# CHAPTER IV

## RESULTS

### 4.1 *Salmonella* prevalence

#### 4.1.1 *Salmonella* prevalence in pig slaughterhouse

Overall, *Salmonella* was isolated from 36.9% (32/87) of all samples collected and from 34.9% (22/63) of carcass samples. *Salmonella* was mostly obtained from workers' hands, with 50% (6/12) (Table 6).

**Table 1** *Salmonella* prevalence from overall and sample types in pig slaughterhouses

| Sample type | %Prevalence (No. *Salmonella* positive/n) | | | |
|---|---|---|---|---|
| | SH A | SH B | SH C | Overall |
| Carcass surface | 23.8 (5/21) | 38.1 (8/21) | 42.9 (9/21) | 34.9 (22/63) |
| Workers' hands | 25.0 (1/4) | 100 (4/4) | 25.0 (1/4) | 50.0 (6/12) |
| Cutting boards | 25.0 (1/4) | 50.0 (2/4) | 25.0 (1/4) | 33.3 (4/12) |
| **Overall** | **24.1 (7/29)** | **48.3 (14/29)** | **37.9 (11/29)** | **36.9 (32/87)** |

SH= Slaughterhouse, A= Van Lam, B= Van Giang, C= My Hao

Table 6 showed the *Salmonella* prevalence in slaughterhouse was highest in slaughterhouse B (48.3%) and lowest in slaughterhouse A (24.1%). Pig carcasses in slaughterhouse C had the highest rate of *Salmonella* contamination (42.9%). *Salmonella* positive was found 100% on workers' hands in slaughterhouse B. Among

3 slaughterhouses related to overall *Salmonella* prevalence, there was no statistically significant difference (p-value = 0.16, $\chi^2$ test).

**4.1.2 *Salmonella* prevalence in pork markets**

Table 7 shows the overall *Salmonella* prevalence in the market was 41.4%. *Salmonella* prevalence on pork at the market was 42.9%. Sellers' hands and cutting boards in pork markets were positive 33,3% and 41.7% of cases, respectively.

**Table 2** *Salmonella* prevalence from overall and sample types in pork markets

| Sample type | % Prevalence (No. *Salmonella* positive/n) | | | |
|---|---|---|---|---|
| | District A | District B | District C | Overall |
| Pork | 14.3 (3/21) | 47.6 (10/21) | 66.7 (14/21) | 42.9 (27/63) |
| Sellers' hands | 25.0 (1/4) | 0.0 (0/4) | 75.0 (3/4) | 33.3 (4/12) |
| Cutting boards | 25.0 (1/4) | 25.0 (1/4) | 75.0 (3/4) | 41.7 (5/12) |
| **Overall** | **17.2 (5/29)** | **37.9 (11/29)** | **69.0 (20/29)** | **41.4 (36/87)** |

A= Van Lam, B= Van Giang, C= My Hao

Results on *Salmonella* prevalence in the markets of the 3 districts are shown in Table 7. The highest *Salmonella* prevalence in pork markets was 69 % in district C and lowest in district A (17.2%). *Salmonella* prevalence on pork, sellers' hands and cutting boards in district C were the highest as compared to the two other districts (66.7%, 75% and 75%, respectively). There was a statistically significant difference on pork samples among the 3 districts (p- value = 0.0018, Fisher' exact test).

**4.1.3 Comparison between *Salmonella* prevalence in pig slaughterhouse with the market**

Overall prevalence of *Salmonella* in pig slaughterhouse (36.9%) was lower than in the market (41.4%). In district A and B, *Salmonella* prevalence at slaughterhouse was higher than in the market. In district C, *Salmonella* prevalence at slaughterhouse (37.9%) was almost 2 times lower than in the market (69.0%) (Table 8 and Figure 3).

**Table 3** Compared *Salmonella* prevalence in pig slaughterhouse and market

| Place | *Salmonella* prevalence (%) | |
|---|---|---|
| | **Slaughterhouse** | **Market** |
| District A | 24.1 | 17.2 |
| District B | 48.3 | 37.9 |
| District C | 37.9 | 69.0 |
| **Overall** | **36.9** | **41.4** |
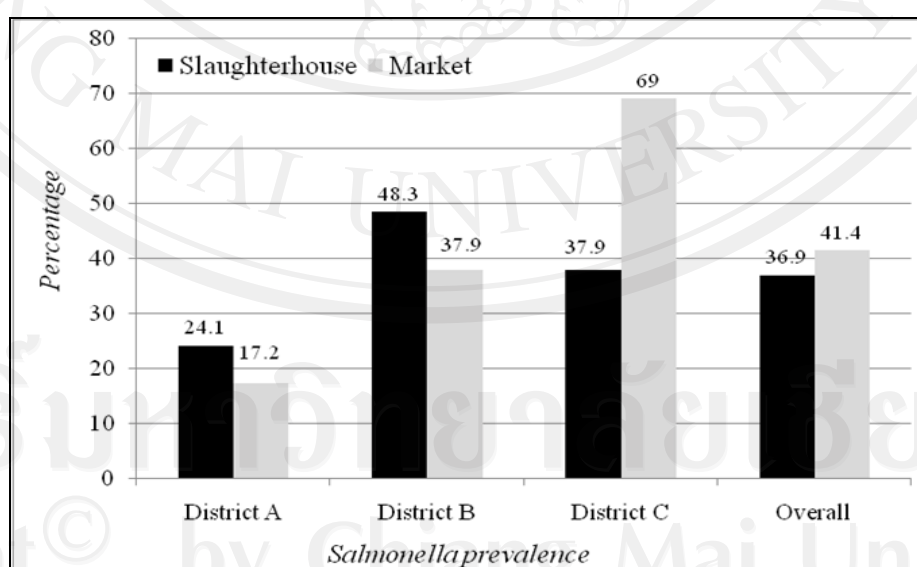


A= Van Lam, B= Van Giang, C= My Hao

**Figure 1** *Salmonella* prevalence in pig slaughterhouse and market in 3 districts

### 4.2 *Salmonella* number

#### 4.2.1 *Salmonella* number in pig slaughterhouses

The highest number of *Salmonella* on carcass and cutting boards was less than 0.075 MPN/cm$^2$ and 1.2 MPN/cm$^2$, respectively, and less than 0.3 MPN/g from belly skin samples. *Salmonella* enumeration from workers' hands ranged from 0 to 7.0 MPN/hand (Table 9).

**Table 4** *Salmonella* number from different sample types in 3 slaughterhouses

| Sample types | Unit | No. of *Salmonella* | 95% CI |
|---|---|---|---|
| Carcass surface | MPN/cm$^2$ | < 0.075 | 0.0 - 0.24 |
| Belly skin | MPN/g | < 0.3 | 0.0 - 0.95 |
| Workers' hands | MPN/hand | 0 - 7.0 | 0.0 - 50.0 |
| Cutting boards | MPN/cm$^2$ | < 1.2 | 0.0 - 3.80 |

#### 4.2.2 *Salmonella* number in pork market

The numbers of *Salmonella* the market are shown in Table 10. The number ranged from less than 0. 3 MPN/g to 15 MPN/g (on pork). The highest numbers of *Salmonella* (detected on sellers' hands) was 4.6 MPN/hand and 0.368 MPN/cm$^2$ (on cutting boards).

**Table 5** *Salmonella* numbers from different sample types in market in 3 districts

| Sample types | Unit | No. of *Salmonella* | 95% CI |
|---|---|---|---|
| Pork | MPN/g | < 0.3 - 15 | 3.7 - 42.0 |
| Sellers' hands | MPN/hand | 4.6 | 0.7 - 19.0 |
| Cutting board | MPN/cm$^2$ | 0.368 | 0.056 - 1.52 |

**4.2.3 Compare *Salmonella* MPN in pig slaughterhouses and pork market**

Table 11 shows *Salmonella* MPN on pork samples had a wider range (from < 0.3 to 15 MPN/g) compare to carcass samples (<0.3 MPN/g). *Salmonella* MPN detected from sellers' hands (0 - 4.6 MPN/hand) was relatively lower than on workers' hands (0 - 7 MPN/hand). *Salmonella* MPN found on cutting board at slaughterhouse was higher than finding in cutting board at the market.

**Table 6** *Salmonella* number in pig slaughterhouses and pork market from difference sample types

| Sample | Unit | Number of *Salmonella* | |
| --- | --- | --- | --- |
| | | **Slaughterhouses** | **Markets** |
| Carcass - Pork | MPN/g | < 0.3 | < 0.3 - 15 |
| Worker - Seller hands | MPN/hand | 0 - 7.0 | 4.6 |
| Cutting boards | MPN/cm$^2$ | < 1.2 | < 0.368 |

Table 12 describes the change of *Salmonella* MPN on carcasses and pork samples. In general, from carcass to pork sample, there was an increase in the number of *Salmonella*. Sample number 141 shows an increase of *Salmonella* MPN from less than 0.3 MPN/g to 2.3 MPN/g.

**Table 7** Change of *Salmonella* MPN during 2 consecutive sampling occasions

| Sample ID | Carcasses at slaughterhouses | | Pork at markets | |
| --- | --- | --- | --- | --- |
| | No. of *Salmonella* | 95% CI | No. of *Salmonella* | 95% CI |
| **101** | <0.3 MPN/g | 0.0 - 0.95 | <0.3 MPN/g | 0.0 - 0.95 |
| **113** | <0.3 MPN/g` | 0.0 - 0.95 | Not enumerate | Not enumerate |
| **141** | <0.3 MPN/g | 0.0 - 0.95 | 2.3 MPN/g | 0.46 - 9.4 |
| **173** | <0.075 MPN/cm$^2$ | 0.0 - 0.24 | <0.3 MPN/g | 0.0 - 0.95 |
| **174** | <0.075 MPN/cm$^2$ | 0.0 - 0.24 | 0.92 MPN/g | 0.14 - 3.8 |

**4.3 Risk factors for *Salmonella* contamination**

**4.3.1 Risk factors for *Salmonella* contamination in pig slaughterhouses**

From observation at 3 slaughterhouses, differences in practice as well as management were obtained. Table 13 shows the potential risk factors that might lead to *Salmonella* positive on pig carcass samples. In this study, there were none of those potential factors in 3 slaughterhouses that were statistically significant. "Time arrived at lairage (in the morning/afternoon)" or "Disease in farm area (in 6 months recently) (yes/no)". That might indicate a risk of getting *Salmonella* contamination on pig carcass 5 or 10 time higher, respectively.

**Table 8** Risk factors determination related to *Salmonella* "qualitative" and observation in slaughterhouses

| Factors | OR (95% CI) | *p* -value |
| --- | --- | --- |
| Using water tank | 2.18 (0.67 - 7.07) | 0.191 |
| Slaughter square area ($\leq 50$ m$^2$) | 1.67 (0.57 - 4.95) | 0.35 |
| Free entry slaughter area | 2.18 (0.67-7.07) | 0.191 |
| Private farm type | 2 (0.29 - 13.74) | 0.631 |
| Pig transport distance (> 30 km) | 1.33 (0.2 - 9.08) | 1.00 |
| Time arrived at lairage (in the morning/afternoon) | 5.7 (0.53 - 61.41) | 0.179 |
| Disease in farm area (in 6 months recently) | 10.5 (1.03 - 107.2) | 0.063 |
| Number of pigs on processing at the same time (>2 pigs) | 1.2 (0.41 - 3.66) | 0.709 |

### 4.3.2 Risk factors of *Salmonella* contamination in pork markets

Table 14 shows the results of combination *Salmonella* "qualitative" and observation at pork markets to identify risk factors of *Salmonella* contamination. Four risk factors were significantly associated to *Salmonella* positive (wood table surface, using bucket water, cutting on table surface and selling both retail and wholesale).

**Table 9** Risk factors determination related to *Salmonella* "qualitative" and observation in pork markets

| Factors | OR (95% CI) | *p* -value |
|---|---|---|
| Table surface pork contaced is wood | 6.6 (2.02 - 21.55) | *0.002\** |
| Table surface pork contaced is inox/steel | 0.19 (0.02-1.7) | 0.223 |
| Usually use insect control equipments while selling | 1.76 (0.6 - 5.23) | 0.303 |
| Using meat grinder | 2.41 (0.8 - 7.22) | 0.113 |
| Using bucket (mobile) water in shop | 4.46 (1.46 - 13.65) | *0.007\** |
| Cutting on table surface | 4.46 (1.46 - 13.65) | *0.004\** |
| Shop sells retail only | 0.48 (0.17 - 1.38) | 0.170 |
| Shop sells both retail and wholesale | 4.71 (1.28 - 17.27) | *0.030\** |
| Contain pork in basket to transport to the shop | 2.8 (0.98 - 8.0) | 0.052 |
| Wash table end of selling time by water and detergent | 0.44 (0.1 - 1.84) | 0.326 |

(\*): Statistically significance

### 4.4 *Salmonella* serotypes

### 4.4.1 *Salmonella* serotypes in pig slaughterhouses

Table 15 shows *Salmonella* serotypes circulating in 3 slaughterhouses (31 serotypes poly I and 1 serotype poly II). Within 31 serotypes poly I, *S.* Typhimurium and *S.* Derby dominated 19.4 %, followed by *S.* Rissen (16.1%). All serotypes presence in slaughterhouse were mostly found on pig carcass. *S.* Derby, *S.* Meleagridis and *S.* Rissen were detected on all 3 sample types.
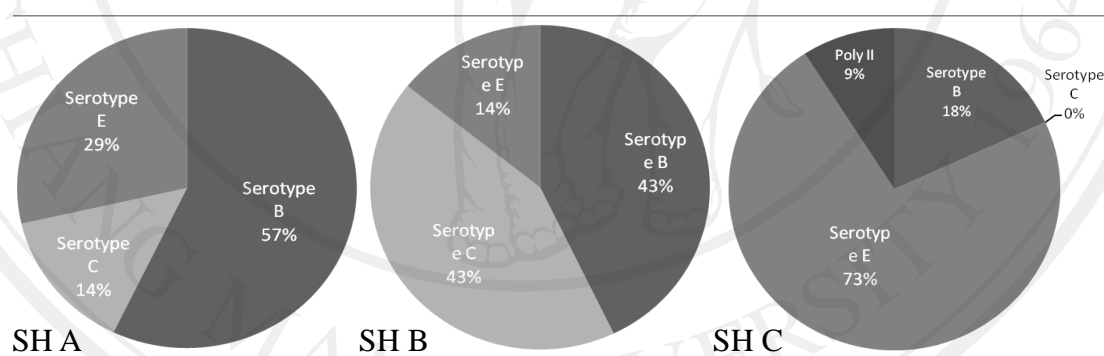
**Table 10** *Salmonella* serotypes circulated in 3 pig slaughterhouses and sample types

| Serotype | Carcass | Workers hands | Cutting board | Total | Percentage |
|---|---|---|---|---|---|
| *S.* Anatum | 1 | | | 1 | 3.2 |
| *S.* Derby | 3 | 2 | 1 | 6 | 19.4 |
| *S.* Give | 1 | 1 | | 2 | 6.5 |
| *S.* London | 4 | | | 4 | 12.9 |
| *S.* Meleagridis | 2 | 1 | 1 | 4 | 12.9 |
| *S.* Rissen | 2 | 2 | 1 | 5 | 16.1 |
| *S.* Typhimurium | 5 | | 1 | 6 | 19.4 |
| *S.* Weltevreden | 3 | | | 3 | 9.7 |
| *Total Poly I* | | | | *31* | *100* |
| *Poly II* | | | | *1* | |

Table 16 shows *Salmonella* serotypes found in the 3 slaughterhouses. *S.* Typhimurium was the highest rate in slaughterhouse A, *S.* Derby and *S.* Rissen dominated in slaughterhouse B and *S.* Meleagridis and *S.* Weltevreden were mostly found in slaughterhouse C. Figure 8 illustrates the detected *Salmonella* groups (poly I (B, C, E) and poly II) in the 3 slaughterhouses. Group E was dominant in slaughterhouse C. Group B, C, E were detected in the both slaughterhouse A and B.

**Table 11** *Salmonella* serotypes circulated in each of the 3 slaughterhouses

| Serotype | SH A | SH B | SH C |
|----------|------|------|------|
| *S.* Anatum | | 1 | |
| *S.* Derby | | 6 | |
| *S.* Give | 2 | | |
| *S.* London | | 3 | 1 |
| *S.* Meleagridis | | | 4 |
| *S.* Rissen | 1 | 4 | |
| *S.* Typhimurium | 4 | | 2 |
| *S.* Weltevreden | | | 3 |
| *Poly II* | | | 1 |
| *Total* | 7 | 14 | 11 |



**Figure 2** *Salmonella* group circulated in the 3 slaughterhouses

SH= Slaughterhouse;  A = Van Lam, B = Van Giang, C = My Hao

**4.4.2 *Salmonella* serotypes in the market**

Table 17 shows the distribution of *Salmonella* serotypes in pork markets. Nine serotypes circulated in pork markets with the highest presence on pork samples. The most frequent serotype was *S.* Derby (19.4%), followed by *S.* Anatum and *S.* Meleagridis (16.7%).

**Table 12** Distribution of *Salmonella* serotypes in the markets

| Serotype | Pork | Sellers hands | Cutting boards | Total | Percentage |
|---|---|---|---|---|---|
| *S*. Anatum | 4 | 1 | 1 | 6 | 16.7 |
| *S*. Bovismorbificans | | 1 | 1 | 2 | 5.6 |
| *S*. Derby | 6 | 1 | | 7 | 19.4 |
| *S*. Give | 1 | | | 1 | 2.8 |
| *S*. London | 4 | | 1 | 5 | 13.9 |
| *S*. Meleagridis | 4 | 1 | 1 | 6 | 16.7 |
| *S*. Rissen | 4 | | 1 | 5 | 13.9 |
| *S*. Stanley | 2 | | | 2 | 5.6 |
| *S*. Weltevreden | 2 | | | 2 | 5.6 |
| **Total** | | | | **36** | **100** |

Table 18 shows *S*. Anatum, *S*. Derby and *S*. Meleagridis as mostly found serotypes in the market in district C. *S*. Rissen was high in the market in district B. *S*. Anatum was present in all the three districts. Figure 5 shows *Salmonella* group E dominated in the market in district C. Group B, C and E distributed the same proportion in the market in district B.

**Table 13** *Salmonella* serotypes presence in pork markets of each district

| Serotype | District A | District B | District C |
|---|---|---|---|
| *S*. Anatum | 1 | 1 | 4 |
| *S*. Bovismorbificans | 2 | | |
| *S*. Derby | | 2 | 5 |
| *S*. Give | 1 | | |
| *S*. London | | 2 | 3 |
| *S*. Meleagridis | 1 | | 5 |
| *S*. Rissen | | 4 | 1 |
| *S*. Stanley | | 2 | |
| *S*. Weltevreden | | | 2 |
| **Total** | **5** | **11** | **20** |

District A                    District B                    District C
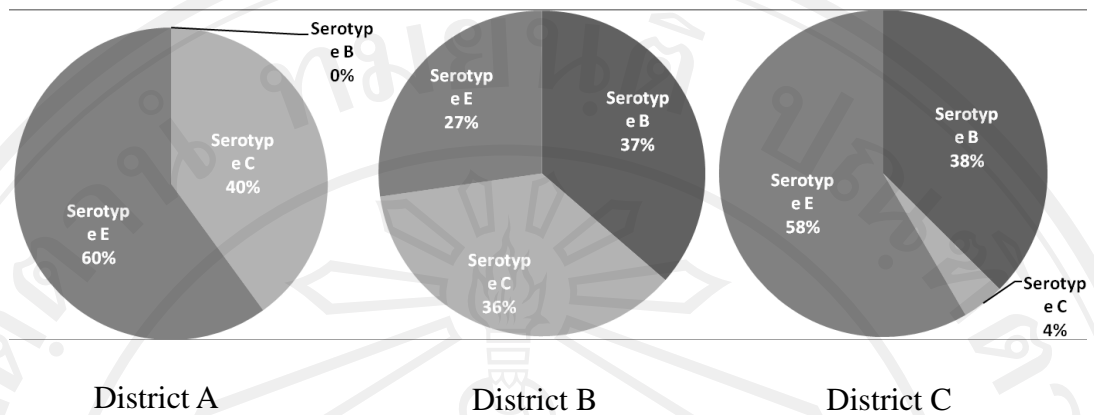
**Figure 3** *Salmonella* groups in the market in 3 districts

District A = Van Lam, B = Van Giang, C = My Hao

**4.4.3 Compare *Salmonella* serotype in pig slaughterhouses and pork market**

*S.* Derby, *S.* Rissen and *S.* Meleagridis were detected from all carcasses, pork, environment samples and dominated the other serotypes. *S.* Bovismorbificans and *S.* Stanley were only present at the market, *S.* Typhimurium was only found in slaughterhouse (Table 19 and Figure 6).

**Table 14** *Salmonella* serotypes prevalence in slaughterhouses and markets

| Serotype | Carcass-SH | Environment-SH | Pork-MK | Environment-MK | Total |
|---|---|---|---|---|---|
| *S.* Anatum | 1 | | 4 | 2 | **7** |
| *S.* Bovismorbificans | | | | 2 | **2** |
| *S.* Derby | 3 | 3 | 6 | 1 | **13** |
| *S.* Give | 1 | 1 | 1 | | **3** |
| *S.* London | 4 | | 4 | 1 | **9** |
| *S.* Meleagridis | 2 | 2 | 4 | 2 | **10** |
| *S.* Rissen | 2 | 3 | 4 | 1 | **10** |
| *S.* Stanley | | | 2 | | **2** |
| *S.* Typhimurium | 5 | 1 | | | **6** |
| *S.* Weltevreden | 3 | | 2 | | **5** |
| **Total** | **21** | **10** | **27** | **9** | **67** |
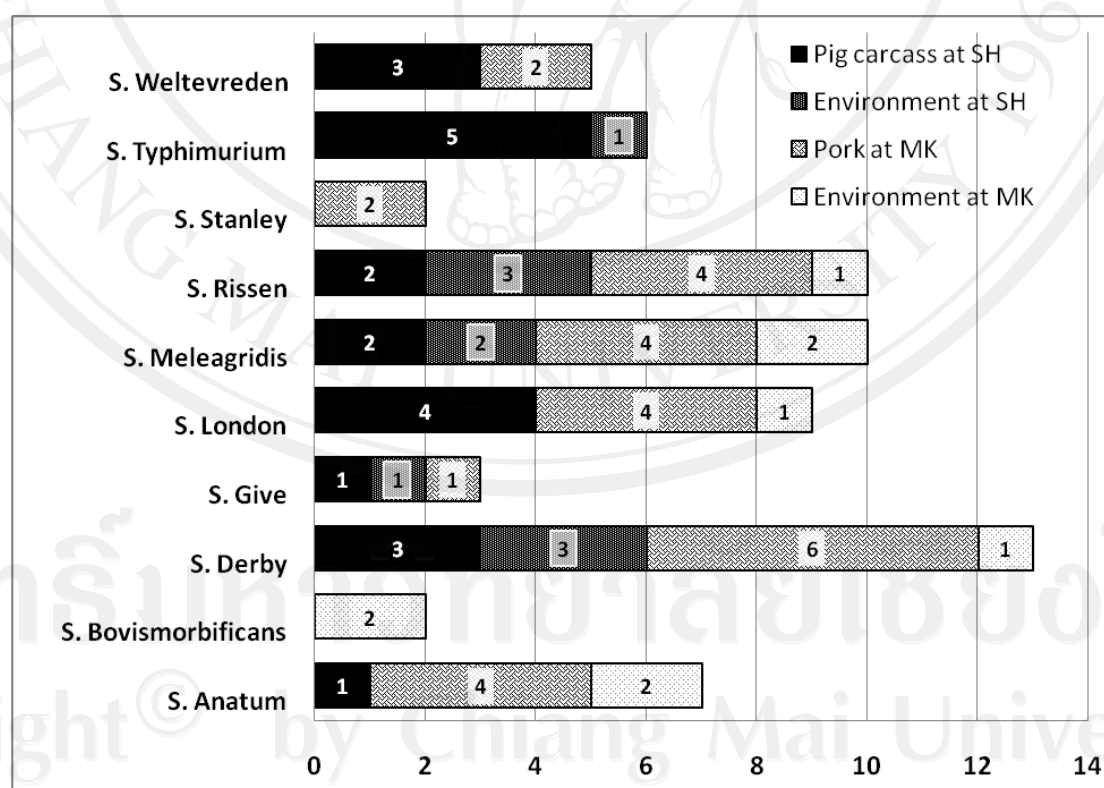


**Figure 4** *Salmonella* serotypes prevalence in slaughterhouses and markets

SH = Slaughterhouse, MK= Market

### *4.4.4 Results of following carcasses in 2 consecutive sampling occasions*

We followed 26 swabbed carcasses from slaughterhouse to the market in order to collect pork samples again. Figure 7 shows the changes of *Salmonella* positive and negative samples. There were 8 positive and 18 negative carcass samples at slaughterhouse. From 8 positive carcass samples, 5 pork samples were positive again and 3 were negative. From 18 negative carcass samples, 4 samples were positive and 14 samples stayed negative.
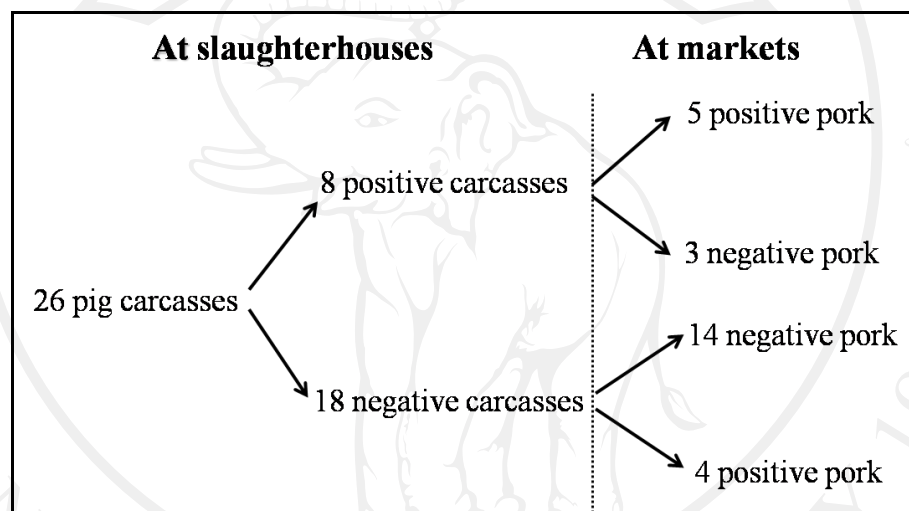


**Figure 5** Change of *Salmonella* positive and negative samples during 2 consecutive sampling occasions

Table 20 shows *Salmonella* serotypes of 5 positive cases during 2 consecutive sampling occasions. Only one sample (ID 173) had the same serotype from carcass to pork, other samples were not the same serotype.

**Table 15** *Salmonella* serotypes of positive carcass and positive pork from the same individual

| Sample ID | *Salmonella* serotype | |
|:---:|:---:|:---:|
| | **Carcass** | **Pork** |
| 101 | Derby | Stanley |
| 113 | Rissen | Meleagridis |
| 141 | London | Weltevreden |
| 173 | Meleagridis | Meleagridis |
| 174 | Meleagridis | Anatum |

**4.5 Quantitative and qualitative findings related to food safety**

Aside from laboratory results, perception and practice behaviors related to food safety in relevant groups were also investigated. Those were done by using qualitative and quantitative approaches. This qualitative approach included focus group discussions (FGD) and in-depth interviews (IDI). The quantitative approach included questionnaire and observation at slaughterhouse / slaughterhouse owners and pork shop using a developed checklist. Subjects in the pork production chain (slaughter workers, pork sellers and consumer) and stakeholders (people living around slaughterhouse, veterinary staff) were selected for the FGD and IDI. An overview on tools used, groups included and key topics is provided in Table 21. In addition, common issues related to human, animal and environmental health interaction for better situation understanding were used in the analysis.

General information about participants and interviewees in the three studied districts such as education, gender and age were recorded (details see Appendix 4). Education of all participants were secondary school or higher. Males are mostly

observed in slaughterhouse worker groups, whereas mostly females were observed in sellers groups. Most participants were older than 30 years old.

**Table 16** Tools used, groups involved and key topics investigated

| **Quantitative tools** | |
| --- | --- |
| *Questionnaire* | *Key topics* |
| Pig origin questionnaire (12)* | - Slaughter pigs, transport and quarantine information |
| *Observation* | |
| Pig slaughterhouse (3) | - Slaughterhouse (lairage, facilities) management |
| | - Hygiene practice in slaughtering and waste manage |
| Pork shop (19) | - Equipment and facilities |
| | - Hygienic status and practice |
| **Qualitative tools** | |
| *Focus group discussion* | *Key topics* |
| Slaughter workers (2 FGD) | - Hygienic practice in slaughtering |
| | - Perception, knowledge about pork borne diseases |
| Pork sellers (3 FGD) | - Pork selling practice |
| | - Pork borne diseases (knowledge, awareness, perception) |
| *In-depth interview* | |
| People living around slaughterhouse (9 IDI) | - Advantages and disadvantages of slaughterhouse in the area |
| Pork consumer (9 IDI) | - Criteria for selecting pork |
| | - Pork borne diseases (knowledge, awareness, perception) |
| Public health staff (3 IDI) | - Food safety management and collaboration |
| Veterinary staff (3 IDI) | - Food safety management and collaboration |

\* Repeatedly applied at 4 consecutive visits of 3 slaughterhouses

**4.5.1 Results on slaughterhouse and market checklists and questionnaires**

*4.5.1.1 Results from checklists and questionnaires in slaughterhouses*

Data collection at slaughterhouse level was conducted at the 3 investigated slaughterhouses including questionnaires (on pig origin, transportation and lairage) and observation checklists (hygienic practice and slaughterhouse management). The capacity of the three slaughterhouses ranged from 10 to 40 pigs per day with 4 to 6 permanent workers. Slaughtering was operated mostly in the early morning, from 1 am till 6 am. Results of observation are shown in Table 22.

**Table 17** Observation on hygienic practice and slaughterhouse management

| Observation | Yes/All |
| --- | --- |
| Slaughter area poses to lairage without hygienic measures | 3/3 |
| Pigs entry lairage in separate way | 1/3 |
| Slaughterhouse in the same compartment with the house | 2/3 |
| Using disinfection matrices in slaughterhouse | 0/3 |
| Slaughter on the floor | 3/3 |
| Evisceration by experience workers | 3/3 |
| Carcass and internal organs are separated directly | 1/3 |
| Workers wear apron | 0/3 |
| Workers wear uniform | 0/3 |
| Workers wear boots | 3/3 |
| Separate workers in each stage of slaughtering | 0/3 |
| Using tank water for washing carcass and floor | 2/3 |
| Washing floor after slaughtering each pig | 0/3 |
| Washing knife, hook, hand after each pig | 0/3 |
| Slaughter floor is usually washed after each pig | 1/3 |
| Use cloth for wiping carcass and hand/equipments | 3/3 |
| People can freely walk on every slaughter areas | 2/3 |
| Present of meat inspectors/vet authority officers | 1/3 |
| Solid waste is put into public garbage areas | 1/3 |

Related to hygienic practice, slaughter and processing in these slaughterhouses was done on the floor with limited separation areas for bleeding, scalding, or dehairing. All 3 slaughterhouses had an experienced worker assigned for evisceration.

In 2 slaughterhouses, water was stored in an open water barrel and used to wash the floor, carcasses, hands and equipments. The other slaughterhouse used pipe water directly to wash the floor, carcasses, and hands. In the 3 slaughterhouses, waste was used to produce biogas. Related to *biosecurity*, all slaughterhouses practiced to buy pig from single origin herds, which were then slaughtered over the following days before pigs from other origin would be introduced. No abnormal clinical signs (e.g. thin or sick pigs) were observed at any time of the slaughterhouse visits in the lairage. Related to h*ygienic measures,* one slaughterhouse had a separate entrance for pigs, but in all slaughterhouses selected, people could access freely into the slaughter area. Workers frequently wear boots; however uniforms or aprons were never used.

Results from questionnaires and recording sheets focused on variables linked to pig origin, transportation and lairage time. These information included data on time, duration and distance of transport, production system, trace back, disease situation, and quarantine. Results are summarized in Table 23.

**Table 18** Mean of variables recorded for pig transportation and lairage time

| Variables | Unit | n | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| No. of pig transport/time | head | 12 | 23 | 7 | 17 | 40 |
| Transport duration | hour | 12 | 1.76 | 1.24 | 0.5 | 4.17 |
| Transport distance | km | 12 | 60.8 | 50.4 | 15 | 150 |
| Time arrived at lairage | clock | 12 | 13.9 | 4.17 | 10 | 22 |
| Time spent in lairage | hour | 12 | 13.1 | 4.17 | 5 | 17 |

Number of pigs transported to the slaughterhouse varied from 17 to 40 pigs per time. Transport duration range from 0.5 to 4.17 hours and distance from 15 to 150 km, respectively. The transportation was done by slaughterhouse owners' trucks. Those trucks were specifically designed for live pigs transport containing to avoid droppings or urine within the truck. Quarantine documents are strictly required when shipping pigs from other districts or provinces, but not for transportation within a

district. During transportation, pigs would be checked on the related information (number, source, purchase documents, certificate of quarantine, etc) at checkpoints by local veterinary authorities and/or trade authorities.

### *4.5.1.2 Results from checklists in pork markets*

To determine hygienic practice and conditions at pork markets, 19 pork shops were included in the observation. All sellers were women and sold pork only. Results are presented in Table 24.

All pork shops sold pork retail or both, wholesale and retail. Approximately half of all sellers covered the transported carcass or pork (10/19) while mostly motorbikes were used (18/19). None of them stored the pork for sell in cool cabinets or covered it by any measures. Most of the sellers did not used gloves to handle pork, however they always wore apron. All shops were separate to the sewerage and 8 of them were located at a special area for pork selling only. The tables used in shops were all higher than 60 cm and had a wood surface (7/19), steel surface (7/19), nylon or granite/enamel tile surface (5/19). During selling, all pork shop used cloth to wipe and clean the table or equipment but also either hand.

**Table 19** Observation on hygienic practice and conditions at pork shops

| Observation | Yes/All |
|---|---|
| Pork is put in cool cabinet | 0/19 |
| Pork is covered by equipment | 0/19 |
| Pork is closed or next to internal organs | 0/19 |
| Shop is next to the sewerage | 0/19 |
| Shop sells wholesale only | 0/19 |
| Seller wears gloves | 1/19 |
| Wash table at the end of selling time by water and detergent | 2/19 |
| Wipe hand on apron | 3/19 |
| Shop sells both retail and wholesale | 3/19 |
| Table surface pork contacted is granite/enamel tile | 4/19 |
| Shops' offal is put freely to area around | 4/19 |
| Using bucket (mobile) water in shop | 5/19 |
| Cutting on table surface directly | 5/19 |
| Table surface pork contacted is wood | 7/19 |
| Table surface pork contacted is steel | 7/19 |
| Shop located in the specific area for pork selling | 8/19 |
| Carcass was transported to the shop without covering | 10/19 |
| Using cutting board | 15/19 |
| Shops' offal is put in bin/place for treatment | 15/19 |
| Shop sells retail only | 16/19 |
| Clean table end of selling time by wiping cloth | 17/19 |
| Using wipe cloth during selling time | 18/19 |
| Seller wears apron | 18/19 |
| Pork/carcass was shipped to the shop by motorbike | 18/19 |
| Only pork are sold | 19/19 |
| Table is higher than 60 cm | 19/19 |
| Using wipe cloth for all pork, hand and equipments | 19/19 |

**4.5.2 Focus groups discussions and in-depth interviews.**

*4.5.2.1 Result from focus groups discussions*

*i. Focus groups discussions among slaughterhouse workers:*

FGD were organized in 2 of the 3 slaughterhouses, one slaughterhouse (in My Hao) did not agree to participate.

*(1) Regulations or hygienic Standard Operation Procedure (SOP) followed in slaughtering process:* There were no specific regulations or rules for worker to be followed in their slaughterhouses. But it was the "internal rule", that senior workers would show how to operate to juniors, and then it becomes habit and routine work within the group. They try to keep clean and coordinate the slaughter process in an organized way (e.g. storage of knifes or hook). *"Both slaughter workers and slaughterhouse owner have to have awareness to keep clean and observe hygiene during slaughtering. There was no punishment or regulations, we just remind to each other when one did not do appropriately"* (FGD in Van Lam)

*(2) Training program on food safety and slaughtering process:* One FGD group (Van Giang) mentioned as related to knowledge about food safety or hygienic practices that they learned it by doing from other workers experience, not from training. However, Van Lam group said that they had attended some training programs on food safety that was organized by the province.

*(3) Ranking given potential risks:* Based on their perception and knowledge on practice, some potential risks that might refer to carcass contamination. Among those potential risks, participants were asked to rank them based on their importance. The highest importance was allocated to number 1, 2 and so on to less important (up to 9). Results are presented in Table 25.

**Table 20** Ranking given potential risks to microbial contamination on carcass

| Potential risks | Van lam | Van Giang |
|---|---|---|
| Feces in lairage | 1 | 7 |
| *Feces on live pigs* | *1* | *3* |
| *Puncture intestine* | *2* | *2* |
| Feces on the bleeding area | 2 | 4 |
| Wash intestine at slaughter areas | 2 | 5 |
| *Water source* | *3* | *1* |
| Boots at all places | 6 | 7 |
| *Transport vehicle* | *7* | *9* |
| *Cloths* | *5* | *8* |

Although there were some different responses, both groups emphasized that feces on live pigs, punctured intestines and water source were most important. *"Feces drop on carcass or disrupting intestines are more important in term of contamination to carcass"* (FGD in Van Lam). In contrast, cloths using for carcass dry wiping, transport vehicle, wearing boots at all places were ranked as less important sources in both discussed groups. *"Cloth is the last, because everyone has to wash and keeps it clean every day. So there is no problem. After selling and working day, they use to wash and dry them for the following day"* (FGD in Van Giang).

*(4) Perception, knowledge about pig diseases: Participants in both FGD:* Two groups described that FMD, PRRS, fluke and worm, pig diarrhea are diseases can affect pork quality and safety. Two main important diseases mentioned repeatable were FMD and PRRS.

*(5) Zoonoses knowledge and perception:* Some of them mentioned here cysticercosis and leptospirosis, but were not really concerned. *"There have been risks of leptospirosis or cysticercosis. This was observed a long time ago (4-5 years). Now these trends are fewer than before. However, every year there may have 1 to 2 cases*

*reported"* (FGD in Van Giang). In addition some common animal diseases were considered to have a zoonotic impact such as FMD and PRRS by some respondents.

*(6) Origin of information:* Most information about pig disease and pork borne diseases participants mentioned from mass media, newspaper, internet or television. Veterinary or public health services were not mentioned as a source of information.

*(7) Observed human illness related pig or pork:* There were no observed cases of illness or diarrhea among themselves in last 6 months. They were not much worried about such diseases because they trust in pig companies and in control measures applied there. In addition, they mention to wear masks, gloves, and boots to protect their health, to limit risk in case of suspected diseases pigs. However, own observations did not show any mask and glove to be used during slaughter.

### ii. Focus groups discussions in pork sellers:

FGD were organized in each of 3 selected districts.

*(1) Use of wood surface tables in pork shop:* Most of them mentioned that they prefer and used wood surface tables, even if government helped them to build table with enamel tiles or granite surface. They explained that wood would be easier to clean than tiles or granite. It was also mentioned that the meat will look drier and keep longer fresh when presented on wood tables. *"Table surface can help pork stay dry and keep pork fresher."* (FGD in Van Lam).

*(2) Cloth usually used to dry pork, clean equipment, hand or table:* All three sellers groups stated that they use dry cloth to clean in their selling time. *"It is need to have dried cloth to wipe pork and table to avoid wet, so pork will be less pale and rancid"* (FGD in Van Giang).

*(3) Glove and mask using:* They mentioned about wearing apron, thin gloves, but rarely used mask or protective hat. However, wearing hat, mask and even gloves

may give a perception to buyers that the pork or shop owner might have health problems (skin or respiratory disease) and thus the buyer got scared to buy pork. "*Buyers even thought that my hands might have some problem when using gloves*" (FGD in Van Giang).

*(4) Leftover pork:* All 3 groups said that they would sell it for the shop which served meals for people or sell at a relatively lower price. In Van Giang and Van Lam, the remained pork could be processed into other foods (such as: "nem chạo" –boiled pork/skin with roasted rice powder, or "giò thủ"- mix cooked pork with spicy) then sell to consumers.

*(5) Ranking on perception of potential risk factors to pork contamination:* Ranking results are presented in Table 26 (1 is the most important, 8 is less important)

**Table 21** Ranked potential risk factors related to microbial contamination on pork at market (only done in two locations)

| Potential risks | Van lam | My Hao |
|---|---|---|
| Cleanness of surrounding shop area | 1 | 4 |
| Insects (files, bluebottle, ant, cockroach) | 2 | 5 |
| *Dirty /waste water drain next to shop* | *2* | *2* |
| *Cleanness of table surface* | *3* | *1* |
| Water for wash hand, knife, table | 4 | 4 |
| Bags - Basket (pork transport) | 5 | 3 |
| Cloths used many times in selling day | 6 | 2 |
| Pork transportation to the market | 7 | 3 |
| *Clothes, shoes of sellers* | *8* | *6* |

Although some differences between both FGD groups exist, *Cleanness of table surface* and *Dirty /waste water drain next to shop* as well as *The cleanness of*

*surrounding shop area* ranged highest. Both groups ranked: *Bags - Basket (for pork transport), Pork transportation to the market* and *Water for wash hand, knife, and table* in the middle. *Clothes, shoes of sellers* were listed as less important as related to risk of microbial contamination in pork.

*(6) Pork quality and zoonoses:* All of three groups mentioned that the pork quality was strongly related to the slaughtered pig and the way of slaughtering. It was seen as a very critical point. *"Focusing on pig restraint and slaughter, if we struggle with the pig long time, the pork did not have good quality"* (FGD in Van Giang). In summer, pork was quicker to become rancid than in winter.

Relevant pig diseases including zoonoses considered by all three FGD groups were PRRS and FMD, classic swine fever, pastuerellosis, leptospirosis. Two FGD stated leptospirosis, FMD and classic swine fever as potential zoonoses and one other group did not know any information about it.

*(7) Observed human illness related pig or pork:* None of the participants (3 FGD) stated that they and their family members have been affected with any disease related to pigs or had symptoms after consuming pork during recent 6 months or even 1 year.

### 4.5.2.2 Result from in-depth interviews

### i. In-depth interview in people living around slaughterhouse:

Around each of 3 slaughterhouses, we selected 3 households to present this group. In each household, one adult was interviewed.

*(1) Advantages of slaughterhouse's presence in their living area*: Most of interviewees refer to advantages of slaughterhouse's presence as providing job, more convenience to buy fresh pork and create business opportunities (Table 27). Three respondents in My Hao said pig slaughterhouses created a "trade village" that

produces much pork for markets. Pork was distributed to markets around therefore people can buy easier and fresher. *"Slaughterhouse here provides pigs and pork sources for butchers and pork sellers, no need to go far. Slaughterhouse creates work for some workers."* (A 57 years old man in Van Giang).

**Table 22** Advantages of slaughterhouse's presence (Yes/Total)

| Issues | All | Van Lam | Van Giang | My Hao |
|---|---|---|---|---|
| Provide labors | 9/9 | 3/3 | 3/3 | 3/3 |
| Available pork to buy | 7/9 | 1/3 | 3/3 | 3/3 |
| Business opportunities | 4/9 | 0/3 | 1/3 | 3/3 |
| Benefit for you | 0/9 | 0/3 | 0/3 | 0/3 |

*(2) Disadvantages of slaughterhouse's presence in their living area:* Some disadvantages pointed out through interview are presented in Table 28. Referring to noise, all respondents mentioned that they got familiar with the presence of slaughterhouse and so the noise is not much disturbing. *"No disadvantage, don't know due to sleep deeply, environment around is normal. The noise was negligible"* (51 years old man in Van Lam). Three out of nine interviewees said that the presence of the slaughterhouse could cause smell, polluted water, and animal disease spread. Among those disadvantages, impact on human health was mention by 5 out of 9 interviewees. *"Sometimes in summer, hot and humid, smell might raise and then inhale into respiratory or heavy rain could stagnate the dirty water, so that might cause itch on people's hands, foots"* (42 years old man in Van Lam).

**Table 23** Disadvantages of slaughterhouse's presence (Yes/Total)

| Issues | All | Van Lam | Van Giang | My Hao |
|---|---|---|---|---|
| Noise | 0/9 | 0/3 | 0/3 | 0/3 |
| Polluted environment | 1/9 | 1/3 | 0/3 | 0/3 |
| Dust | 1/9 | 0/3 | 1/3 | 0/3 |
| Polluted air | 2/9 | 2/3 | 0/3 | 0/3 |
| Flies/Mosquitoes | 2/9 | 0/3 | 1/3 | 1/3 |
| Smell | 3/9 | 1/3 | 0/3 | 2/3 |
| Polluted water | 3/9 | 2/3 | 0/3 | 1/3 |
| Animal disease spread | 3/9 | 2/3 | 0/3 | 1/3 |
| Health effect | 5/9 | 2/3 | 1/3 | 2/3 |

***ii. In-depth interview in pork consumer:***

We selected 9 consumers from the 3 districts, with 3 consumers in each district.

*(1) Pork selection criteria:* Interviewees were asked to make a score (from 1-lowest to 10-highest importance) to rank the importance when selecting pork purchased for home consumption. Table 29 shows the results for scoring, sorted from high to low (mean). Specific ranks for each respondent are presented in the Appendix 4.

**Table 24** Result of criteria ranking in pork selection

| Criteria | Number of respondents | Mean ± SD |
|---|---|---|
| Bright red, soft and sticky | 9 | 9.6 ± 0.7 |
| Freshness, good smell | 9 | 9.6 ± 0.5 |
| Cleanness | 9 | 9.1 ± 0.8 |
| Trust on seller | 9 | 9 ± 1.1 |
| Considered as safe meat | 9 | 8.9 ± 0.9 |
| Good storage | 9 | 8.6 ± 1.8 |
| Nutritional value | 9 | 8.2 ± 2.0 |
| Pork inspection document | 9 | 8 ± 1.7 |
| Accessibility | 9 | 7.4 ± 1.7 |
| Price | 9 | 6.6 ± 1.1 |
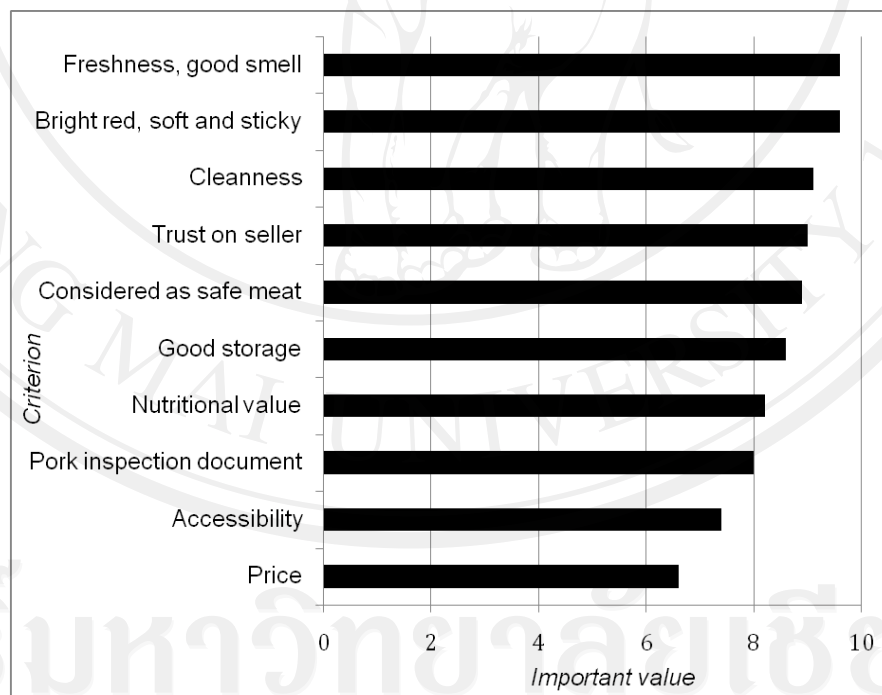


**Figure 6** Result of criteria ranking in pork selection

According to the scores, the most important criteria to select pork were "*bright red, soft and sticky*" followed by "*freshness and good smell*". Other high scores were "*trust on pork seller*" and "*cleanness*". In contrast, the lowest important criteria were

"*price*" and "*accessibility*". Three out of nice (3/9) interviewees marked *"good storage"* as a lowest important criterion. *"I will not choose pork that was too much lean. The most important is natural, bright red color of pork"* (A 50 years old woman in Van Lam).

*(2) Perception on low quality pork:* Five out of 9 interviewees responded that less safe pork might have been originated from sick or dead pigs. Most of interviewees said that less safe pork might have strange color, smell badly or look wet. *"Pork from sick pig (FMD, PRRS); pork is less fresh, bad smell, rancid…"* (A 35 years old woman in Van Lam) and *"Pork color is pale, strange smell, and feel wet when touching pork"* (A 58 years old woman in My Hao).

*(3) Knowledge on zoonoses:* 7 out of 9 mentioned at least one zoonotic disease. They described diseases such as cysticercosis, Streptococcus suis, leptospirosis, anthrax, or diarrhea in pig. One interviewee mentioned not knowing any such diseases, and one other mentioned PRRS, FMD could affect also humans. *"Cysticercosis caused teania disease in human due to eating effected cysticercosis pork. Prevention: when buying has to see the pork, cut have no dot look like white rice seed in meat."* (A 51 years old man in Van Lam). *"Streptococcus, via eating, contact, prevent: don't eat raw pork, blood, or not well done internal organs, do not contact with raw pork if having scratch on skin (hand)"* (A 38 years old woman in My Hao).

*(4) Observed human illness related pig or pork*: Almost all interviewees stated that no cases of illness or diarrhea were observed from eating pork, pork products in their family in the recent 12 months. One interviewee mentioned that her 3 years old daughter got once diarrhea, after pork consumption but she didn't know clearly about the cause.

***iii. In-depth interview public health staff:***

One public health staff from each the 3 sampled districts was selected. Two of

them are at district health care center, and the other is at commune health care station.

*(1) Responsibilities related to food safety, zoonoses:* All of 3 interviewees said that their responsibilities were on "cooked food" (other raw meat was under veterinary authorities' duty). Their main duties included:

- Regularly follow and apply the regulation, direction or documentation of upper level for implementation or management of food borne diseases and zoonoses.

- Observe, check other food centers, restaurant, food processing shops or plants to apply regulation, guideline on food safety.

- Require health certificate of workers, sellers related to food such as gloves, wash hand, mask, apron, health check, etc.

- Taking care of training, guide, assist food shop, restaurants, food centers or canteen in factories, etc. on food safety and hygienic practice.

*(2) Collaboration on food safety, zoonoses management:* Three interviewees responded about reporting and updating within sector, district or provincial authorities. They had regular meetings (monthly, 2 months/time, events or festivals, especially on *"Food safety action month,* annually", etc).

Two of them said that the collaboration with other sectors such as Agriculture department, Veterinary station, Commercial department, Trade department, and police, etc. was effective. *"The collaboration is becoming uniform, well interacts"* (53 years old man in My Hao). However, one interviewee mentioned that there was still need for further strengthening and collaboration. *"The collaboration among agencies still need to be improved and well organized and lead from higher to lower level"* (43 years old woman in Van Lam)

***iv. In-depth interview veterinary staff:***

The same number with public health staff groups, total 3 vets of 3 selected districts were interviewed.

*(1) The gap in the inspection:* Three interviewees mentioned that food safety management responsibilities are divided by public health and vets sector: Raw meat or undercook food is under inspection of veterinary authorities, and cooked food is under health care sectors. Inspection duties of veterinary include transportation, slaughterhouse, market and raw meat processing. All 3 interviewees said that they mostly cover inspection duties in big or medium slaughterhouses (more than 10-20 slaughter pigs/days) and not frequently for small or private butchers (less than 10 pigs and "farm" slaughter). *"At slaughterhouse level, it cannot be sure for 100% that all pigs were under inspection at slaughterhouse; 80-90% is a good number. The government still has difficulties to take care of that duty"* (A 36 years old veterinarian).

*(2) Collaboration on food safety, zoonoses management:* Three interviewees emphasized the collaboration was under a task force team which involved public health, commercial, trade management, veterinary, environment, police, etc... This task force team operated depending on situation or "problem based" or in occasion of the "*Food safety action month*".

Two interviewees ensured that the collaboration among professional sectors (health care, veterinary, agriculture, environment, trade…) is more effective. *"More effective, because if there had just vet authorities, will not have enough power and impact to manage the work which related to many sectors."* (A 36 years old veterinarian). However, other interviewed veterinarians expressed their opinion that the effectiveness of collaboration needs to improve, have to have action plans together as well as set up a good mechanism for implementation and management.