Quantitative risk assessment of human salmonellosis in the smallholder pig value chains in urban of Vietnam

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INTRODUCTION

In Vietnam, food safety and especially pork safety are of major matter to both consumers and policy makers; it is frequently reported in the media and is the subject of high level policy discussions (1, 2). Nontyphoidal *Salmonella* spp. are one of the most important causes of foodborne disease (3). Previous studies in Vietnam have found prevalences of *Salmonella* in cut pork at market ranging from 37 up to 69% (4-7). However, the extent to which this hazard translates into human health risk depends on consumer behaviors especially those relating to cooking and consumption. The aim of this study is to present a quantitative microbial risk assessment (QMRA) model for the smallholder pork value chains in Vietnam and an estimate of salmonellosis risk in humans.

RESEARCH APPROACHES

A cross-sectional was carried out for sample collection along the smallholder pork value chain between April 2014 and February 2015 in Hung Yen Province. A total of 36 pig farms, 25 slaughterhouses (72 slaughtered pigs) and 108 pork shops were randomly selected by sampling.

Salmonella qualitative and quantitative tests were done following ISO 6579:2002 and 3-tube MPN method (8, 9), respectively. Consumer households survey was also conducted using face-to-face interviews (30 urban consumer households) and focus group discussion to explore pork cooking practices and consumption behavior.

Codex Alimentarius Commission QMRA (10) was applied. Bacteria growth and dose–response relationship models were obtained from the literatures (11, 12). Four parts of developed risk model were described in Figure 1.

Monte Carlo simulation was performed using @Risk (Palisade, Corporation, US) for 10,000 iterations. Sensitivity analysis was conducted selecting all the uncertainty parameters and run for 1000 iterations at seven quantile values.

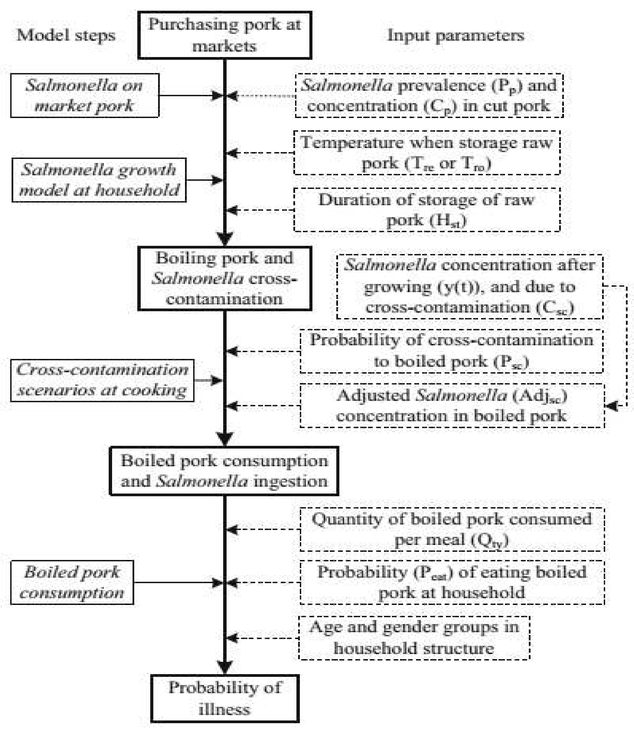

Figure 1. Steps and input parameters of the developed salmonellosis risk assessment model from retail pork to consumption in urban Hung Yen, Vietnam *(thin solid arrow model steps, dotted arrow input parameters, thick solid arrow model flow)*

RESULTS

Smallholder pig value chains to urban Hung Yen

The portions of fattening pigs raised in the small, medium and large scale farms were 5.5, 29.2 and 65.3%, respectively (Figure 2).

Exposure assessment

Each person consumed an average of 74 (minimum 20 to maximum 200) g boiled pork/meal. Amount of boiled pork consumed varied by age and gender group: 37 g/meal (children), 100 g/meal (adult male), 87 g/meal (adult female) and 73 g/meal (elder). The frequency of eating boiled pork was 117 (minimum of 50 to maximum of 205) times/year.

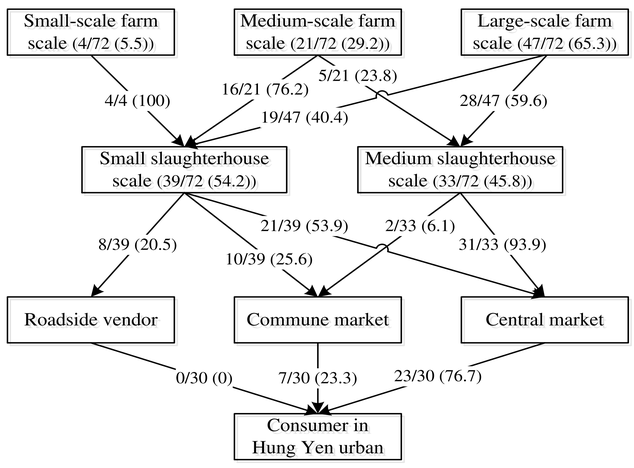

Figure 2. Smallholder pig value chains flow provides pork to urban Hung Yen, Vietnam *(numbers in blankets are in percentage)*

Salmonella prevalence in the smallholder pig value chains

Table 1. *Salmonella* prevalence on pen floor at farm, feces and carcass at slaughterhouse and cut pork at market in Hung Yen, Vietnam

Sample type	*Salmonella* prevalence (No. of positive/n, %)			
	Small	Medium	Large	Overall
Pig pen floor swab at farm	1/2 (50.0)	6/22 (27.3)	5/12 (41.7)	12/36 (33.3)
Fecal sample at slaughterhouse*	13/39 (33.3)	15/33 (45.5)	-	28/72 (38.9)
Pig carcass swab at slaughterhouse	14/39 (35.9)	16/33 (48.5)	-	30/72 (41.7)
Cut pork at wet market**	6/17 (35.3)	10/23 (43.5)	32/68 (47.1)	48/108 (44.4)

(*) Fecal sample was collected from rectum after evisceration, (**) At wet market, small scale was defined as roadside vendor (1-2 stalls), medium scale as commune market (3-20 stalls) and large scale as central market (over 20 stalls)

Risk characterization

Table 2. Annual incidence rate of human salmonellosis due to boiled pork consumption by age and gender groups in urban Hung Yen, Vietnam

Age and gender groups	Estimated annual salmonellosis incidence rate (Mean (90% CI)) (%)
Children (under 5 years old)	11.18 (0 - 45.05)
Adult female (6-60 years old)	16.41 (0.01 - 53.86)
Adult male (6-60 years old)	19.29 (0.04 - 59.06)
Elder (over 60 years old)	20.41 (0.09 - 60.76)
Overall	**17.7 (0.89 - 45.96)**

Sensitivity analysis

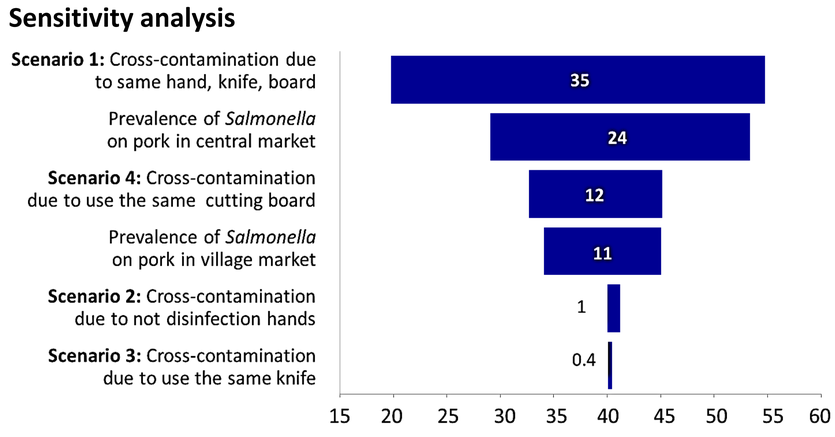

Figure 3. Daily incidence of salmonellosis *(No. of cases/10,000 people)*

DISCUSSION

This study is the first published QMRA applied for food safety in Vietnam in international peer-reviewed literature. Risk-based approaches are now standard for food-safety issues in developed countries, as well as being the basis of rules governing international trade in food products. However, use of risk assessment, and especially quantitative risk assessment, has been limited in LMIC (18). There were several limitations in the study. First was the uncertainty of reduction in cooking that we don't know how accurate the reduction at household is. Secondly, since the speculative nature of modeling, particularly as the model hasn't been validated. Thirdly, the amount and frequency of pork eating also varied by individual and time. In addition, our model was not able to simulate the differing susceptibility in different consumer groups (e.g. children or elder) as well as to the specific *Salmonella* strains.

CONCLUSSION

This study shows high levels of *Salmonella* from farm to final product (pork at market) along the smallholder pig value chains. The risk of salmonellosis in humans due to boiled pork consumption appears to be high. Feasible mitigations to improve hygiene practices are required to reduce the risk for the consumer. Control at farm may benefit from good agricultural practices as well as technological innovations such as water acidification (19). Similarly good practices and adequate infrastructure can improve hygiene at slaughter and retail. Given the important role of cross-contamination in the kitchen, public education should address household practices.

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