FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Prevalence of *Salmonella* spp. and *Staphylococcus aureus* in chicken and pork meat from Cambodian markets

SAFE FOOD, FAIR FOOD FOR CAMBODIA PROJECT
Rortana Chea
National of Animal Health and Production Research Institute (NAHPRI)

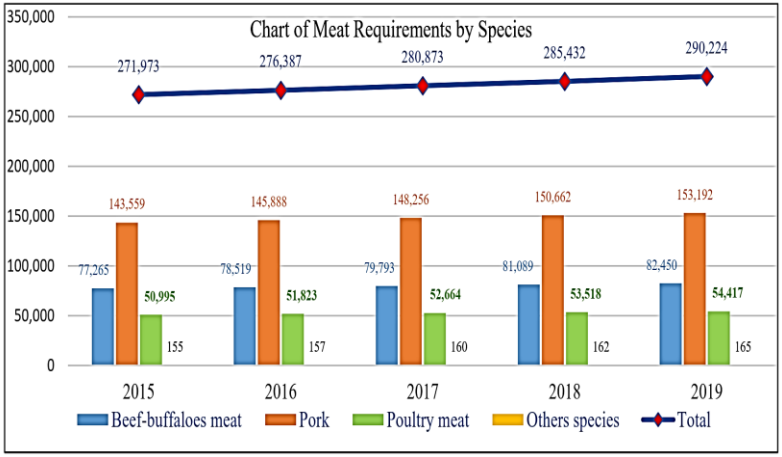
Project final workshop
Phnom Penh, 21–22 June 2021

USAID FROM THE AMERICAN PEOPLE

EMORY UNIVERSITY · ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE · CGIAR · UF IFAS UNIVERSITY of FLORIDA

Key facts

- Foodborne diseases (FBDs) are the illness conditions caused by the ingestion of food containing biological, chemical, or physical hazards.
- *Salmonella* is 1 of 4 key global causes of diarrheal diseases.
- The recent estimation of cost of illness due to foodborne bacteria was about USD 92 per-episode and 63 USD$ per day (SFFF, 2019),
- Annul net of chicken meat consumption in 2019: 290,224 ton/year (GDAHP, 2019.
- Basic food hygiene practices, such as "cook thoroughly", can help to prevent FBDs.



Objective of this study

- To determine the prevalence of *Salmonella* spp. and *S. aureus* in chicken and pork meat and cutting boards for chicken and pork in Cambodian traditional markets and supermarkets .

Materials and methods

- This cross-sectional study was carried out between October 2018 and August 2019.
- Markets comprised 532 samples from 52 traditional markets and 6 supermarkets in 25 provinces/municipalities of Cambodia.
- Specimen: pork, chicken and swab of cutting boards
- Bacteria pathogen: *Salmonella* and *Staphylococcus*
- Protocols:
  - Detection *Salmonella* species (ISO 6579-1_2017)
  - Most Probable Number of *Salmonella* (Pavic et al., 2010)
  - Enumeration and Detection *Staphylococcus* (ISO-6888-1, 1999)

Sampling and Sample collection

Table 1. Number of samples collected from traditional markets and supermarkets in Cambodia

Sampling round	Chicken meat	Chicken cutting board	Pork cutting board	Pork
Traditional market[1]	156	52	52	156
Repeat sampling[2]	30	10	10	30
Supermarkets[3]	18	-	-	18
Total specimen	**204**	**62**	**62**	**204**
	Total specimen = 532			

[1]Three markets were included in Phnom Penh and Siem Reap, while two markets were included in the other 23 provinces,
[2] The total 80 sample were re-sampling from Battambang, Phnom Penh, Siem Reap, and Sihanoukville.
[3]Four supermarkets in Phnom Penh and two supermarkets in Siem Reap,

Results

Table 2. Prevalence of *Salmonella* spp. and *S. aureus* in chicken, cutting board of chicken, pork and cutting board of pork in Cambodian markets by province.

Provinces/Municipalities	Markets [1]	Total Sample Collected [2]	Total Positive Samples	Number of *Salmonella* Positive Samples (%)					Number of *S. aureus* Positive Samples (%)				
				Chicken	Cutting Board Chicken	Cutting Board Pork	Pork	Average [4] MPN/g	Total Positive Samples	Chicken	Cutting Board Chicken	Cutting Board Pork	Pork
Phnom Penh	3 (2 times)	48	13 (27.1)	8 (44.4)	1 (16.7)	0 (0%)	4 (22.2)	16.1	12 (25.0)	5(27.8)	1 (16.6)	1 (16.6)	5 (27.8)
Siem Reap	3 (2 times)	48	31 (64.6)	14 (77.8)	3 (50.0)	1 (16.7)	13 (72.2)	2.6	12 (25.0)	8 (44.4)	0	0	4 (22.2)
Battambang	2 (2 times)	32	14 (43.8)	4 (33.3)	2 (50.0)	2 (50.0)	6 (50.0)	5.9	10 (31.3)	5 (41.7)	2 (50.0)	0	3 (25.0)
Preah Sihanouk	2 (2 times)	32	18 (56.3)	9 (75.0)	1 (25.0)	2 (50.0)	6 (50.0)	25.4	11 (34.4)	7 (58.3)	0	0	4 (33.3)
Takeo	2	16	8 (50.0)	3 (50.0)	1 (50.0)	1 (50.0)	3 (50.0)	15.7	5 (31.3)	2 (33.3)	1 (50.0)	0	2 (33.3)
Kampong Cham	2	16	5 (31.3)	1 (16.7)	1 (50.0)	0	3 (50.0)	15.0	10 (62.5)	5 (83.3)	1 (50.0)	1 (50.0)	3 (50.0)
Tboung Khmum	2	16	7 (43.8)	2 (33.3)	1 (50.0)	1 (50.0)	3 (50.0)	8.3	6 (37.5)	3 (50.0)	0	0	3 (50.0)
Kep	2	16	10 (62.5)	3 (50.0)	1 (50.0)	0	6 (100)	58.6	4 (25.0)	1 (16.7)	0	0	3 (50.0)
Kampot	2	16	10 (62.5)	3 (50.0)	1 (50.0)	1 (50.0)	5 (83.3)	55.2	5 (31.3)	4 (66.7)	0	0	1 (16.7)
Kampong Speu	2	16	6 (37.5)	3 (50.0)	0	0	3 (50.0)	3.5	11 (68.8)	6 (100)	0	0	5 (83.3)
Kandal	2	16	6 (37.5)	1 (16.7)	1 (50.0)	2 (100)	2 (33.3)	107.5	3 (18.8)	3 (50.0)	0	0	0
Kampong Chhnang	2	16	9 (56.3)	4 (66.7)	2 (100)	0	3 (50.0)	51.5	10 (62.5)	3 (50.0)	2 (100)	1 (50.0)	4 (66.7)
Oddor Mean Chey	2	16	7 (43.8)	3 (50.0)	0	1 (50.0)	3 (50.0)	1.28	0	0	0	0	0
Koh Kong	2	16	0	0	0	0	0	0	3 (18.8)	2 (33.3)	0	0	1 (16.7)
Paillin	2	16	5 (31.3)	3 (50.0)	1 (50.0)	1 (50.0)	0	4.4	4 (25.0)	2 (33.3)	0	0	2 (33.3)
Bantheay Mean Chey	2	16	2 (12.5)	0	1 (50.0)	1 (50.0)	0	0.29	4 (25.0)	2 (33.3)	1 (50.0)	0	1 (16.7)
Pursat	2	16	5 (31.3)	1 (16.7)	2 (100)	1 (50.0)	1 (16.7)	8.6	2 (12.5)	2 (33.3)	0	0	0
Prey Veng	2	16	6 (37.5)	1 (16.7)	0	1 (50.0)	4 (66.7)	1.3	4 (25.0)	4 (66.7)	0	0	0
Svay Rieng	2	16	3 (18.8)	1 (16.7)	1 (50.0)	0	1 (16.7)	15.0	9 (56.3)	3 (50.0)		1 (50.0)	4 (66.7)
Mundulkiri	2	16	13 (81.3)	5 (83.3)	2 (100)	2 (100)	4 (66.7)	2.6	6 (37.5)	2 (33.3)	0	1 (50.0)	3 (50.0)
Ratanakiri	2	16	7 (43.8)	4 (66.7)	0	0	3 (50.0)	2.0	5 (31.3)	2 (33.3)	0	0	3 (50.0)
Steung Treng	2	16	4 (25.0)	1 (16.7)	0	0	3 (50.0)	10.1	8 (50.0)	3 (50.0)	1 (50.0)	1 (50.0)	3 (50.0)
Kratie	2	16	6 (37.5)	2 (33.3)	0	1 (50.0)	3 (50.0)	5.2	8 (50.0)	3 (50.0)	1 (50.0)	1 (50.0)	3 (50.0)
Kampong Thom	2	16	8 (50.0)	3 (50.0)	2 (100)	0	3 (50.0)	106.1	0	0	0	0	0
Preah Vihear	2	16	11 (68.8)	5 (83.3)	2 (100)	1 (50.0)	3 (50.0)	76.6	3 (18.8)	1 (16.7)	1 (50.0)	0	1 (16.7)
Total [3]	52	496	214 (43.1)	84 (45.2)	26 (41.9)	19 (30.6)	85 (45.7)	23.2	155 (31.3)	78 (41.9)	12 (19.4)	7 (11.3)	58 (31.2)

[1] Three markets were included in Phnom Penh (PP) and Siem Reap (SR), regarded as having the highest population, while two were included in the other 23 provinces. [2] The total number of each specimen was different in Phnom Penh and Siem Reap (18 chicken, 6 chicken cutting boards, 18 pork, and 6 pork cutting boards); Battambang (BB) and Preah Sihanouk (PSH) (12 chicken, 4 chicken cutting boards, 12 pork, 4 pork cutting boards), compared to other provinces (6 chicken, 2 chicken cutting boards, 6 pork, 2 pork cutting boards). [3] The total 496 samples included the 80 repeated samples of the 4 provinces/municipalities (PP, SR, BB, PSH) and excluded 36 samples from supermarkets. [4] Samples with MPN/g < 0.3, negative with *Salmonella* spp. were counted as 0, and not included in the average. MPN/g >110 was assigned randomly between 111 and 250 MPN/g for the calculation.

Table 3. The prevalence of *Salmonella* spp. and *S. aureus* in chicken, pork, cutting board pork and cutting board chicken from traditional markets, supermarkets, and variation within one year.

Market Types	Total Positive Sample	Chicken (No. of Positive (%))	Chicken Cutting Board (No. of Positive (%))	Pork (No. of Positive (%))	Pork Cutting Board (No. of Positive (%))	*p*-Value [4]
Traditional Market						
Dry season [1] (n = 416)		n = 156	n = 52	n = 156	n = 52	
Salmonella spp. & *S. aureus*	68	32 (20.5)	5 (9.6)	30 (19.2)	1 (1.9)	0.006
Salmonella spp.	169	63 (40.4)	22 (42.3)	70 (44.9)	14 (26.9)	0.150
S. aureus	144	72 (46.2)	11(21.2)	54 (34.6)	7 (13.5)	<0.001
Wet season [2] (n = 80)		n = 30	n = 10	n = 30	n = 10	
Salmonella spp. & *S. aureus*	9	6 (20.0)	0	3 (10.0)	0	-
Salmonella spp.	45	21 (70.0)	4 (40.0)	15 (50.0)	5 (50.0)	-
S. aureus	10	6 (20.0)	0	4 (13.3)	0	-
Supermarkets [3] (n = 36)		n = 18	-	n = 18		
Salmonella spp. & *S. aureus*	1	0	-	1 (5.6)	-	-
Salmonella spp.	10	3 (16.7)	-	7 (38.9)	-	-
S. aureus	1	0	-	1 (5.6)	-	-
Overall (n = 532)		n = 204	n = 62	n = 204	n = 62	
Salmonella spp. & *S. aureus*	78	38 (18.6)	5 (8.1)	34 (16.7)	1 (1.6)	0.166
Salmonella spp.	224	87 (42.6)	26 (41.9)	92 (45.1)	19 (30.6)	0.249
S. aureus	155/532	78 (38.2)	11 (17.7)	59 (28.9)	7 (11.3)	<0.001

[1] The samples were from 2 markets in each of 23 provinces and 3 markets in Phnom Penh and Siem Reap. [2] The 80 repeated samples in the wet season were only from 4 provinces/municipalities, including Phnom Penh, Siem Reap, Battambong and Preah Shihanouk. [3] The samples were from 4 supermarkets in Phnom Penh and 2 supermarkets in Siem Reap and collected only in the dry season. [4] Chi-square test.

In total, 30.6 to 45.1% of the samples were positive for *Salmonella* spp. and 11.3 to 38.2% were positive for *S. aureus*.

The prevalence of both bacteria in meat samples (chicken and pork) was significantly higher than that on cutting boards used for chicken and pork (*p*-value < 0.001).

The prevalence of *Salmonella* spp. increased during the wet season, while the prevalence of *S. aureus* was the opposite

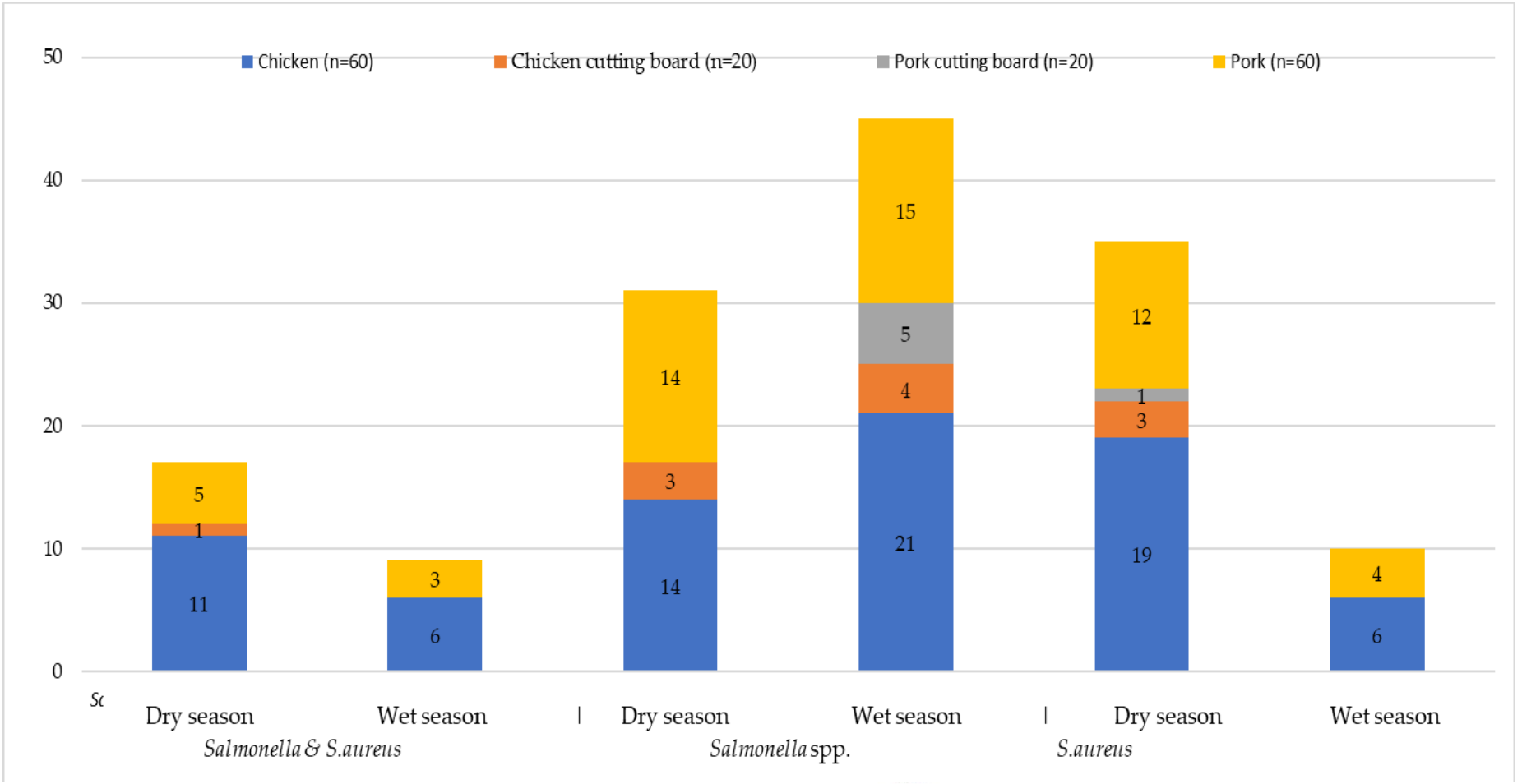


Table 4. Multivariable logistic regression of *Salmonella* spp. and *S. aureus* contamination and co-contamination in samples from Cambodian markets

Pathogens	Variables	Odds Ratio	95% CI	Coefficient	S.E.	*p*-Value
Salmonella spp. & *Staphylococcus aureus*	Species (chicken compared to pork)	1.28	0.78–2.1	0.25	0.25	0.32
	Sample (meat compared to cutting board)	4.66	1.97–11.03	1.54	0.44	<0.001
	Market type (supermarket compared to traditional market)	0.11	0.01–0.84	−2.18	1.02	0.034
	Season (dry compared to wet season)	0.64	0.3–1.36	−0.45	0.38	0.24
	Constant			−3.05	0.44	<0.001
Salmonella spp.	Species (chicken compared to pork)	1.03	0.72–1.46	0.03	0.18	0.86
	Sample (meat compared to cutting board)	1.47	0.96–2.24	0.38	0.22	0.07
	Market type (supermarket compared to traditional market)	0.51	0.24–1.1	−0.67	0.39	0.09
	Season (wet compared to dry season)	1.89	1.16–3.06	0.63	0.25	0.01
	Constant			−0.69	0.21	0.001
Staphylococcus aureus	Species (chicken compared to pork)	1.60	1.07–2.37	0.47	0.2	0.021
	Sample (meat compared to cutting board)	3.55	2.05–6.15	1.27	0.28	<0.001
	Market type (supermarket compared to traditional market)	0.04	0.01–0.3	−3.2	1.02	0.002
	Season (wet compared to dry season)	0.26	0.12–0.51	−1.37	0.36	<0.001
	Constant			−1.89	0.28	<0.001

The prevalence of *Salmonella* was not significantly different between these two market types (*p*-value = 0.09).

High prevalence in traditional markets regarding of both *Salmonella* spp. and *S. aureus* (*p*-value = 0.034) and with only *S. aureus* (*p*-value = 0.002).

The prevalence of *S. aureus* was significantly higher (*p*-value < 0.001) in meat samples than in cutting boards

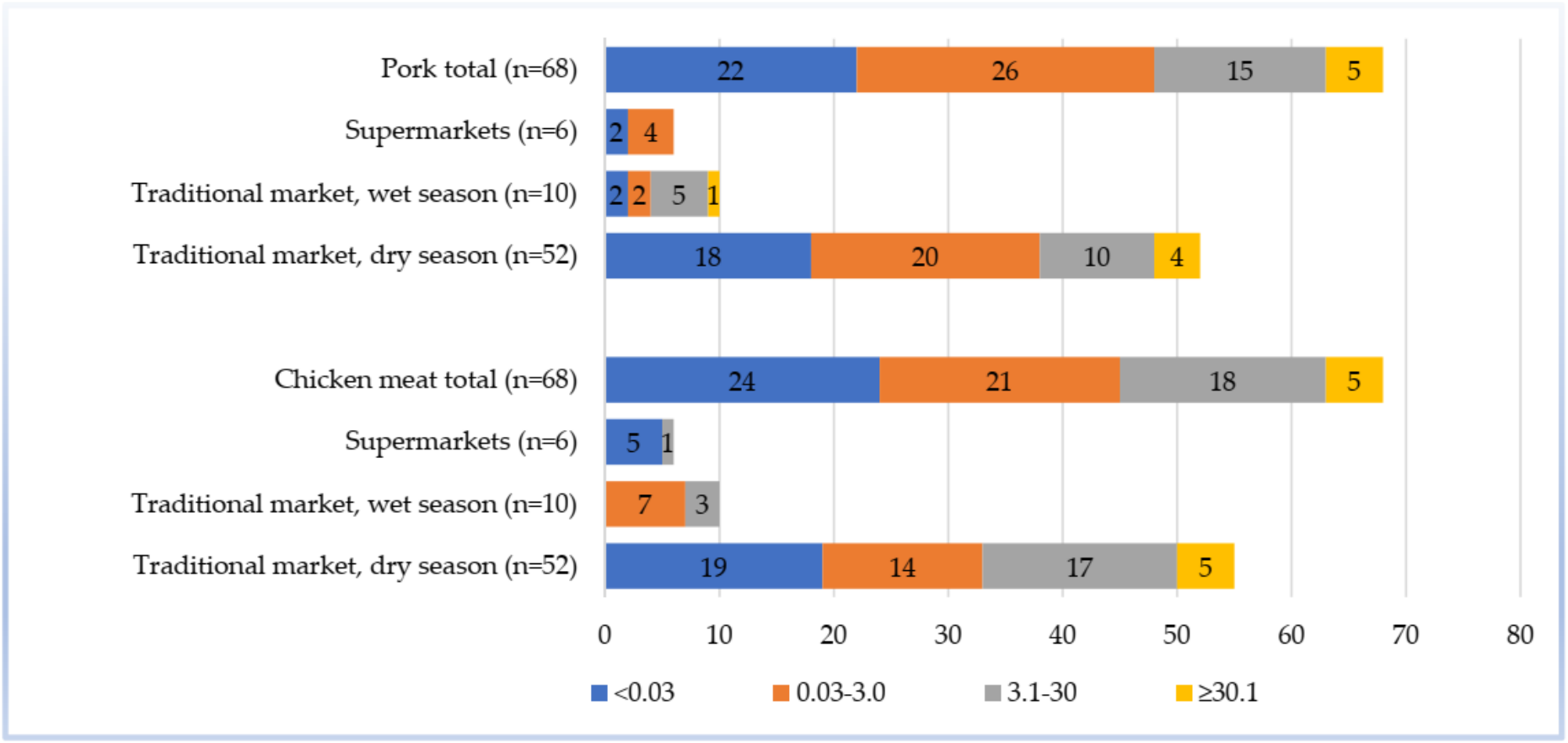


Figure 2. Frequency of *Salmonella* spp. most probable number (MPN/g) ranges in meat samples (n = 136) collected from Cambodian markets.

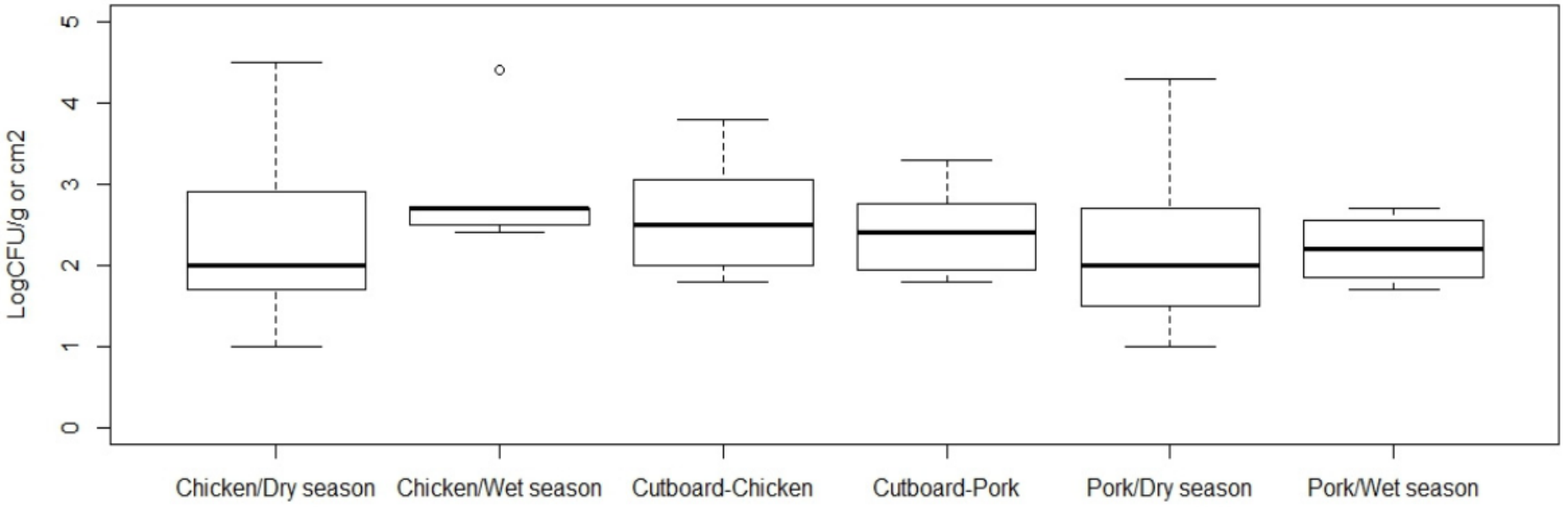


Figure 3. Contamination of coagulase-positive staphylococci (Log CFU/g or cm^2) in samples collected from Cambodian traditional markets in dry and wet seasons. Cutting board samples in chicken and pork shops were only collected in the dry season.

An average Log CFU/g of CPS from chicken meat and pork samples was higher in wet season compared to dry season, 2.3 (SD 1.0) versus and 2.8 (SD 0.7) in chicken, and 2.1 (SD 0.9) versus 2.2 (SD 0.4) in pork.

Table 5. Variables associated with Log CFU/g of coagulase-positive staphylococci in samples collected from Cambodian markets.

Variable	Coefficient	95% Confidence Interval	Std Error	*p*-Value
Market type (supermarket compared to traditional market)	−1.054	−1.471–−0.638	0.212	<0.001
Meat type (chicken compared to pork)	0.250	0.044–0.456	0.105	0.017
Sample type (meat compared to cutting board)	0.648	0.402–0.894	0.125	<0.001
Season (dry compared to wet)	−0.590	−0.880–−0.300	0.147	<0.001
Constant	0.927	0.516–1.338	0.209	<0.001

Results from linear regression showed that the CPS contamination in meat in supermarkets was lower than in traditional markets (*p*-value < 0.001; Table 5).

Regarding meat types, the load of CPS in chicken was significantly higher than in pork (*p*-value = 0.017), whereas the load of CPS in meat was significantly higher than in cutting board (*p*-value < 0.001, Table 5).

Conclusions

- In conclusion, this study found a high prevalence of both Salmonella spp. and S. aureus in chicken meat and pork samples, which could cause serious FBD in humans.
- Vulnerable people who consume fresh chicken meat and pork purchased from the traditional market might be at risk of contracting FBD.
- The pathogens may exist and contribute to common foodborne illness in Cambodia, with limited of reports accessed.

Recommendations

- Interventions to improve hygienic standards in Cambodian markets are strongly recommended on the traditional market from provinces at higher prevalence of *Salmonella* spp. and/or *S. aureus*.

- The further studies were suggested on how *Salmonell*a spp. and/or *S. aureus* could cross-contaminated to ready-to eat food or any common food in Cambodian household.

FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

pathogens
an Open Access Journal by MDPI

Prevalence of *Salmonella* spp. and *Staphylococcus aureus* in Chicken Meat and Pork from Cambodian Markets

Chea Rortana; Hung Nguyen-Viet; Sothyra Tum; Fred Unger; Sofia Boqvist; Sinh Dang-Xuan; Sok Koam; Delia Grace; Kristina Osbjer; Theng Heng; Seng Sarim; Or Phirum; Roeurn Sophia; Johanna F. Lindahl

Pathogens **2021**, Volume 10, Issue 5, 556

Prevalence of Salmonella and Staphylococcus aureus in meat in Cambodian markets

Chea Rortana, Delia Grace, Hung Nguyen, Sothyra Tum, Sinh Dang-Xuan, Sok Koam, Theng Heng, Seng Sarim and Johanna Lindahl

Introduction

Methods

A nationwide multi-hazard survey in markets in Cambodia found the prevalence in meat (pork and chicken) of *Salmonella* was 43% and of *Staphylococcus* was 31%.

The prevalence of *Salmonella* found in chicken 45.2%, cutting board of chicken 41.9%, pork 45.7% and cutting board of pork 11.3%. The prevalence of *S. aureus* found in chicken 41.9%, cutting board of chicken 19.4%, pork 45.7% and cutting board of pork 30.6%.

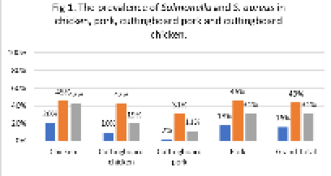
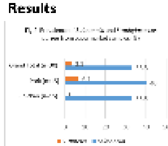


Fig 1. The prevalence of *Salmonella* and *S. aureus* in chicken, pork, cuttingboard pork and cuttingboard chicken.

Results



Recommendations

Research gaps or future opportunities

FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Prevalence of *Salmonella* and *Staphylococcus aureus* in meat in Cambodian markets

Introduction

Fresh meat can be contaminated with microorganisms during harvest, slaughter or processing and handling (Xuan *et al.*, 2019). Foodborne diseases are important in low middle-income countries, because of their high health burden and huge economic cost (Grace, 2015).

Objectives

1. To assess the prevalence of *Salmonella* and *S. aureus* in animal source foods (chicken and pork) sold at Cambodian traditional markets
2. Quantify *Salmonella* in the collected specimen.

Materials and methods

Sampling was conducted probabilistically from retail markets for pork and chicken meat in 25 provinces/municipal of Cambodia between October 2018 and August 2019, including repeat sampling in wet season in 4 provinces (Phnom Penh, Sihanoukville, Battambang and Siem Reap) after approximately 5 months.

The 456 specimens were collected aseptically in retail wet market at about 9-11 am of each day: chicken meat (n=186), chicken cutting board (n=62), pork (n=186) and pork cutting board (n=62).

All specimens were tested for presence of *Salmonella* (ISO 6579-1_2002) and *Staphylococcus aureus* (ISO 6888-1-1999), while one third of specimen were tested for most probable number (MPN) *Salmonella* using traditional procedure (Pavic *et al.*, 2010).

Fig 2: Traditional market in Kampong Cham, chicken and pork meat seller participated in interview and sampling meat and cutting board.

Fig 3: Bacterial isolation-25g meat + 225 mL of BPW was mixed by stomacher for *Salmonella* and *S. aureus* isolation.

Results

Among the total isolates, the prevalance of *Salmonella* was 43.1% (chicken 45.2%, cuttingboard chicken 41.9%, cuttingboard pork 30.6% and pork 45.7%).

The prevalance of *S. aureus* was 31.3% in all sample (chicken 41.9%, cuttingboard chicken 19.4%, cuttingbord pork 11.3% and pork 31.2%). Majority of specimen showed MPN less than 30 as presented in Table 1. According to Table 3 and Table 4, the prevalance of *Salmonella* trend higher than *S.aureus* which mean, the higher risk of *Salmonella* among chicken and pork in Cambodian tradiational markets

Table 1: Prevalence of *Salmonella* and *S. aureus* in chicken pork, chicken and cutting board swab, in 25 provinces/municipal of Cambodia.

Sample type	N. Specimen	N. positive both *Salmonella* and *S. aureus*	*Salmonella* positive	*S. aureus* positive
Chicken	186	38 (20.4%)	84 (45.2%)	78 (41.9%)
Cuttingboard chicken	62	6 (9.7%)	26 (41.9%)	12 (19.4%)
Cuttingboard pork	62	1 (1.6%)	19 (30.6%)	7 (11.3%)
Pork	186	33 (17.7%)	85 (45.7%)	58 (31.2%)
Grand Total	**496**	**78 (15.7%)**	**214 (43.1%)**	**155 (31.3%)**

Table 2. The MPN profiles of *Salmonella* from the 124 tested sample

Sample types	<0.3	0.3–3.0	3.1–30.0	30.1–110	>110
Chicken (n=62)	19	21	17	2	3
Pork (n=62)	20	22	15	1	4

Table 3. Number of positive *Salmonella* from difference sampling seasons, where first sampling was during dry season and second sampling in raining season

Specimen type	Positive *Salmonella* first sampling	Positive *Salmonella* Second sampling	Positive *S. aureus* first sampling	Positive *S. aureus* second sampling
Chicken	63/156	21/30	72/156	6/30
Cuttingboard chicken	22/52	4/10	12/52	0/10
Cuttingboard pork	14/52	5/10	7/52	0/10
Pork	70/156	15/30	54/156	4/30
Total sample	169/416	45/80	145/416	10/80

Table 4. Positive samples collected in all different provinces

Name of Province	Number of Specimen	*Salmonella* Number	*Salmonella* %	*S. aureus* Number	*S. aureus* %
Phnom Penh	48	13	27.1	12	25.0
Siem Reap	48	31	64.6	12	25.0
Battambang	32	14	43.8	10	31.3
Sihanouk	32	18	56.3	11	34.4
Takeo	16	8	50.0	5	31.3
Kampong Cham	16	5	31.3	10	62.5
Tbaung Khmum	16	7	43.8	6	37.5
Kep	16	10	62.5	4	25.0
Kampot	16	10	62.5	5	31.3
Kampong Speu	16	6	37.5	11	68.8
Kandal	16	6	37.5	3	18.8
Kampong Chhnang	16	9	56.3	10	62.5
Oddor Mean Chey	16	7	43.8	0	0.0
Koh Kong	16	0	0.0	3	18.8
Pailin	16	5	31.3	4	25.0
Banthey Mean Chey	16	2	12.5	4	25.0
Pursat	16	5	31.3	2	12.5
Prey Veng	16	6	37.5	4	25.0
Svay Rieng	16	3	18.8	9	56.3
Mondulkiri	16	13	81.3	6	37.5
Ratanakiri	16	7	43.8	5	31.3
Steung Treng	16	4	25.0	8	50.0
Kratie	16	6	37.5	8	50.0
Kampong Thom	16	8	50.0	0	0.0
Preah Vihea	16	11	68.8	3	18.8
Total	496	214	43.1	155	31.3

Conclusions

This study has detected two major foodborne bacteria, among the most common causes of foodborne illness in Cambodia. This indicates the importance of food safety and improved hygiene for public health.

References

Dang-Xuan, S et al., (2019). Risk factors associated with *Salmonella* spp. prevalence along smallholder pig value chains in Vietnam. International journal of food microbiology 290: 105-115.
Grace, D. (2015). Food safety in low and middle income countries. International journal of environmental research and public health, 12(9), 10490-10507.
ISO 6579-1:2002. Microbiology of food and animal feeding stuffs — Horizontal method for the detection of *Salmonella* spp.
ISO 6888-1:1999. Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species) — Part 1: Technique using Baird-Parker agar medium.
Pavic et al., (2010). A validated miniaturized MPN method, based on ISO 6579:2002, for the enumeration of Salmonella from poultry matrices. Journal of applied microbiology, 109(1), 25-34.

Acknowledgements

This study is made possible by the generous support of the American people through the United States Agency for International Development (USAID) and its Feed the Future Innovation Lab for Livestock Systems managed by the University of Florida and the International Livestock Research Institute. The contents are the responsibility of the presenter and do not necessarily reflect the views of USAID or the United States Government.

USAID FROM THE AMERICAN PEOPLE

LDC

EMORY UNIVERSITY

ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

CGIAR

UF IFAS UNIVERSITY of FLORIDA

Thank you for your attention

FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

www.feedthefuture.gov

USAID
FROM THE AMERICAN PEOPLE

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

CGIAR

UF IFAS
UNIVERSITY of FLORIDA