Table 4. For example a peer-to-peer pilot training on basic hygiene of meat traders in Nigeria (Ibadan/Lagos) led to a significant decrease of unacceptable meat from 98% to 79% ($p < 0.001$) and market improvements in knowledge, attitude and practice. The training also included the provision of boots, hats, aprons, fly-proof netting and food-safe disinfectants; banners and promotional material. While the cost of training was USD 9 per butcher an estimated gain through diarrhoea avoided was USD 780 per butcher (Grace et al. 2012a & 2012c).

Workshops and stakeholder consultations

A workshop on food safety and value chain interventions was held in Hanoi in May 2016, bringing together researchers and representatives from development projects and private businesses involved in food safety and the improvement of vegetable, fruit and meat value chains. Five initiatives were presented and discussed.

Key lessons included (i) the importance of engaging with all value chain actors and facilitating ownership to address improvements in food safety; (ii) working with local authorities to increase chances of success of the food safety interventions and (iii) ensuring there are sustainable incentives for value chain actors to change their behaviour.

Identified challenges in improving food safety in Vietnam were the lack of consumer trust in food safety certification and branding schemes and how to balance the increased cost of food safety interventions across all actors in the value chain. None of the initiatives was able to share reliable evidence on improved food safety.

Table 4: Examples from the literature of intervention options

Particulars	Kenya	Kenya	Ibadan and Lagos, Nigeria	Assam state, India
Value chain	Informal milk sector	Export, improved and typical slaughterhouse	Meat	Informal milk sector
Intervention	Training in hygiene and business practices; provision of hygienic dairy cans with wide necks; a certificate was given to successful trainees and this reduced harassment by officials	Training in hygiene; raising awareness on food safety; there were no investments in infrastructure and the motivation was that meat would be safer for consumers	Peer-to-peer training on basic hygiene; provision of boots, hats, aprons, fly-proof netting and food-safe disinfectants; banners and promotional material; use of butcher associations to monitor performance and ensure compliance	In-depth training needs analysis; training of trainers; training covered hygiene and business skills; traders motivated by better relations with officials and positive publicity; farmers by visible reduction in mastitis
When	1997–2005	2010–2011	2009–2011	2009–2013
Number of traders	25,000–30,000	Several hundred in the three slaughterhouses	Around 900 in the market	Around 300 traders and 600 producers in the main milk shed
Number of market actors trained	In 2010, 4200 traders registered nationally. In pilot areas, 85% of traders had been trained	Around 100 trained	80 directly by the project and around 420 by peer-to-peer training	265 traders and 480 producers have been trained
Consumers reached	Around 0.5 to 5 million	Nearly 1 million	Around 360,000	Around 1.5 million
Gender aspects	Not explicit; women around one-third of traders	Not included; all workers were men	Yes; targets for women's participation and gender dimensions researched	Not explicit, but nearly all traders and farmers are men
Documented impact	Improved knowledge, attitude and practice after training. Improved milk safety after training; reduction in unacceptable coliforms from 71% to 42%. High economic benefits from the initiative, USD 33.5 million a year	No change in knowledge, attitude and practice after training; the management did not provide soap or other necessities and were rather indifferent to practices and there was no obvious incentive for behaviour change	Reduction of unacceptable meat from 98% to 79% ($p < 0.001$). Significant improvements in knowledge, attitude and practice. Cost of training was USD 9 per butcher and estimated gain through diarrhoea averted was USD 780 per butcher.	Improved knowledge, attitude and practice after training. Significantly higher milk production after training (7.8 litres) than before (6.8 litres) and tendency for reduced mastitis. Sector level benefits in Kamrup at least USD 5.6 million a year
Policy influence	High; legislation changed and new institutions	None	Low; only engagement with market authorities	High; new institutions but no change to legislation

Status of the initiative	Training and certification is episodic and project-led but trained vendors have an important share of the market	None; one-off training	The pilot was intended to investigate efficacy and acceptability and did not have a strategy for sustainability	Training and monitoring is ongoing and supported by government
Reference	Omore and Baker (2011) Kaitibie et al. (2010)	Mwai (2011)	Grace et al. (2012a) Grace et al. (2012c)	Lapar et al. (2014) Lindahl et al. (2014) Melin (2015)

Complementary studies

Pilot trial at slaughterhouse

The introduction of a low-cost, off-the-ground slaughtering rack (designed with the slaughterhouse owner) and other measures to reduce contamination in the treatment group (n = 10) significantly improved slaughter hygiene compared to the control using a business-as-usual approach (n = 10). The improvement in hygiene was indicated by lower coliform load (p = 0.002) on the carcass surface compared to the control. The pilot trial also demonstrated that technical solutions must go along with behaviour change of butchers (Photos 1 and 2).

Photos 1 and 2: Workers at a pig slaughterhouse in Hung Yen province, Vietnam testing the use of an off-the-ground slaughtering rack, February 2016 (photo credit: Hanoi University of Public Health/Sinh Dang Xuan).

Gendered evaluation of VietGAHP adoption

VietGAHP has been defined by Ministry of Agriculture and Rural Development (MARD) as a set of criteria to ensure agriculture product quality, food safety, product traceability among others (Circular 48/2012/TT-BNNPTNT). VietGAHP guidelines for farmers can be classified into three groups according to the level of compliance and uptake by target adopters. The first group includes practices that farmers cannot implement in the short-term. The application of these practices is constrained by limitations of land and capital resources by farmers. The second group comprises indicators that are relatively easy to implement according to the results of the focus group discussions with farmers but still

with lower than expected levels of compliance. These include practices such as recording information of vaccination and disease treatment. There appears to be consensus among farmers that these practices are necessary; however, only a few farmers were able to consistently follow them. This may be a consequence of inadequate knowledge of farmers about the advantages of those activities in terms of managing production costs, diseases and animal health in general. The third group consists of indicators that are easy to implement and currently, most farmers who have tested VietGAHP have been able to comply. For example, most farmers using VietGAHP have set up disinfection systems at the entrance of pig houses to prevent the spread of diseases.

We found positive economic gains from adoption of VietGAHP. More importantly, productivity gains from adoption need not require uptake of the full VietGAHP package. Designing a more streamlined version of VietGAHP that is less costly to adopt could encourage more uptake by a wider, more economically diverse group of users. Exposure via demonstration effects could facilitate scaling up of VietGAHP. Non-adopters in exposed sites have been observed to apply practices aligned with VietGAHP guidelines that are affordable and easy to apply. Peer-to-peer learning is an effective strategy in enhancing capacity for uptake; capacity development of target users who could transition as trainers to other potential adopters in the scaling out process could be explored. With exposure being strongly linked to uptake, training opportunities for non-exposed groups are worthwhile to pursue. Inclusion of a training module on VietGAHP in national extension programs could also facilitate the scaling process.

Producers recognize economic incentives from healthier pigs that are preferred by traders. Market incentives from consumer demand for VietGAHP pork in fresh pork markets remains to be tapped. Future work will continue to explore credible market signals of VietGAHP that consumers trust and are willing to pay for, with complementary supporting institutions to support uptake.

Willingness to change and pay for improved food safety in the smallholder pork value chain

Small-scale pig farmers are flexible in livestock production and expressed willingness to change practices when linked to stable and profitable output. Butchers in small-scale slaughterhouses are willing to change, depending on the desire to maintain long-term employment (family labour). However, they are more likely to invest in or pay for improvement of slaughterhouses if they are assured of stable outputs that could pay for the improvements. Pork sellers are willing to pay higher prices for pork from abattoirs when ensured on quality and known source. Consumers are willing to pay a higher price for pork that has assurance of food safety. There was high consumer demand for information on safe pork. There is a lack of trust in safe product certification; consumer trust still largely depends on the relationship with sellers built over repeated transactions.

Potential of participatory video as a best-bet intervention in the smallholder pig value chain

Farmer-to-farmer (peer based) participatory learning is increasingly popular in agricultural extension projects. While projects report positive outcomes in the short term, the long-term impacts of these participatory interventions often go unstudied.

In 2014, as a component of the PigRisk project, the long-term impact of a participatory video made with pig farmers in central Vietnam in 2010 was studied through a focus group discussion with the respective farmer groups.

The greatest impact of participatory video on behaviour change among farmers appeared to be during the process of making the video together (direct learning) and soon after watching it for the first time. Many of these lessons were in line with VietGAHP. Farmers enjoyed the opportunity to share and debate ideas with each other directly and expressed their intention to try new techniques.

Participatory video has potential for application in the smallholder pig value chain in Vietnam for direct farmer-to-farmer learning through a carefully designed participatory process, as a component of mixed methods for monitoring and evaluation or to capture narratives and communicate to policymakers the real situations of livestock keepers.

Objective 3: To sustainably improve capacity to assess and manage risks in smallholder pig value chains by engaging stakeholders and co-generating evidence

The project inception meeting was held in Hanoi, Vietnam on 12–14 August 2012. An overview of the project was presented as well as the concepts of risk assessment and risk management. In attendance were various stakeholders including government ministry representatives, development practitioners, scientists, private sector stakeholders and researchers from the areas of animal health, public health, economics and ecology. Facilitated by project team members from ILRI and primary project partners from HUPH and Hanoi University of Agriculture, the workshop introduced participants to the key research activities of the project. Discussions centred on the crucial distinction between risks and hazards and how this affects decision-making at consumer and policy-making levels. Exploring the concept of incentive-based approaches in improving human and animal health management also elicited strong interest from the participants. The Director General of ILRI, Dr Jimmy Smith, highlighted the ongoing challenge of food scarcity and high food prices and the importance of Southeast Asia in ILRI's research agenda.

Outcome Mapping and Outcome Harvesting

Outcome Mapping was initiated through a workshop in which the project's vision, mission, and goals were identified. This included also boundary partners which are individuals or groups with whom the project interacts and expects to influence e.g. value chain actors, researchers or policy makers. In late 2014, Outcome Mapping was replaced by Outcome Harvesting, a simplified method of Outcome Mapping, to monitor changes in the boundary partners. In early 2015, the principles of Outcome Harvesting were used to capture project outcomes from the perspectives of the project partners (HUPH and VNUA) and policymakers in Hung Yen and Nghe An.

The research teams observed improved capacity and confidence in using risk-based approaches and value chain analysis. The VNUA economic team was recognized as value chain specialists and had been contacted by several institutions to provide training. A taskforce on food safety risk assessment including researchers and policymakers was formed in 2013, with researchers from HUPH as lead members. The project provided an opportunity to work across disciplines and institutions, a first for some team members. The high turnover of members due to pursuit of higher studies was a challenge.

Policymakers provided preliminary evidence of application of PigRisk findings in decision-making. However, the use of findings was limited due to lack of an official research report and proposed solutions. Policymakers were satisfied with the level of engagement with the research team but noted that project outputs needed emphasis on solutions not only research findings. Interventions should focus on communication and training for farmers. These comments were taken in consideration in the development of the follow-on project Safe Pork (LS/2016/143).

Policy communication and advocacy

The mid-term review was held in March 2016 with the support of reviewers from ACIAR. Field visits were made to Hung Yen and Nghe An provinces to give an opportunity to the research teams and the reviewers to discuss with various stakeholders in the pork value chain including farmers, retailers and slaughterhouse owners. While the general reflection was very positive, specific recommendations were provided including further cross-cutting

analysis, clear definition of publications and communication outputs, review of proposed activities originally designed in objective 2 (e.g. randomized control trials), formulation of key messages and defining the potential of developed tools and models.

The final workshop was held on 7 September 2017, followed the next day by the inception workshop of the Safe Pork project. The final workshop was attended by a range of stakeholders from government ministries, ACIAR, ILRI, international organizations, the private sector, and researchers on animal health, public health and economics. Key results and recommendations from the project were shared and discussed. A panel session featuring representatives from the private sector, government and international organizations discussed food safety along the pig value chain, lessons from the project and the way forward. The Safe Pork project (*Market based approaches to improving the safety of pork in Vietnam inception workshop*) was launched on 8 September 2017. Project objectives, partnerships, activities and outputs were presented and discussed.

8 Impacts

A conventional animal health research-for-development project may seek to identify and characterize some animal health problem or to develop and pilot some modern technology. PigRisk was more ambitious. It was part of a portfolio of CGIAR projects that seek to change the way food safety is managed in informal markets with the aim of decreasing human health burden and improving livelihoods for farmers and other actors along the chain.

This approach necessitates a shift from the farm to the consumer and policymaker and a broadening of perspective from a small group of farmers to the entire food system. The food safety approach has set out a theory of change (Johnson et al. 2015). In short, we believe that new, light-touch, incentive-based approaches are essential to improve food safety in informal markets. Equally important is generating evidence on burden and building capacity in stakeholders to assess and manage foodborne disease.

As such, the outputs, outcomes and impacts of PigRisk focused on evidence and enabling environment rather than farm practices. We generated new evidence on the high burden of disease and built substantial capacity in risk-based approaches. We are moving down our impact pathway towards the next step of solid information on feasible approaches for food safety in Vietnam while building the motivation and capacity to implement these.

8.1 Scientific impacts – now and in 5 years

The project used a One Health approach to food safety research by bringing a multi-disciplinary research team to work together and work with other sectors such as private sectors, policymakers and communities to advance the application of One Health on the ground. The research team included veterinarians, medical doctors, environmental health experts and economists working with local stakeholders in pig production, slaughtering, processing and retail. The multi-disciplinary approach led to a better understanding of food safety situation and better identification of interventions by considering of the perspectives of different sectors. This contributed to operationalizing One Health in Vietnam, which does not happen often in research projects.

PigRisk generated key scientific evidence for the first time on quantitative risk assessment of health and economic burden of foodborne diseases in Vietnam; 16% of people get salmonellosis from eating pork and USD 105 is lost due to treatment of one foodborne disease case. These data were cited in a major report on food safety risk assessment in Vietnam (World Bank 2017) and at discussions by the national food safety working group.

The project also had an impact on the methods used in teaching and training of food safety and value chain assessment. Scientific outputs on risk-based approaches were used in training on food safety risk assessment. Training workshops were collaboratively organized and run by project team members from ILRI and national partners from the Department of Animal Health, Ministry of Agriculture and Rural Development, VNUA and HUPH. VNUA developed a textbook on risk-based management of food safety.

ILRI researchers and members of the national task force on food safety risk assessment were commissioned by the World Bank to develop a technical report on the challenges and opportunities of food safety management in Vietnam. Following the publication of this comprehensive report, the Government of Vietnam has expressed interest in implementing measures to improve risk assessment, risk communication, risk management and foodborne disease surveillance. The authorities in Hanoi, Ho Chi Minh City and Hai Phong are working with the World Bank to develop plans to implement the report's recommendations with a budget of over USD 300 million from the World Bank.

In the next five years, it is reasonable to say that project results will be cited by scientific communities on food safety and the risk-based approach to food safety will be taken up by

several groups in developing countries. For example, the Safe Food, Fair Food for Cambodia project funded by USAID and implemented by Cambodian partners with ILRI will use a similar approach to examine foodborne risks in Cambodia. This could be replicated in other countries and food commodities other than pork.

Already ILRI research on food safety informal markets has clearly and significantly influenced some global initiatives. These include:

- ILRI scientists authored an investment report on Food Safety commissioned by BMGF/DFID. This was the basis for the first ever BMGF/DFID call for proposals to address food safety in informal markets.
- ILRI scientists authored a White Paper on Food Safety commissioned by USAID. This is the background to a new Feed the Future Innovation Lab on food safety launched in 2019.
- ILRI is part of the World Bank “Safe Food Imperative” which launched a major report in 2018.
- ILRI is part of the Global Food Safety Partnership study on capacity building for food safety which will be launched in 2019.
- ILRI was asked to present at the US National Academy of Science initiative for updating advice for food safety governance in Washington, 2019.
- ILRI is part of the organising committee for the First International Food Safety Conference of the WHO/FAO/AU to be held in February 2019.

People trained during the PigRisk project are likely to continue teaching and research on food safety in informal markets, taking advantage of examples, information, protocols and tools from the project.

PigRisk results were widely published in 10 international and 12 national peer-reviewed journal articles and over 50 paper and poster presentations were given at national and international conferences and workshops.

Writing of scientific outputs will continue after the end of the project and a write shop funded by the CGIAR Research Program on Agriculture and Health is planned. Five more international journal articles are expected until 2019. A list of project publications is attached in Section 10.2.

8.2 Capacity impacts – now and in 5 years

Capacity building of research teams was a key component of the project through short-term, medium-term and long-term training of researchers, graduate and postgraduate students and health authorities. Over 100 undergraduate and graduate research fellows (37 males and 65 females) received training while working on PigRisk-related research topics. Table 5 gives an overview of the numbers of medium-term to long-term students trained, by institution and degree. Some of the MSc students and both PhD students will continue to work on pork value chains or food safety in the Safe Pork project.

Table 5: Numbers of medium-term to long-term students trained, by institution and degree

Institute	Total	Male	Female	BSc/BVM	MSc	PhD
VNUA economics	78	23	55	67	10	1
VNUA veterinary science	20	13	7	19	1	0
HUPH	4	1	3	2	1	1*
Total	102	37	65	88	12	2

*Thesis defended in February 2018 at Rakuno Gakuen University, Japan

Capacity building resulted not only in increased knowledge of national research teams for the execution, but also provided a sound knowledge basis being applied beyond the PigRisk project. HUPH and VNUA have become the go-to institutions for support in training in their respective areas of expertise. For example:

- HUPH researchers conducted training courses in risk assessment at national and regional universities including VNUA (food technology), the Veterinary Public Health Centre for Asia Pacific and Chiang Mai University, Thailand.
- HUPH researchers contributed substantially to the World Bank technical report on food safety risk assessment in Vietnam, the national food safety working group and the national taskforce for food safety risk assessment.
- HUPH researchers supported One Health training under the South East Asia One Health University Network, expertise which they partly gained through the PigRisk project.
- Economics researchers from VNUA were asked to give training on value chain assessment.

National scientists involved

VNUA, Faculty of Economics and Rural Development, Department of Quantitative Analysis (VNUA economic)

- Scientists: 11 (Team leader: Pham Van Hung)
- Duong Nam Ha continues with his PhD at Tasmania University until July 2019 under a John Allwright Fellowship
- Nguyen Anh Duc completed his MSc in 2017 and started his PhD at Adelaide University in December 2017
- Vu Khac Xuan completed his MSc at Melbourne University in December 2017 and started his PhD in February 2018
- Students: 78

VNUA animal health and veterinary medicine

- Scientists: 4 (Team leader: PH Ngan)
- Vu Thi Thu Tra continues her PhD program at Freie Universitaet Berlin, Germany until 2020.
- Veterinary students: 20

HUPH

- Scientists: 5 (Team leader: Pham Duc Phuc),
- Dang Xuan Sinh is undertaking repeated study courses (since May 2016) at Rakuno Gakuen University, Japan to get in-depth training by Dr Kohei Makita on quantitative risk assessment and risk factor analysis related to food safety. This will provide him with advanced knowledge and skills in epidemiology and statistics to finalize his doctoral program with the support of the project team. He has completed his PhD program in February 2018.
- Graduate students: 4

- In addition, in 2014, Hung Nguyen was a John Dillon fellow of ACIAR at his time at HUPH.

Hanoi Medical University

- Scientists: Hoang Van Minh and Tran Tuan Anh

Visiting scientists, internships or volunteers supporting capacity building

- Boubacar Sidibé, a volunteer on food safety policy from Vétérinaires Sans Frontières Canada, visited HUPH from April to June 2016 to provide capacity development in the form of training and mentoring on food safety policy and communication using information from PigRisk. Outputs included a policy brief, communication materials and a conventional framework for a food safety project.
- Christie Chang from the Institute for Rural Futures, University of New England, collaborated with the VNUA team to organize two workshops on value chain analysis which included lecturers and students from the Faculty of Economics and Rural Development and Faculty of Accounting and Business, VNUA. Christie was supported by the CGIAR Research Program on Livestock and Fish.
- Seth de Vlieger (BSc intern) supported the development of dissemination materials.
- Steven Quan Lam (MPH), a volunteer on monitoring and evaluation from Vétérinaires Sans Frontières Canada, guided HUPH staff on monitoring and evaluation through hands-on training from March to July 2016. He led the Outcome Harvesting activity which focused on documenting outcomes from the perspective of researchers and local policymakers.
- Tarni Cooper, an Australian veterinarian, conducted research on the potential of participatory video as a best-bet intervention in the smallholder pig value chain in Vietnam.
- Terumi Yokozawa (DVM, Rakuno Gakuen University, Japan) conducted study on the prevalence of *Salmonella* along the value chain from pig slaughterhouses to markets.

A continuous key pillar supporting policy capacity development impacts through training and skill-building was provided through the national task force that was funded by the CGIAR Research Program on Agriculture for Nutrition and Health. The task force is envisioned to provide the platform for policy linkages and advocacy through which PigRisk project outputs can be mainstreamed for policy influencing and policymaking.

ILRI staff involved

- Scientists: Delia Grace, Fred Unger, Hung Nguyen-Viet, Karl Rich, Kohei Makita and Lucilla Lapar (Jeffrey Gilbert, Korapin Tohtubtiang and Rainer Assé were involved from the project's inception until December 2013)
- Research associate: Nguyen Thinh (since 2016)
- Regional communication specialist: Chi Nguyen (since May 2017)

Australian Volunteers for International Development at ILRI

- Andrew Nguyen supported project communication from June to October 2012.

- Max Barot worked with the research teams between December 2015 and March 2017 and defended his MSc thesis on biosecurity and disease control practices of Vietnamese smallholder pig farmers in May 2017.

Short-term and medium-term training courses

Various training courses were conducted for university researchers, government authorities and risk assessors. These included training on One Health/ecohealth, value chain assessment, system dynamics modelling and risk assessment. Figure 6 gives a schematic overview of the short- and medium-training courses. By the end of the project, those who had received training had developed the capacity to also offer training to other groups. This included more than 200 short-term trainees and 102 medium to long term students.

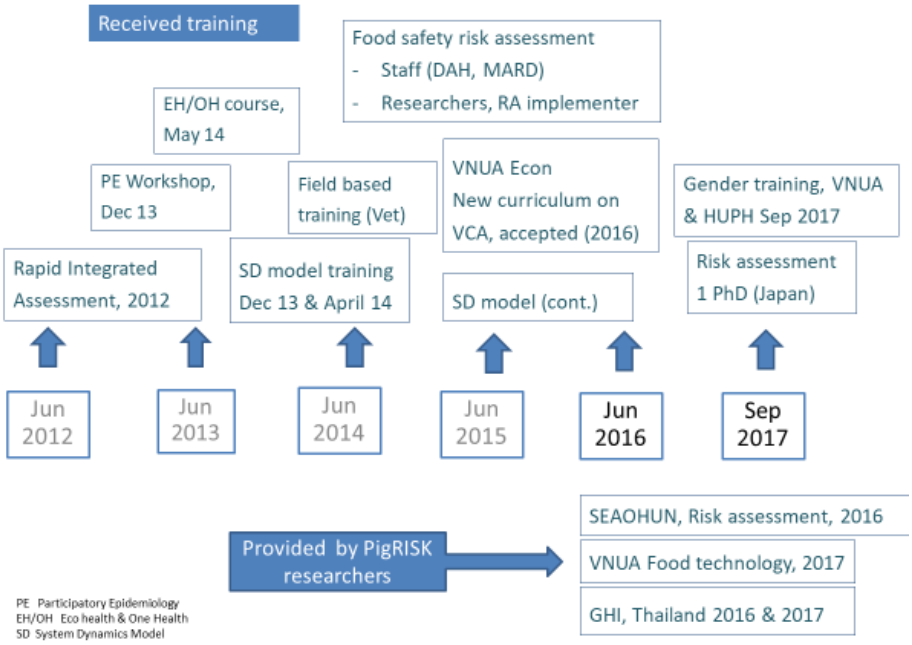

Figure 6: Overview of short-term and medium-term training courses by the PigRisk project.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Ex-ante analysis suggested substantial benefits can be attained in the pig value chain because the health burden and costs of illness are both high and preventable; nearly half the marketed pork is contaminated with *Salmonella* with illness affecting 1-2 in 10 consumers a year (Sinh Dang-Xuan et al. 2017). Our study estimated the costs per treatment episode and per hospitalization day for foodborne diarrhoea case were USD 106.9 and USD 33.6, respectively (Hoang Van Minh et al. 2015), so the national burden is enormous. Improving food safety will contribute to reducing such costs.

Food safety improvements bring about economic benefits to value chain actors in several ways. Our research estimates value added at USD 40–70 per 100 kg live weight, based on value chain studies in Hung Yen and Nghe An provinces, and these are within the range of estimates obtained in previous ILRI studies (Lapar et al. 2012) that estimated value added per 100 kg live weight at USD 33 at producer, USD 9 at butcher and USD 7 at retailer nodes in the pork value chain. These estimates provide a baseline on which to

compare estimates of potential economic impacts of food safety improvements in the pork value chain.

Food safety could be engendered from improved farm practices that minimize zoonotic animal health risks at farm that could potentially be transmitted to other value chain nodes beyond the farm. An example is the adoption of a set of best practices such as VietGAHP. Results from ex-ante assessment of impacts of adoption of VietGAHP as an example of pork value chain upgrading in Vietnam suggest that while production costs increase from change in practices, such investment could be recovered from productivity gains (at least 13%) and reduced losses at farm (at least two-thirds lower mortality), more pigs sold (by almost twice) by producers at higher market prices (by at least 4% per kg) and overall higher profits to producers. Specifically, estimates from our evaluation of VietGAHP suggest that a farmer adopting VietGAHP could likely realize higher profits of USD 5–20 per pig than a non-adopter.

Food safety improvements beyond the farm that could lead to food safety outcomes could also be achieved through improved slaughterhouse hygiene that delivers safe pork to retail markets, thereby increasing the supply of safe pork and benefitting consumers by reducing risks from pork-borne illness, reducing costs of illness associated with these and generating potential positive effects on public health outcomes. From better health comes wealth, and our simulation results suggest that higher incomes from lower costs of illness (healthier, more productive people; lower treatment costs) (20% higher than baseline) stimulates higher demand for safe pork and engenders higher supply response from producers due to higher market prices.

While costs of slaughterhouse operations increase in the short run due to investment costs of upgrading, these costs could be recouped over time as increasing demand for safe pork and accompanying price premia induces higher derived demand for hygienic slaughterhouse facilities. As this work is ongoing, no concrete estimates of impacts, particularly on the valuation of potential public health gains from food safety interventions, in absolute dollar values can yet be provided and only relative values (in percent changes from the baseline) are provided to show economic benefits from slaughterhouse upgrading in this example.

8.3.2 Social impacts

Increased awareness on gender issues has been gained, based on various trainings and incorporation of gender aspects into applied tools. Informal observations by the study team confirmed that women have adopted practices such as regular record keeping. This needs to be formally documented and followed up.

The impact pathway of the project is part of the overall theory of change that links CGIAR research to the development impact of improved food safety. Initial scoping work has identified animal-source foods sold in informal markets in developing countries as the most important food safety issue. A theory of change has been developed to guide research in this area (Johnson et al. 2015).

In addition to the health impacts, concerns about food safety can reduce consumption of nutritious foods and reduce market access for smallholders. The theory of change identifies outcomes along the pathway from intervention to impact, along with the underlying causal assumptions. The results show that for some parts of the impact pathway, outcomes and causal links are well defined and supported by evidence, while for others, more evidence must be gathered to validate hypothesized causal relationships in specific contexts.

The research carried out by PigRisk is an important part of generating this evidence. Thus, the impact pathway of the project is not just through working with beneficiaries but rather in developing innovative approaches for informal markets which can be supported by government and development partners to reach hundreds of thousands of informal

sellers, benefit tens of millions of consumers through safer foods, and millions of smallholder farmers through safeguarded market access.

As mentioned in the section on scientific impact, a large development project on food safety, funded by the World Bank and initiated from the World Bank (2017) technical report which PigRisk researchers contributed to, will bring social impact to people in Hanoi, Ho Chi Minh City and Hai Phong provinces and beyond through safer food and better health.

8.3.3 Environmental impacts

The environmental impact of PigRisk was assessed in collaboration with HUPH through the work of Hung Nguyen-Viet who has since moved to ILRI. Initial assessment surveys suggest that improved pig waste management is likely to be a component of the interventions tested by the project and upscaled by the CGIAR Research Program on Livestock. Hung Nguyen-Viet is a member of the Waste to Worth Focus Group of the global livestock dialogue. Activities on pig waste management using biogas were implemented by the Ecohealth Field-building Leadership Initiative and HUPH with funding from the International Development Research Centre. From this project, interventions to improve biogas management have improved effluent microbial quality and hygiene practices of pig producers at farm level. Scaling out and up biogas technologies in pig productions is facing challenges as farmers don't have a good business model to use biogas or to convert it in other energy form like electricity or heat. The environmental impact of livestock and particularly of pig production was under-addressed but was included in the national policy on supporting smallholder livestock. However, the implementation of livestock environmental policy is still limited and needs to be further addressed.

8.4 Communication and dissemination activities

Various communication and dissemination activities were undertaken, tailored for specific target audiences. Feedback meetings and regular consultations were organized with government authorities and value chain actors (producers, butchers and retailers) in Hung Yen (3) and Nghe An (4). Scientific messages for specialist audiences were presented at expert workshops and conferences. Selected key events are outlined below.

Major project meetings

Biannual planning and progress meetings among the project team were organized by the coordinator to monitor progress aligned with outputs and milestones, to identify challenges and to discuss how to overcome them. For some meetings, representatives from ACIAR or researchers from projects/institutions working on related topics were invited to inform them on PigRisk or contribute to the meetings. The final project workshop was held in Hanoi in September 2017.

Workshops

- Roundtable discussion on food safety and risk management in Vietnam, January 2016: ILRI organized and contributed to this roundtable discussion initiated by the World Bank. During the event, PigRisk researchers presented project-related scientific outputs.
- Food safety and value chain interventions workshop, Hanoi, May 2016 (see details in Chapter 7): The workshop aimed to provide an exchange platform for food safety initiatives in Vietnam.

- Feedback workshops in Nghe An (April 2017) and Hung Yen (May 2017): The workshops were attended by local representatives from the Sub-department of Animal Health, Department of Food Safety, Department of Health, producers, butchers, pork retailers and consumers. Key project results achieved from June 2012 to May 2017 were reported. Participants suggested ways of improving food safety in the smallholder pig value chain. Their feedback was incorporated into the Safe Pork project proposal which was finalized during the workshop. There was also a suggestion to initiate a policy dialogue.
- Policy dialogue in Nghe An (August 2017): Following the feedback workshops, a policy dialogue was initiated with government authorities from Hung Yen and Nghe An provinces. During the dialogue, recommendations based on project findings were presented and discussed. A policy brief was developed and shared with relevant authorities.

Conferences

Scientists presented PigRisk-related research at over 20 international conferences. This included five keynotes, 21 presentations, 11 poster presentations and 7 papers in conference proceedings.

Technical paper on food safety risk management in Vietnam: Challenges and opportunities

The World Bank commissioned ILRI and the food safety risk assessment taskforce to conduct a food safety risk management study in Vietnam to identify opportunities and challenges and the way forward for food safety in Vietnam. This was done following a request by the Government of Vietnam to the World Bank. PigRisk researchers from ILRI and HUPH were involved in this study and contributed specifically to the section of the report on hazards and risk using scientific outputs from case studies carried out under PigRisk. The final report was launched in March 2017 in the presence of the Deputy Prime Minister of Vietnam.

Photo 3: Vietnam Deputy Prime Minister Vu Duc Dam (standing) speaks at the launch of a World Bank-commissioned food safety report in Hanoi, Vietnam on 27 March 2017. Other high-level participants (from right) are Vice Minister of Industry and Trade, Tran Quoc Khanh; World Bank Vietnam Country Director, Ousmane Dione; World Bank Practice Manager, Nathan Belete and Vice Minister of Health, Truong Quoc Cuong (photo credit: International Livestock Research Institute/Chi Nguyen).

Taskforce for food safety risk assessment

The national taskforce for food safety risk assessment has conducted several activities in research, training and advocacy in food safety risk assessment since 2013. The taskforce has been officially institutionalized by HUPH and is now recognized as a technical entity bringing together experts in risk assessment to conduct research, training and advocacy in food safety risk assessment in Vietnam. Most of the members of the taskforce are part of the national working group on food safety.

Media releases

Strong media presence during key meetings and workshops was evidence of the high level of interest of attending journalists on the topic of food safety in informal markets.

Below is a list of key media releases and video clippings:

- Hung Nguyen-Viet. 2014. *PigRisk project and lessons learned from the ACIAR John Dillon Fellowship in Australia in 2014.* Video. Canberra, Australia: ACIAR. http://hdl.handle.net/10568/44928
- PigRisk project inauguration at Melia Hotel https://www.youtube.com/watch?v=tT9Xw_O77bg&index=2&list=PLCLZXIdq9v2TBJBuPA2Y0F_zy0FbCgraX
- Việt Nam góc nhìn của bạn (Strengthening the smallholder pig value chain in Vietnam) https://www.youtube.com/watch?v=Wa_yT76_suA&t=591s&list=PLCLZXIdq9v2TBJBuPA2Y0F_zy0FbCgraX&index=15

- Measures to improve pork safety in Vietnam https://www.youtube.com/watch?v=pQ2lXSmC97s&t=17s&list=PLCLZXIdq9v2TBJBuPA2Y0F_zy0FbCgraX&index=16

Websites and blogs

A project website (wiki) was developed and regularly updated. News articles and project updates targeted at general audiences were also regularly uploaded on various websites and blogs including VietPIG, HUPH website, ILRI Asia blog, ILRI News blog and AgHealth blog.

Write shop, Dalat, August 2017

The goal of the write shop was to finalize a range of scientific outputs from previous and ongoing research by ILRI and partners in Southeast Asia. This included two PigRisk manuscripts.

South-to-south cooperation on pig production

ILRI Vietnam holds study tour for Nagaland officials (June 2016)

9 Conclusions and recommendations

9.1 Conclusions

Impacts of pork-borne diseases and opportunities for risk management

Salmonella, a pig-borne bacterial pathogen, is one of the most common causes of foodborne illness in Vietnam. *Salmonella* was present in 44% of marketed pork.

A quantitative microbial risk assessment on the health impact of human salmonellosis in Vietnam found an annual salmonellosis risk incidence of 17.7%. This implies that out of every 10 pork consumers, one to two are at risk of falling ill from salmonellosis each year.

An assessment of the economic cost of acute foodborne diarrhoea caused by *Salmonella* in Vietnam found the average cost per episode treatment at hospital ranged from USD 2.5–7.6 million annually, accounting for 0.005% of GDP.

Simulations showed that interventions at farms and slaughterhouses can reduce the overall incidence of salmonellosis among consumers. A 10% reduction of *Salmonella* on slaughterhouse carcasses leads to a reduction of annual incidence from 17.7% to 11.8%.

Veterinary drug residues and other chemicals were found in relatively few samples. Moreover, these were not likely to constitute a significant risk to human health.

Farmers are the actors suffering most from pig disease risks, with highest burden in piglets. Thus, farmers are the most vulnerable actors in the pig value chain.

Incentive-based innovations to reduce risk and improve health

Evaluation of the adoption of VietGAHP guidelines found that while there was consensus among farmers that improved practices were necessary, large-scale adoption was hampered by the complexity of the guidelines and limited incentives.

Off-the-ground slaughtering racks (as opposed to handling carcasses) reduced contamination of pork but would not be used unless incentives were provided.

Participatory video can be an innovative method of peer-to-peer learning among farmers to influence change in practices. The greatest impact on practice change was during the collaborative process of making the video and soon after watching it for the first time.

Improved capacity to manage health risks

Through training courses, project researchers developed the capacity of national and regional partners in value chain analysis and food safety risk analysis. Over 100 research fellows (undergraduate and graduate) obtained higher level degrees through the project.

A national taskforce on food safety risk assessment was set up with support from project researchers. The taskforce is recognised by the government as a useful resource for research, training and advocacy in food safety in Vietnam. Project researchers and taskforce members contributed significantly to a World Bank-commissioned landmark report on food safety which has been taken up by the Government of Vietnam.

9.2 Recommendations

We distinguish between specific recommendations to continue to improve food safety in Vietnam and broader international public good recommendations.

For Vietnam

- The current policy on slaughterhouses should prioritize good practices and behaviour change of related actors and promote adoption of hygienic practices rather than only focusing on infrastructural improvements.

- Risk communication is key to managing food scares and building trust in the food system. So far, little attention has been paid to this in Vietnam. Improved risk communication requires the development of a food safety communication strategy and better collaboration among relevant state agencies and other actors to deliver practical and coherent food safety messages to the public.
- The current VietGAHP and GHP guidelines that target large-scale operations should be simplified to enhance the adoption of improved practices by smallholder pig farmers and slaughterhouse workers.
- Good agricultural practices can improve food safety and have other benefits, but the current low levels of adoption and lack of perceptible evidence of immediate benefits and food safety outcomes commensurate with effort and investments means that more evidence and innovative approaches are needed to make these attractive. Therefore, greater awareness of the benefits of behavioural changes and incentives for the adoption of good practices is needed.
- Capacity building and technical support for pig farmers on feeding and disease management should be strengthened.
- Future interventions should target consumers to manage the risk of cross-contamination at household level when handling pork.
- National food safety monitoring and surveillance should be strengthened and traceability along the pig value chain improved.
- A gendered approach should be used in testing of interventions as men and women have distinct roles and undertake different activities in the pig value chain.

For donors and the food safety community in low- and middle-income countries

Only recently is information starting to emerge on the health burden of foodborne disease in low- and middle-income countries. Each year there are at least 6 million illnesses and 420,000 deaths from foodborne diseases. This burden is comparable to that of malaria, HIV/AIDS and tuberculosis but investments have only been around a twentieth as much as have gone to the ‘Big Three’.

This has started to change as major donors and international organizations have begun initiatives to develop investment plans for food safety in low- and middle-income countries. These plans are due in 2018–19 and ILRI has been involved in developing these. Research evidence generated by the PigRisk project is thus being used to inform global investment in foodborne disease management in domestic markets.

Not only is there under-investment in food safety, but previous investments have largely failed to generate any benefits for human health in low- and middle-income countries. Key investment advice is:

- Shift from a dominant focus on food safety for export to give more attention to **reducing the burden of foodborne illness** among consumers in domestic markets.
- Shift from the hazard-based approaches to food safety assessment and management to risk-based approaches that are more effective, useful, sustainable and appropriate for low- and middle-income countries.
- Recognize, catalyse and **harness consumer awareness, market forces and private sector leadership** as key drivers of food safety progress to complement the role of national control systems.

On a regional scale, the approach is also being applied in Cambodia with support from USAID and we are seeking opportunities to further extend its application.

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4. Hung Nguyen-Viet, Tran Thi Tuyet-Hanh, Unger, F., Sinh Dang-Xuan and Grace, D. 2017. Food safety in Vietnam: where we are at and what we can learn from international experiences. *Infectious Diseases of Poverty* 6: 39. http://hdl.handle.net/10568/79981
5. Nguyen Thi Ly, Nanseki, T. and Chomei, Y. 2015. Determinants of biogas adoption in manure management of Vietnamese household pig production: A case study in Tien Lu District, Hung Yen Province. *Journal of the Faculty of Agriculture, Kyushu University* 60(2): 577–581. http://hdl.handle.net/10568/76505
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9. Tran Thi Tuyet-Hanh, Dang Xuan Sinh, Pham Duc Phuc, Tran Thi Ngan, Chu Van Tuat, Grace, D., Unger, F. and Hung Nguyen-Viet. 2017. Exposure assessment of chemical hazards in pork meat, liver, and kidney, and health impact implication in Hung Yen and Nghe An provinces, Vietnam. *International Journal of Public Health* 62(Supplement 1): 75–82. http://hdl.handle.net/10568/77702
10. Sinh Dang-Xuan, Hung Nguyen-Viet, Phuc Pham-Duc, Unger, F., Ngan Tran-Thi, Grace, D. and Makita, K. 2018. Risk factors associated with Salmonella spp. prevalence along smallholder pig value chains in Vietnam. Int J Food Microbiol. 290:105-115. http://hdl.handle.net/10.1016/j.ijfoodmicro.2018.09.030
11. Sinh Dang-Xuan, Hung Nguyen-Viet, Phuc Pham-Duc, Grace, D., Unger, F., Nam Nguyen-Hai, Thanh Nguyen-Tien and Makita, K. 2018. Simulating Cross-Contamination of Cooked Pork with Salmonella enterica from Raw Pork through Home Kitchen Preparation in Vietnam. Int J Environ Res Public Health. 15(10). http://hdl.handle.net/10.3390/ijerph15102324
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8. Nguyen Thi Thu Huyen, Pham Van Hung and Ninh Xuan Trung. 2016. Factors contributing to disease risk in pig production in Hung Yen. *Tạp Chí Kinh tế & Phát Triển* (*Journal of Economics and Development*) 229(2): 53–59. http://hdl.handle.net/10568/80412
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4. Nguyen Thi Duong Nga, Lapar, M.L., Pham Van Hung, Tran Van Long, Pham Kieu My, Pham Thi Toan and Unger, F. 2017. *An evaluation of economic viability of small scale slaughterhouses in Vietnam: Implication for pig value chain development.* In: Proceedings of the 9th Asian Society of Agricultural Economists (ASAE) international conference, Bangkok, Thailand, 11–13 January 2017. Bangkok, Thailand: Kasetsart University: 813–828. http://hdl.handle.net/10568/80375
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1. Grace, D., Unger, F., Roesel, K., Tinega, G., Ndoboli, D., Sinh Dang-Xuan, Hung Nguyen-Viet and Robinson, T. 2015. *Present and future use of antimicrobials in pigs with case studies from Uganda and Vietnam.* Presentation at the Safe Pork 2015 Conference, Porto, Portugal, 7–10 September 2015. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/68304
2. Hung Nguyen-Viet, Lapar, L. and Grace, D. 2014. *Pork value chain in Vietnam: Now, future and challenges.* Presentation at a seminar for veterinary students, School of Animal and Veterinary Sciences, Charles Sturt University, Wagga Wagga, Australia, 13 March 2014. Nairobi: ILRI. http://hdl.handle.net/10568/56898
3. Hung Nguyen-Viet, Nguyen Tien Thanh, Dang Xuan Sinh, Luu Quoc Toan, Pham Van Hung and Grace, D. 2013. *Rapid integrated assessment of food safety related to pork in Vietnam: A consumer perspective.* Presentation at the First African Regional Conference of the International Association on Ecology and Health (Africa 2013 Ecohealth), Grand-Bassam, Côte d'Ivoire, 1-5 October 2013. Hanoi, Vietnam: Hanoi University of Public Health (HUPH). http://hdl.handle.net/10568/33801
4. Hung Nguyen-Viet, Unger, F., Dang Xuan Sinh, Dominguez-Salas, P. and Grace, D. 2017. *Nexus between One Health, nutrition and food safety.* Presented at the Asia-Pacific regional symposium on sustainable food systems for healthy diets and improved nutrition, Bangkok, Thailand, 10–11 November 2017. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/89676
5. Hung Nguyen-Viet. 2017. *From measuring to managing: The experience of food safety in Vietnam.* Presentation at a Brussels Development Briefing on "Better targeting food safety investments in low and middle-income countries", Brussels, Belgium, 24 May 2017. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/82662
6. Hung Nguyen-Viet. 2017. *Risk assessment for food safety management in Vietnam.* Presented at an Agrilinks webinar on "Addressing food safety in animal-source foods for improved nutrition", 25 January 2017. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/79782
7. Rich, K.M., Nguyen Thi Thu Huyen, Duong Nam Ha, Nguyen Thi Duong Nga, Vu Khac Xuan, Ninh Xuan Trung, Tran Van Long, Pham Van Hung, Unger, F., Hamza, K. and Lapar, L. 2015. *Using system dynamics for ex-ante impact assessment of food safety policies in pig value chains.* Presented at the Safe Pork Conference, Porto, Portugal, 7–10 September 2015. USA: University of New England. http://hdl.handle.net/10568/71011
8. Sinh Dang Xuan, Hung Nguyen-Viet, Unger, F., Phuc Pham-Duc, Ngan Tran Thi, Grace, D. and Makita, K. 2016. *Prevalence and quantitative microbial risk assessment of Salmonella in pork value chain in Hung Yen province, Vietnam.* Presented at the First Joint Conference of the Association of Institutions for Tropical Veterinary Medicine and the Society of Tropical Veterinary Medicine, Berlin, Germany, 4–8 September 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/77163
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10. Sinh Dang-Xuan, Hung Nguyen-Viet, Phuc Pham Duc, Ngan Tran Thi, Thanh Nguyen Tien, Unger, F., Makita, K. and Grace, D. 2015. *Hygiene and microbial*

contamination along the pork value chain in Vietnam. Presented at the 4th Food Safety and Zoonoses Symposium for Asia Pacific and 2nd Regional EcoHealth Symposium, Chiang Mai, Thailand, 3–5 August 2015. Bangkok, Thailand: Chiang Mai University. http://hdl.handle.net/10568/71008

11. Tran Thi Tuyet Hanh, Sinh Dang-Xuan, Hung Nguyen-Viet, Unger, F., Chu Van Tuat, Ngan Tran Thi and Phuc Pham Duc. 2015. *Antibiotic residues and heavy metals in pork at wet markets in Vietnam.* Presented at the 4th Food Safety and Zoonoses Symposium for Asia Pacific and 2nd Regional EcoHealth Symposium, Chiang Mai, Thailand, 3–5 August 2015. Hanoi, Vietnam: Hanoi University of Public Health. http://hdl.handle.net/10568/71013
12. Unger, F. 2017. *Twenty-first Century disease threats, epidemiology and One Health.* Presented at the Veterinary Medicine International Conference (VMIC 2017), Surabaya, Indonesia, 12 July 2017. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/90691
13. Unger, F., Hung Nguyen-Viet and Grace, D. 2017. *Ecohealth and One Health research in Southeast Asia: Examples, challenges, successes and outlook.* Presentation at the 1st international conference on One Health, Malang, Indonesia, 1–2 March 2017. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/90689
14. Unger, F., Hung Nguyen-Viet, Lapar, L., Marshall, K. and Grace, D. 2016. *Food safety along informal pork market chains in Vietnam: Experience from an integrated research team.* Panel presentation at the Neglected Tropical Diseases (NTD) Asia 2016 conference, Khon Kaen, Thailand, 14–15 January 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/80058
15. Unger, F., Hung Nguyen-Viet, Lapar, L., Phuc Pham Duc, Pham Van Hung, Pham Hong Ngan, Barot, M. and Grace, D. 2016. *Food safety along informal pork value chains in Vietnam: Success and challenges from an interdisciplinary research team view.* Presented at the 4th International One Health Congress and 6th Biennial Congress of the International Association for Ecology and Health (One Health EcoHealth 2016), Melbourne, Australia, 3–7 December 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/80368
16. Unger, F., Hung Nguyen-Viet, Sinh Dang-Xuan, Phuc Pham Duc, Pham Van Hung, Lapar, L., Marshall, K., Duong Van Nhiem and Grace, D. 2016. *Food safety from a global perspective to a country perspective addressing challenges along smallholder pig systems in Vietnam.* Presentation at the Global Health Institute scientific conference, Chiang Mai, Thailand, 19 February 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/80060
17. Unger, F., Hung Nguyen-Viet, Sinh Dang-Xuan, Phuc Pham-Duc and Grace, D. 2016. *Global health issues with focus on food safety in Southeast Asia.* Keynote presentation at the International Symposium on Global Physiology, Yogyakarta, Indonesia, 22 October 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/78130
18. Unger, F., Hung Nguyen-Viet, Sinh Dang-Xuan, Phuc Pham-Duc, Pham Van Hung, Lapar, L., Marshall, K., Duong Van Nhiem, Makita, K. and Grace, D. 2016. *Food safety assessment and challenges along small-scale pig systems in Vietnam.* Presentation at the first joint conference of the Association of Institutions for Tropical Veterinary Medicine and the Society of Tropical Veterinary Medicine, Berlin, Germany, 4–8 September 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/77112
19. Unger, F., Lapar, L., Hung Nguyen-Viet and Grace, D. 2015. *Improving livestock value chains: The example of Vietnam (pigs).* Presented at the Workshop on

Global Health Institute 2015, Chiang Mai, Thailand, 11 February 2015. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/58476

20. Unger, F., Lapar, L., Pham Van Hung, Sinh Dang-Xuan, Pham Hong Ngan, Duong Van Nhiem, Hung Nguyen-Viet and Grace, D. 2015. *Animal health and food safety in smallholder pig value chains in Vietnam.* Presented at the 4th Food Safety and Zoonoses Symposium for Asia Pacific and 2nd Regional EcoHealth Symposium, Chiang Mai, Thailand, 3-5 August 2015. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/71025
21. Unger, F., Lapar, L., Pham Van Hung, Sinh Dang-Xuan, Pham Hong Ngan, Rich, K., Hung Nguyen-Viet and Grace, D. 2015. *Food safety challenges in smallholder pig value chains in Vietnam: From an assessment to feasible interventions using an integrated approach.* Presented at the Safe Pork conference, Porto, Portugal, 7–10 September 2015. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/69464

Presentations at national forums

1. Barot, M. 2016. *Biosecurity and diseases control practices and perceptions of smallholder pig farmers in Vietnam.* Presented at Vietnam National Agricultural University, Hanoi, Vietnam, 8 December 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/78806
2. Grace, D. 2012. *What we have learned about disease risks and food safety in the informal food sector?* Presented at the inception workshop for the 'Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam' project, Hanoi, 14 August 2012. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/21713
3. Hoang Van Minh. 2012. *Incentive-based innovations in improving management of animal and human health risks in smallholder pig value chains in Vietnam: Cluster Randomized Controlled Trial.* Presented at the inception workshop for the 'Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam' project, Hanoi, 14 August 2012. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/21742
4. Hung Nguyen-Viet, Unger, F., Dang Xuan Sinh, Tran Thi Tuyet Hanh and Grace, D. 2016. *Food safety in Vietnam's livestock sector.* Presented at the Vietnam Agricultural Outlook Conference 2016, Hanoi, Vietnam, 27 May 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/75553
5. Lapar, L. 2012. *Reducing disease risks and improving food safety in smallholder pig value chains in Vietnam: What have we learned from previous work?* Presented at the inception workshop for the 'Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam' project, Hanoi, 14 August 2012. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/21715
6. Nguyen Viet Hung. 2012. *Reducing disease risks and improving food safety in smallholder pig value chains in Vietnam: Risk assessment component.* Presented at the inception workshop for the 'Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam' project, Hanoi, 14 August 2012. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/21734
7. Pham Van Hung, Nguyen Thi Duong Nga and Lapar, L. 2015. *Improving the livelihood of small farmers in the pig value chain: Experiences in the north of Vietnam.* Presented at a regional seminar on 'Agriculture Development for the Mekong Delta: How to Increase the Livelihood of Farmers', Can Tho City, Vietnam, 24 April 2015. Hanoi, Vietnam: Vietnam National University of Agriculture. http://hdl.handle.net/10568/71009

8. Pham Viet Hung. 2012. *Reducing disease risks and improving food safety in smallholder pig value chains in Vietnam—Value chain assessment.* Presented at the inception workshop for the 'Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam' project, Hanoi, 14 August 2012. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/21743
9. Randolph, T. 2012. *What have we learned about smallholder systems?* Presented at the inception workshop for the 'Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam' project, Hanoi, 14 August 2012. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/21712
10. Staal, S., Pham Van Hung and Nguyen-Viet, Hung. 2012. *Impact pathways.* Presented at the inception workshop for the 'Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam' project, Hanoi, 14 August 2012. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/21716
11. Unger, F. 2012. *Animal health assessment (including zoonoses) in smallholder pig value chains.* Presented at the inception workshop for the 'Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam' project, Hanoi, 14 August 2012. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/21714
12. Unger, F., Hung Nguyen-Viet, Sinh Dang-Xuan, Phuc Pham Duc, Pham Van Hung, Lapar, L., Marshall, K., Duong Van Nhiem and Grace, D. 2016. *Food safety from a global perspective to a country perspective addressing challenges along smallholder pig systems in Vietnam.* Presentation at the Global Health Institute scientific conference, Chiang Mai, Thailand, 19 February 2016. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/80060
13. Vu Thi Thu Tra, Pham Hong Ngan, Duong Van Nhiem, Ngo Minh Ha and Unger, F. 2015. *Biosecurity practices in small-scale pig farms in Hung Yen and Nghe An, Vietnam.* Presented at Tropentag 2015, Berlin, Germany, 16-18 September 2015. Hanoi, Vietnam: Vietnam National University of Agriculture. http://hdl.handle.net/10568/71016

Posters at international workshops or conferences

1. Duong Nam Ha, Nguyen Thi Thu Huyen, Ninh Xuan Trung, Tran Van Long, Nguyen Anh Duc, Vu Khac Xuan, Nguyen Thi Duong Nga, Pham Van Hung, Rich, K.M., Unger, F. and Lapar, L. 2014. *Characterizing pig value chains in Vietnam: Descriptive analysis from survey data.* Poster presented at Tropentag 2014: Bridging the Gap between Increasing Knowledge and Decreasing Resources Workshop, Prague, Czech Republic, 17–19 September 2014. Hanoi, Vietnam: Vietnam National University of Agriculture. http://hdl.handle.net/10568/56895
2. Duong Van Nhiem, Pham Hong Ngan, Vu Thi Thu Tra, Dinh Phuong Nam and Unger, F. 2015. *Endoparasites in pigs raised in smallholder farms in Hung Yen province of Vietnam.* Poster presented at the 4th Food Safety and Zoonoses Symposium for Asia Pacific and 2nd Regional EcoHealth Symposium, Chiang Mai, Thailand, 3–5 August 2015. Hanoi, Vietnam: Vietnam National University of Agriculture. http://hdl.handle.net/10568/71027
3. Hung Nguyen-Viet, Sinh Dang-Xuan, Tran Thi Tuyet Hanh, Pham Duc Phuc, Grace, D., Unger, F. and Makita, K. 2015. *Risk-based approach to food safety research: Application to pork value chains in Vietnam.* Poster presented at the 5th Leverhulme Centre for Integrative Research on Agriculture and Health (LCIRAH) Annual Research Conference, London, UK, 3–4 June 2015. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/67029

4. Hung Nguyen-Viet, Sinh Dang-Xuan, Tran Thi Tuyet Hanh, Pham Duc Phuc, Grace, D., Unger, F. and Makita, K. 2015. *Risk-based approach for food safety applied to pork value chain in Vietnam.* Poster presented at the Safe Pork conference, Porto, Portugal, 7–10 September 2015. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/69426
5. Hung Nguyen-Viet. 2015. *Task force of risk assessment for food safety in Vietnam: Operational research to assist policy and capacity building.* Poster presented at the 9th European Congress on Tropical Medicine and International Health, Basel, Switzerland, 6–10 September 2015. Nairobi, Kenya: ILRI. http://hdl.handle.net/10568/69432
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1. Best poster, 11th biennial Safe Pork conference, Porto, Portugal, September 2015
2. 29th International Conference for Agricultural Economists, Milan, Italy, August 2015

Forthcoming publications

1. Sinh Dang-Xuan, Ngan Tran-Thi, Phuc Pham-Duc, Hung Nguyen-Viet, Ngoc Pham-Thi, Duong Truong-Quy, Delia Grace Randolph, Fred Unger. Serotypes and Antimicrobial Resistance of *Salmonella* spp. Isolated from the Smallholder Pig Value Chain in Hung Yen and Nghe An Provinces, Vietnam. Journal article in preparation for submission in March 2019)