

Materials & Methods

1. The data for this cross-sectional study was collected from April 2021 to June 2022 through the one health poultry hub project. 251 farms were randomly selected based on previous research^{13,14} on the production and distribution networks in the 4 target sites: Gujarat and Tamil Nadu in India, Bangladesh, and Vietnam. Gujarat and Tamil Nadu are Exotic broiler chicken farms, Vietnam are Hybrid broiler chicken farms and Bangladesh are Exotic broiler and Sonali chicken farms.
2. The investigation encompassed a questionnaire filled by farm managers, the observation of the farm by the interviewers and the collection of biological samples of 3 pathogens: *Salmonella* (non-typhoidal), *Campylobacter* (coli & jejuni) and Avian Influenza (H5 & H9).
3. Formula:

$$\text{morbidity rate} = \frac{1000 \times \text{number of real sick}(n_s)}{\text{total number of chicken}(N) \times (\text{current age} - \text{start age})(\text{days})} \text{ (/1000 bird. days)}$$

$$\text{mortality rate} = \frac{1000 \times \text{number of death}(n_d)}{\text{total number of chicken}(N) \times (\text{current age} - \text{start age})(\text{days})} \text{ (/1000 bird. days)}$$

$$\text{morbidity risk} = \frac{\text{number of real sick}(n_s)}{\text{total number of chicken}(N)} \%$$

$$\text{mortality risk} = \frac{\text{number of dead}(n_d)}{\text{total number of chicken}(N)} \%$$

$$\text{lethality} = \frac{\text{number of dead}(n_d)}{\text{number of real sick}(n_s)} \%$$

4. Using Student's T-test for univariate test, and P values less than 0.05 were considered statistically significant. All statistical analyses were performed using RStudio (V 2023.03.0+386) and Spatial analysis was carried by QGIS (V 3.22.14-Białowieża).

Results

Mortality rate & Morbidity rate

- General description of basic data

(Total number of observations: 251)

1. Animals (Total number of chickens in the sampled batches)

The total number of chickens in the sampled batches had mean value of 3525.51 with standard deviation value of 3463.11. The total number of chickens in the sampled batches ranged between 100 and 27000, and this was not normally distributed and slightly skewed to the right because of little observations in the upper range. The high values in the upper range were considered as part of the variation in total number of chickens and these observations were kept in the datasets.

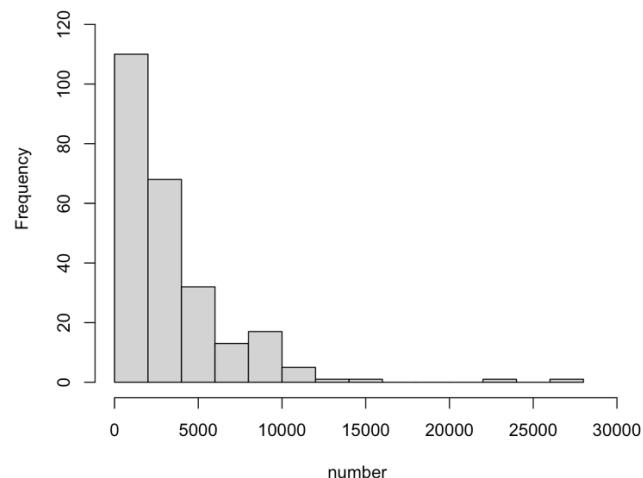
Table Summary table of total number of chickens

	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Animals	249	2 ¹	3525.51	3463.11	100	1000	2600	4500	27000

1:T504, V601.

Histogram

Total number of sampled chickens



2. Age

- Start age (unit: day)

The distribution of the start age showed that there are 7 outliers, which were bigger than 1 day. The presence of outliers needed to be investigated, to identify if they (B521, B630, B644, B645, B641, B612, B686) were different from other farms or this could be an error. These 7 farms' brooding were all conducted in one shed, and all chickens were reared in that shed for many days before being distributed to other sheds until the end of the production cycle, which led to big start age. But we couldn't conclude other farms have no brooding. It was decided to remove these observations, as this may impact the outcomes.

Table 1 Start age's frequency table all sites

Start age	0	1	6	15	25	30	32	Total
Frequency	99(39.4%)	145(57.8%)	1(0.4%)	1(0.4%)	1(0.4%)	3(1.2%)	1(0.4%)	251

The distribution of start age is presented in Table 1 and Table 2. The start age was mainly 0 and 1. For Bangladesh, the frequencies of start age 0 and 1 were approximately equal. For Gujarat, all chickens' start age was 0. For Tamil Nadu, 86% farms' chickens had a start age of 1 and 14% farms' chickens have a start age of 0. The frequencies of the start age 0 and 1 were quite different. For Viet Nam, chickens' start age was all 1.

Table 2 Start age's frequency table by site (only for 0 & 1)

Region	Start age		Total number
	0	1	
Bangladesh	42(45%)	51(55%)	93
Gujarat	50(100%)	0	50
Tamil Nadu	7(14%)	43(86%)	50
Viet Nam	0	51(100%)	51
Total number	99(41%)	145(59%)	244

- Current age (unit: day)

The current age had mean value of 55.48 days with standard deviation value of 34.74. The current age ranged between 22 and 180 days, and this was not normally distributed and skewed to the right because of a number of observations in the upper range. The high values in the upper range were considered as part of the variation in current age and these observations were kept in the datasets.

The current age in Bangladesh had mean value of 43.87 days with standard deviation value of 16.23. It ranged between 22 and 79 days.

The current age in Tamil Nadu had mean value of 37.1 days with standard deviation value of 2.56. It ranged between 31 and 42 days.

The current age in Gujarat had mean value of 37.62 days with standard deviation value of 3.59. It ranged between 35 and 56 days.

The current age in Viet Nam had mean value of 113.06 days with standard deviation value of 33.46. It ranged between 43 and 180 days.

Summary

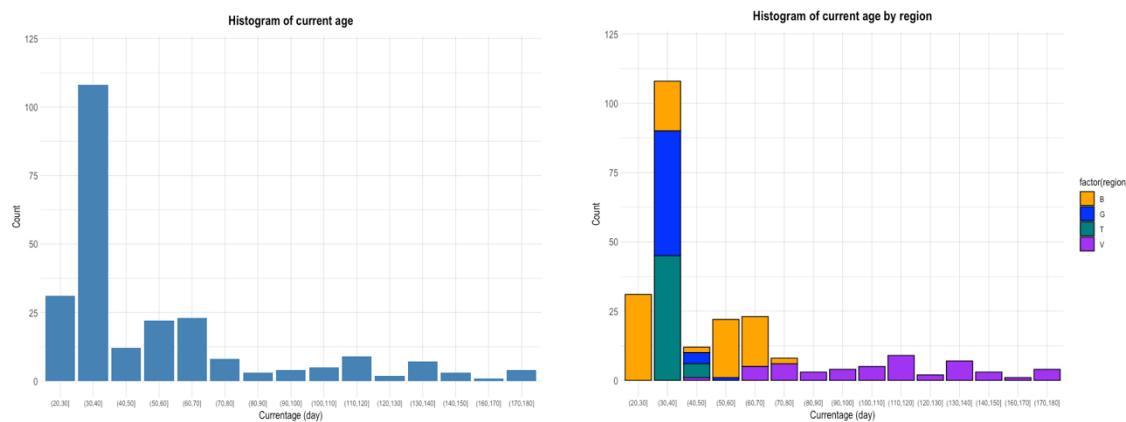
Region	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Bangladesh	92	8	43.87	16.23	22	29	35	60	79
Tamil Nadu	50	0	37.1	2.56	31	35	37	39	42
Gujarat	50	0	37.62	3.59	35	35	37	39	56
Viet Nam	50	1	113.06	33.46	43	86.25	120	135	180
All	242 ¹	9	55.48	34.74	22	35	39	63.75	180

1: V506's current age value is "multiple". So we couldn't know the value of age. Age of B562 is outlier. 7 outliers of start age.

In the histogram of current age by region, distribution of Viet Nam ranged between 43 and 180, which was not concentrated and mainly on the upper range of all sites' current age distribution. But the distributions of Bangladesh, Tamil Nadu and Gujarat ranged between 22 and 80, which was concentrated.

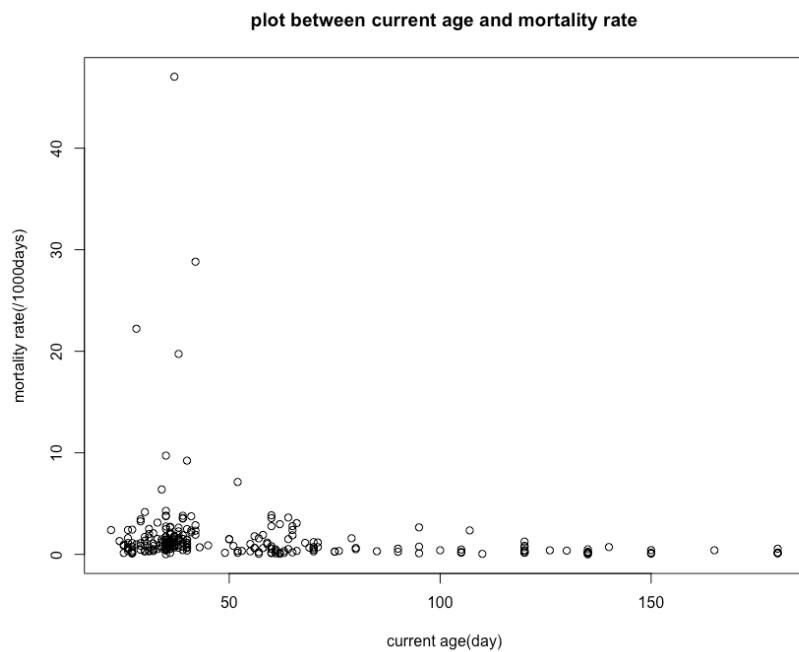
We can conclude that there was bias between different sites because of the different distribution in different sites. So we can't just analyse the overall outcomes. We need to analyse them by site to see differences.

Histogram



- Change of outcome by current age

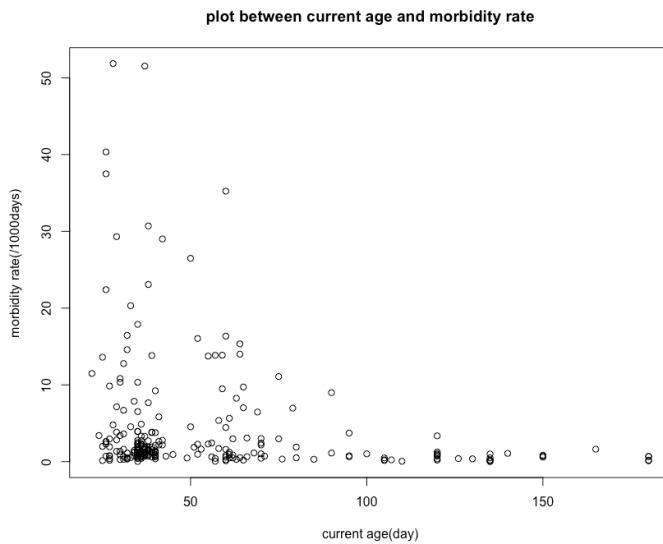
1. Mortality rate ~ age



Most of the points are distributed at the bottom. There is no obvious pattern of distribution.

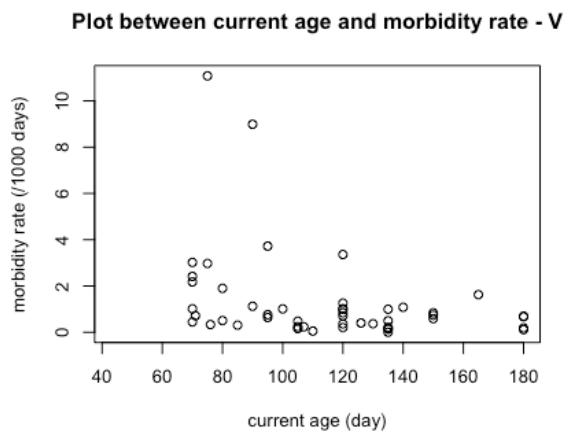
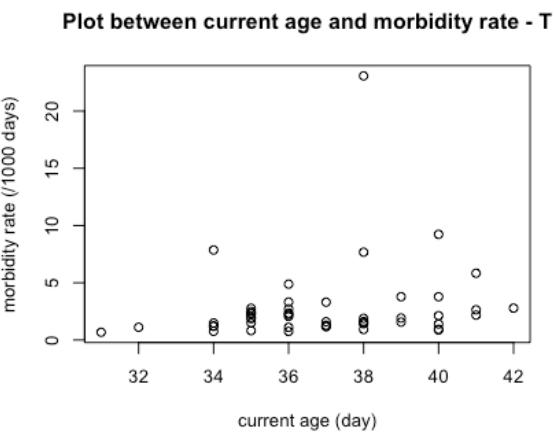
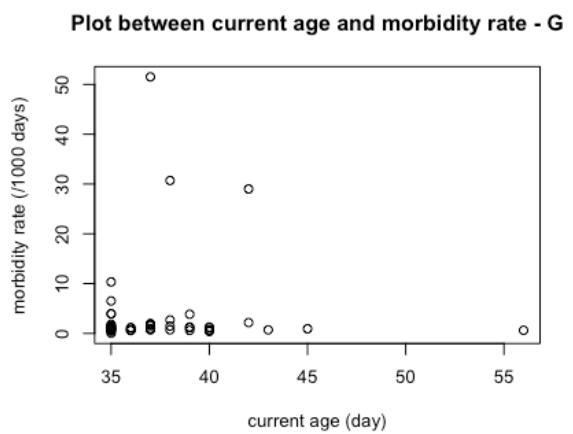
2. Morbidity rate ~ age

The plots form an obvious shape.



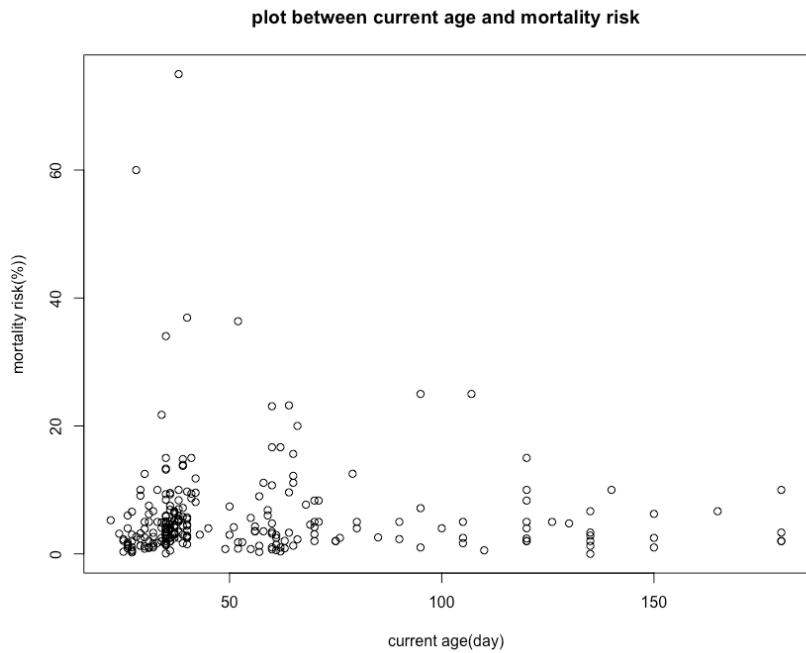
Morbidity rate ~ age by site

The plots by site seem to be a little random, but there are still some shapes, which may be due to the the morbidity rate was calculated by age.



3. Mortality risk ~ age

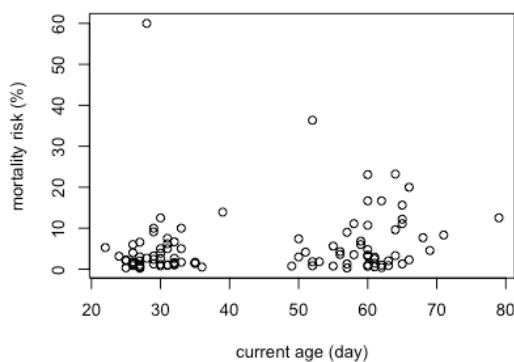
The plots form a shape.



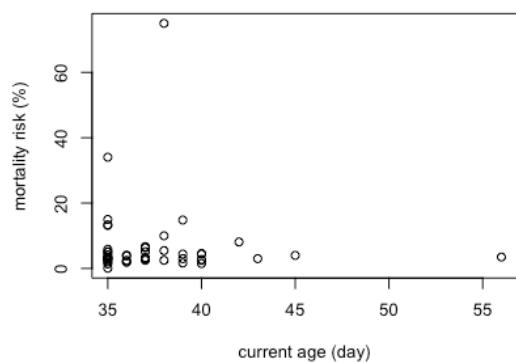
Mortality risk ~ age by region

The plots by site seem to be a little random.

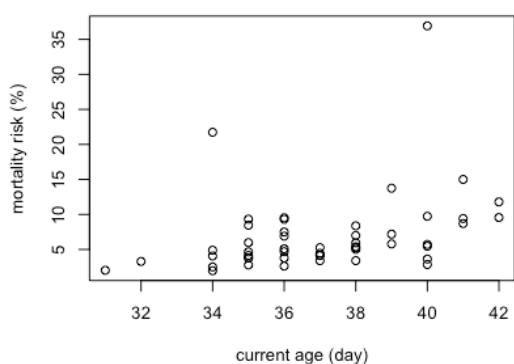
Plot between current age and mortality risk - B



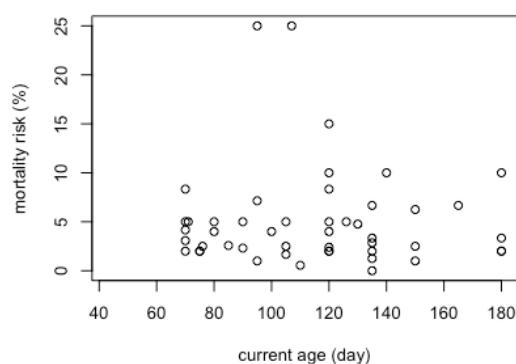
Plot between current age and mortality risk - G



Plot between current age and mortality risk - T

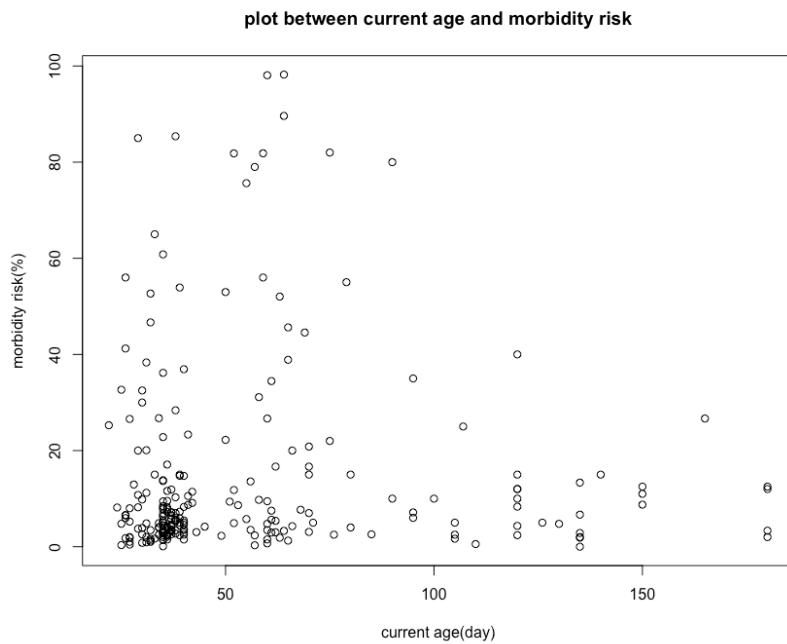


Plot between current age and mortality risk - V



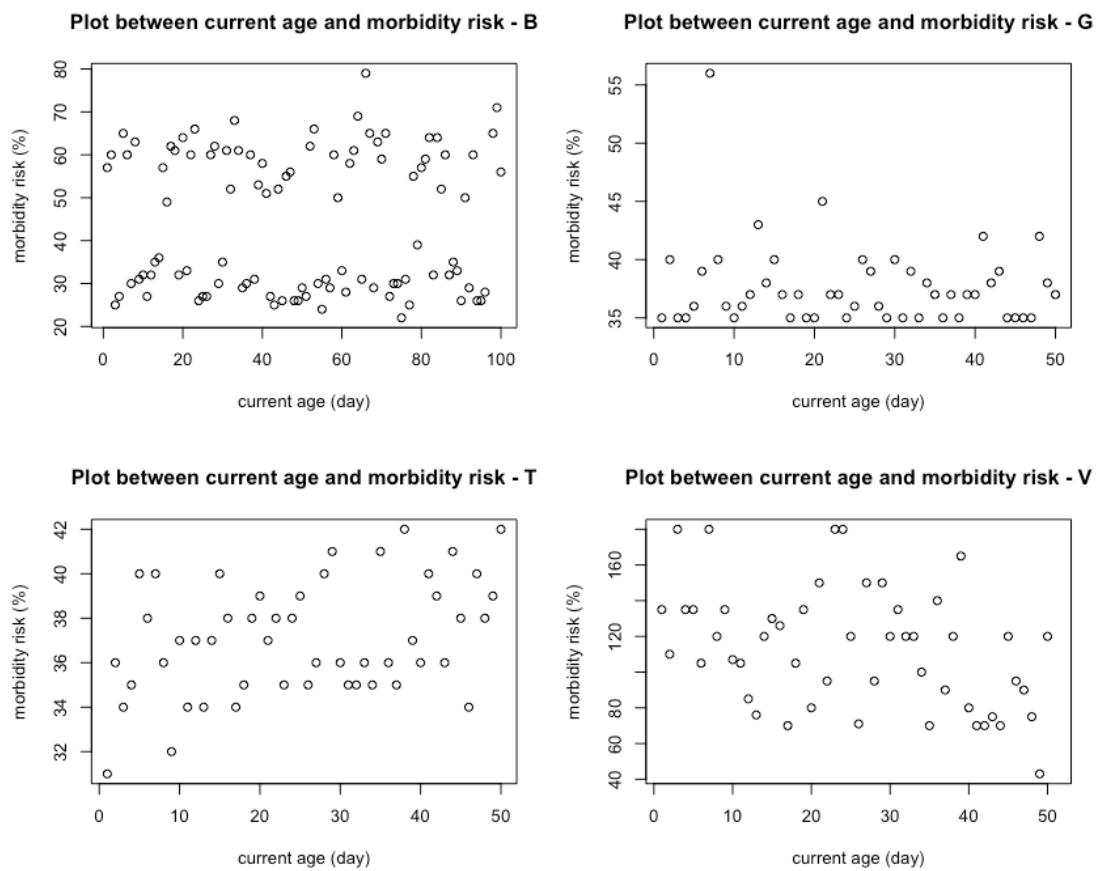
4. Morbidity risk ~ age

The plots form a shape.



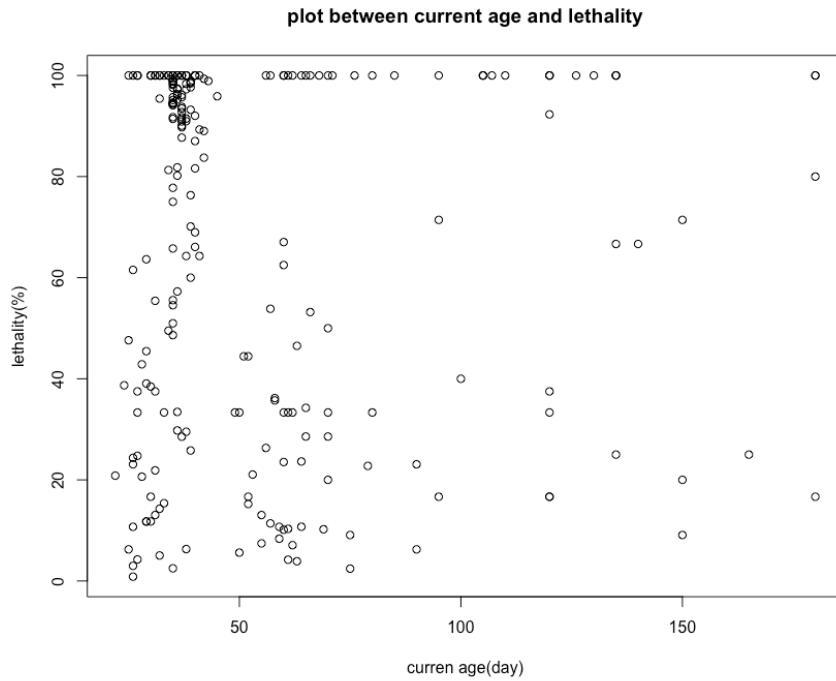
Morbidity risk ~ age (by site)

The plots are randomly distributed.



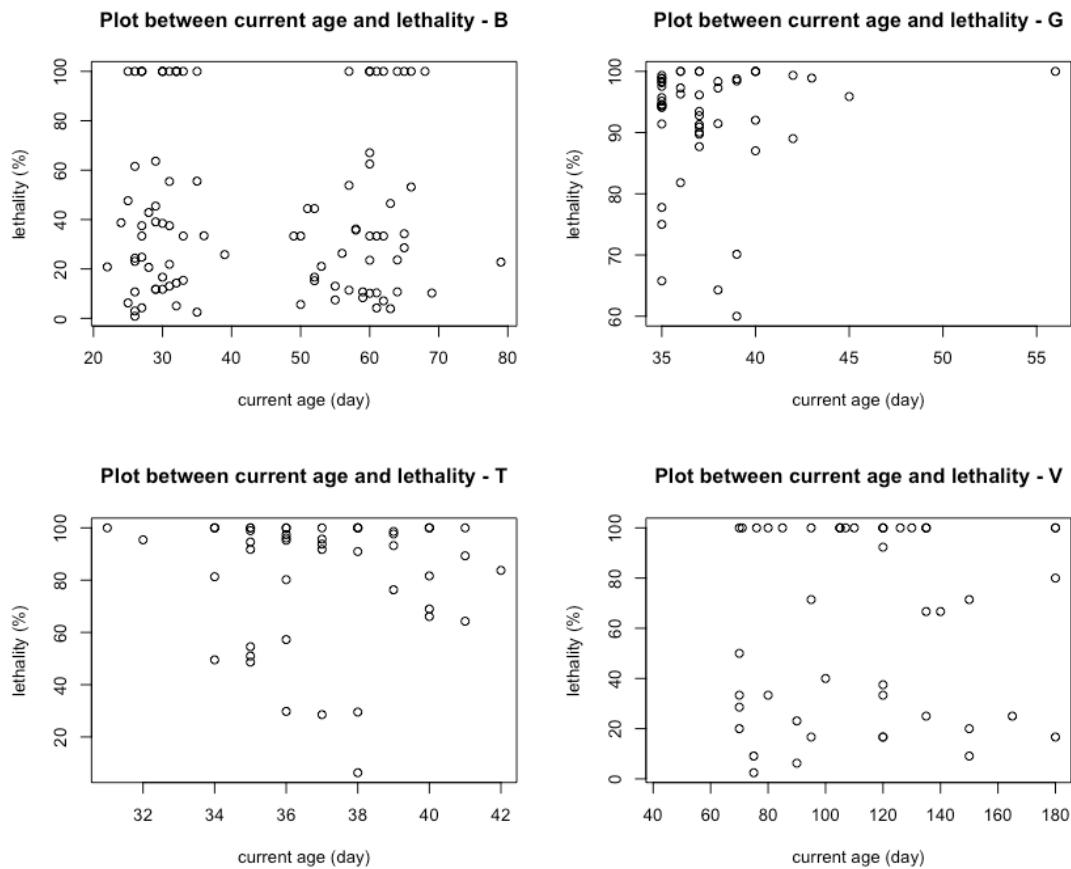
5. Lethality ~ age

The plots are randomly distributed.



Lethality ~ age (by region)

The plots are randomly distributed.



3. Dead and real sick number

- Number of Death

The number of death had mean value of 192.5 with standard deviation value of 264.61. It ranged between 2 and 2300. The high values in the upper range were considered as part of the variation in number of death and these observations were kept in the datasets.

The total number of death in Bangladesh had mean value of 90.75 with standard deviation value of 119.06. It ranged between 3 and 501.

The total number of death in Tamil Nadu had mean value of 323.7 with standard deviation value of 155.62. It ranged between 66 and 700.

The total number of death in Gujarat had mean value of 370.59 with standard deviation value of 447.7. It ranged between 7 and 2300.

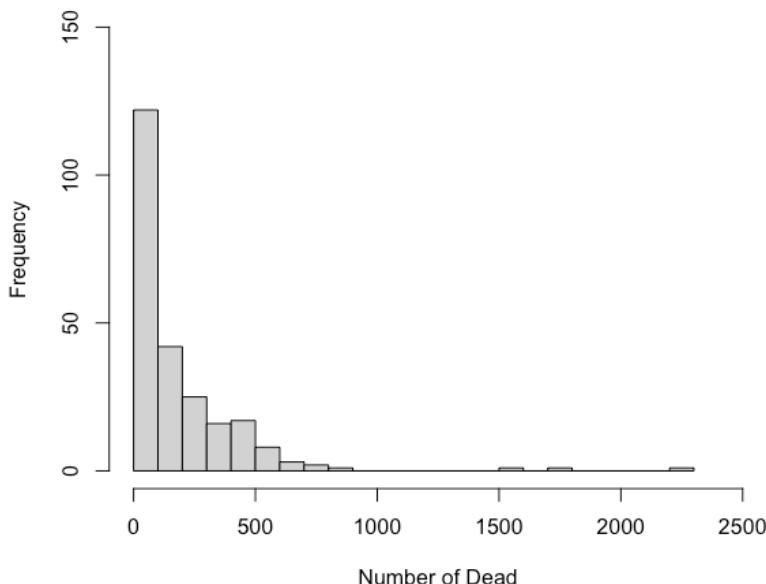
The total number of death in Viet Nam had mean value of 62.66 with standard deviation value of 61.72. It ranged between 2 and 250.

Table 1 Summary table of death number by site and overall

Region	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Bangladesh	92	8	90.75	119.06	3	20	44.5	100	501
Tamil Nadu	50	0	323.7	155.62	66	200	306	416.5	700
Gujarat	50	0	370.59	447.7	7	116	210	461.25	2300
Viet Nam	47	4	62.66	61.72	2	20	50	100	250
All	239	12 ¹	192.5	264.61	2	30	100	280	2300

1: Age of B562 is outlier. 7 outliers of start age. V502, V506, V523, V601 have missing value of dead number

Histogram of dead number



- Number of Real sick

The number of sick chickens in the data did not include the number of dead chickens. But we considered the death of chickens was the result of sick. Therefore, the number of real sick should be the number of sick plus the number of death:

$$\text{number of real sick} = \text{number of death} + \text{number of sick}$$

The number of real sick had mean value of 362.06 with standard deviation value of 5002.12. It ranged between 0 and 4440, and this was not normally distributed and slightly skewed to the right because of little observations in the upper range. The high values in the upper range were considered as part of the variation in number of real sick and these observations were kept in the datasets.

The total number of death in Bangladesh had mean value of 90.75 with standard deviation value of 119.06. It ranged between 3 and 501.

The total number of death in Tamil Nadu had mean value of 323.7 with standard deviation value of 155.62. It ranged between 66 and 700.

The total number of death in Gujarat had mean value of 370.59 with standard deviation value of 447.7. It ranged between 7 and 2300.

The total number of death in Viet Nam had mean value of 62.66 with standard deviation value of 61.72. It ranged between 2 and 250.

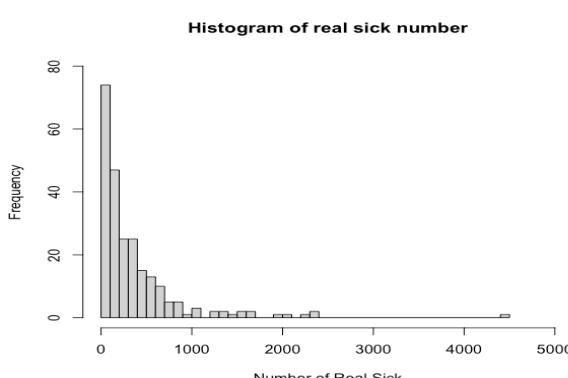
Table 2 Summary table of real sick number by site and overall

Region	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Bangladesh	90	10	375.23	507.72	7	50	152.5	560	2330
Tamil Nadu	49	1	494.08	634.99	104.7	240	354	505	4440
Gujarat	50	0	407.2	482.93	9	130	216	500	2315
Viet Nam	49	2	159.8	252.16	0	25	100	200	1640
All	238	13 ²	362.06	502.12	0	80	200	445.25	4440

2: T542, B622, B623, B641, V502, V506 have missing value of sick number. 7 outlier observations of start age

The distribution of total number of real sick was not normally distributed and skewed to the right because of observations in the upper range. The high values in the upper range were considered as part of the variation in number of real sick and these observations were kept in the datasets.

Histogram



- Summary of Morbidity rate, Mortality rate & Morbidity risk, Mortality risk & lethality - by site & overall

$$\text{Mortality rate} = \frac{1000 \times \text{number of death}(n_d)}{\text{total number of chicken}(N) \times (\text{current age} - \text{start age})(\text{days})} \text{ (/1000bird.days)}$$

$$\text{Morbidity rate} = \frac{1000 \times \text{number of sick}(n_s)}{\text{total number of chicken}(N) \times (\text{current age} - \text{start age})(\text{days})} \text{ (/1000bird.days)}$$

$$\text{mortality risk} = \frac{\text{number of dead}(n_d)}{\text{total number of chicken}(N)} \%$$

$$\text{morbidity risk} = \frac{\text{number of sick}(n_s)}{\text{total number of chicken}(N)} \%$$

The morbidity rate had mean value of 3.95 /1000days with standard deviation value of 7.25. It ranged between 0 and 51.85 /1000days, and this was skewed to the right because of a number of observations in the upper range.

The morbidity risk had mean value of 13% with standard deviation value of 19.49. It ranged between 0 and 98.21%, and this was skewed to the right because of a number of observations in the upper range.

The mortality rate had mean value of 1.7 /1000days with standard deviation value of 4.1. It ranged between 0 and 47.04 /1000days, and this was skewed to the right because of a number of observations in the upper range.

The mortality risk had mean value of 6.03% with standard deviation value of 7.98. It ranged between 0 and 75%, and this was skewed to the right because of a number of observations in the upper range.

All the high values in the upper range were considered as part of the variation in morbidity rate, morbidity risk, mortality rate, mortality risk and these observations were kept in the datasets.

Table 1 Summary table of morbidity rate, mortality rate, morbidity risk, mortality risk

	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Morbidity rate	236	15 ¹	3.95	7.25	0	0.70	1.32	3.33	51.85
Morbidity risk	231	20 ²	13	19.49	0	2.88	5.07	11.37	98.21
Mortality rate	239	12 ³	1.7	4.1	0	0.41	0.85	1.58	47.04
Mortality risk	237	14 ⁴	6.03	7.98	0	2.02	4.00	6.67	75

1: T542, B641, V502, V506 have missing value of sick number. B622, B623's value of sick number are both "most of chickens". T504 has only 5 total number of chickens, which leading to the morbidity rate to be 1.9 / day. Age of B562 is outlier. 7 outliers of start age.

2: The real sick number of some farms (B517, B523, B630, G124, G126, G133) is more than the total number. There has deleted the value of risk greater than 1. T542, B622, B623, B641, V502, V506 have missing value of sick number. T504 has only 5 total number of chickens. 7 outliers of start age.

3: V601's dead number is missing and the total number of chickens (N) is 0. T504 has only 5 total number of chickens, which leading to the mortality risk to be 5800%. V502 and V506's dead number are missing. Age of B562 is outlier. 7 outliers of start age.

4: The dead number of G126, G133 is more than the total number. There has deleted the value of risk greater than 1. V601, V502, V506, T504 have the same problems as note3. 7 outliers of start age.

The morbidity rate was different between different sites. Bangladesh had the highest mean value of morbidity rate. The order of sites from large to small according to the mean value of morbidity rate is: B, G, T, V.

Table 2 Summary table of morbidity rate by site (unit: / 1000 days)

Region	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Bangladesh	90	10	6.1	8.71	0.05	0.66	2.36	9.18	51.85
Tamil Nadu	48	2	2.82	3.52	0.67	1.23	1.9	2.74	23.08
Gujarat	50	0	3.69	9.05	0.02	0.71	1.11	1.81	51.52
Viet Nam	48	3	1.3	2.06	0	0.33	0.7	1.09	11.08
All	236	15	3.95	7.25	0	0.7	1.32	3.33	51.85

The morbidity risk was different between different sites. Bangladesh had the highest mean value of morbidity risk. The order of sites from large to small according to the mean value of morbidity risk is: B, V, T, G. The difference in morbidity rate and risk may be related to the age of chickens in different sites.

Table 3 Summary table of morbidity risk by site (unit: %)

Region	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Bangladesh	88	12	21.73	28.86	0.3	2.85	8.18	32.54	98.21
Tamil Nadu	48	2	10.35	13.16	2.02	4.35	6.97	9.78	85.38
Gujarat	47	3	5.75	6.12	0.08	2.85	3.85	5.62	36.17
Viet Nam	48	3	12.98	16.74	0	3.27	8.54	15	82
All	231	20	14.29	20.31	0	3.17	6	13.75	98.21

The mortality rate was different between different sites. Gujarat had the highest mean value of mortality rate. The maximum mortality rate also came from Gujarat. The order of sites from large to small according to the mean value of mortality rate is: G, T, B, V.

Table 4 Summary table of mortality rate by site (unit: / 1000 days)

Region	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Bangladesh	92	8	1.38	2.5	0.05	0.34	0.74	1.59	22.22
Tamil Nadu	49	1	1.89	1.47	0.59	1.11	1.46	2.26	9.23
Gujarat	50	0	3.25	7.97	0.02	0.68	0.98	1.71	47.04
Viet Nam	48	3	0.48	0.51	0	0.18	0.35	0.57	2.66
All	239	12	1.7	4.1	0	3.17	6	13.75	47.04

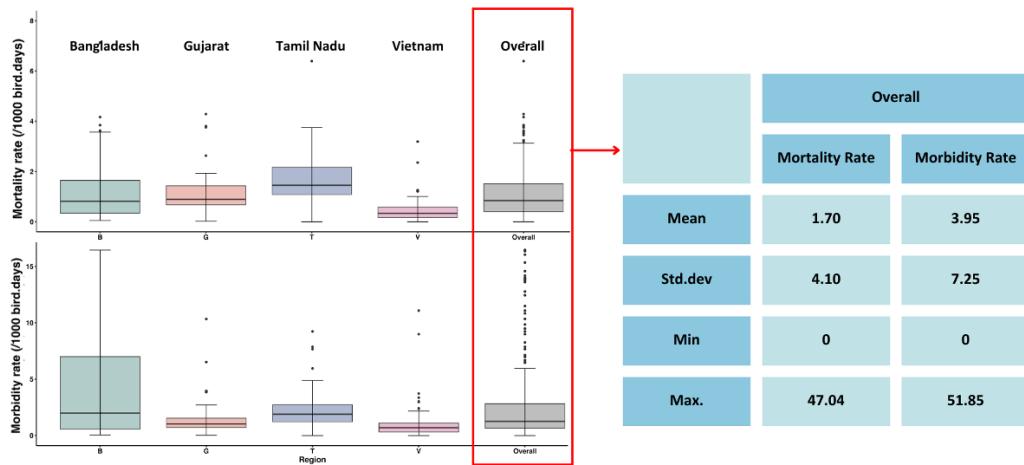
The mortality risk was different between different sites. Tamil Nadu had the highest mean value of mortality risk. The maximum mortality risk came from Gujarat. The order of sites from large to small according to the mean value of mortality risk is: T, G, B, V. The difference in mortality rate and risk may be related to the age of chickens in different sites.

Table 5 Summary table of mortality risk by site (unit: %)

Region	Obs	Missing Obs	Mean	Std.dev.	Min	25%qt	50%qt	75%qt	Max
Bangladesh	92	8	5.57	8.26	0.22	1.27	2.81	6.6	60
Tamil Nadu	49	1	6.94	5.73	1.96	3.79	5.26	8.46	36.93
Gujarat	48	2	6.72	11.44	0.07	2.67	3.51	5.55	75
Viet Nam	48	3	5.07	5.13	0	2	3.67	5.31	25
All	237	14	6.03	7.98	0	2.02	3.89	6.67	75

RESULTS-Description

Mortality rate & Morbidity rate
(/1000 bird.days))



Summary of the lethality

$$\text{Lethality} = \frac{\text{number of dead}(n_d)}{\text{number of real sick}(n_s)} \%$$

The lethality had mean value of 66.3% with standard deviation value of 35.8. It ranged between 0.8% and 100%. Gujarat had extremely high mean value of lethality which was 92.5%. It ranged between 60% and 100%.

Table Summary table of lethality (unit: %)

Region	Lethality(%)			
	mean	Sd.	min	max
Tamil Nadu	83.5	23.7	6.3	100
Bangladesh	45.4	35.6	0.8	100
Gujarat	92.5	10.0	60.0	100
Vietnam	64.8	37.2	2.4	100
Overall	66.3	35.8	0.8	100

- Map of mortality rate and morbidity rate

Figure Point distribution by Morbidity rate

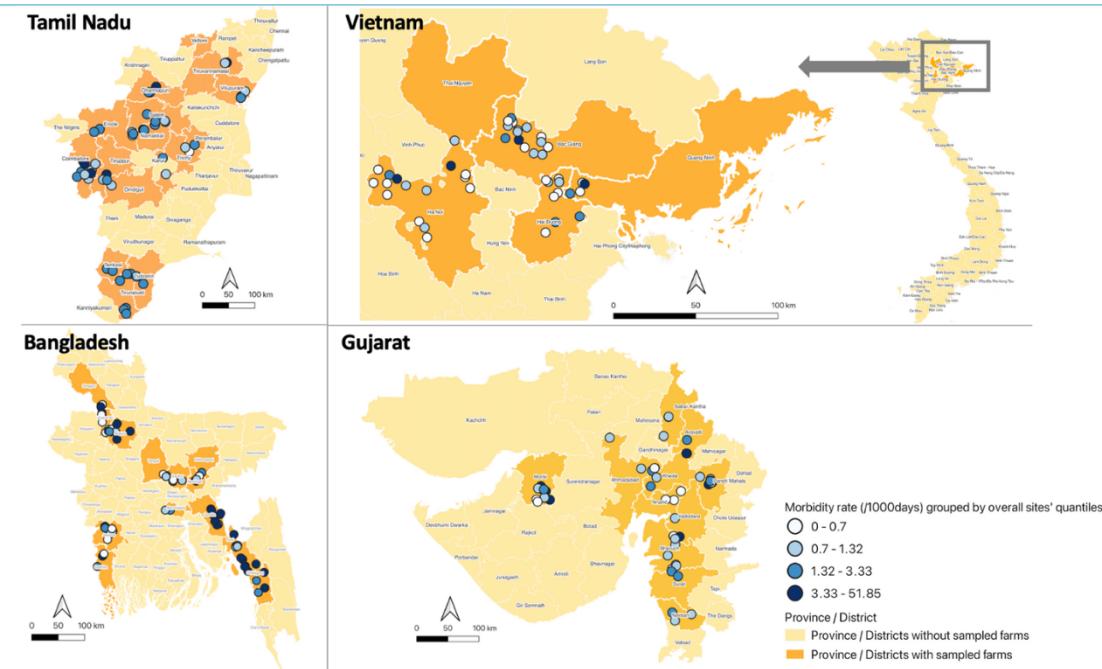
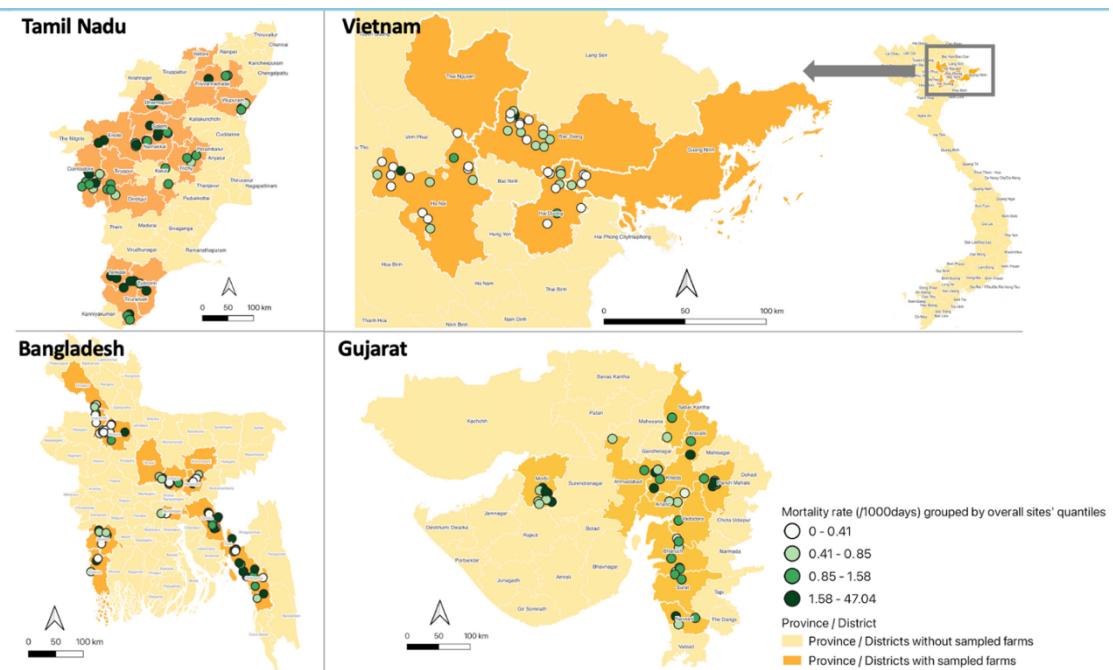


Figure Point distribution by Mortality rate



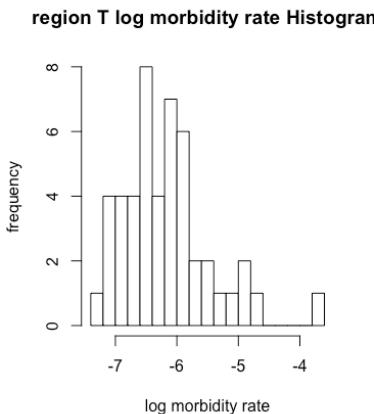
- Normality test of mortality rate and morbidity rate

Normality test for morbidity rate (log transformation)

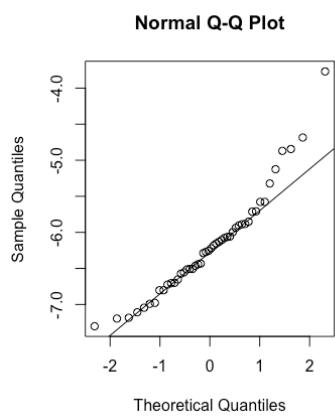
Region-T

Remove an outlier (morbidity rate >1)

Histogram:



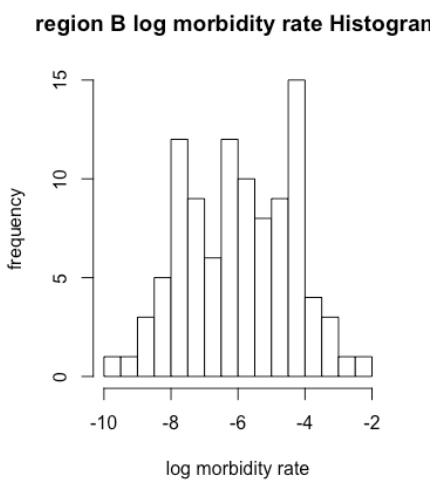
QQ-plot:



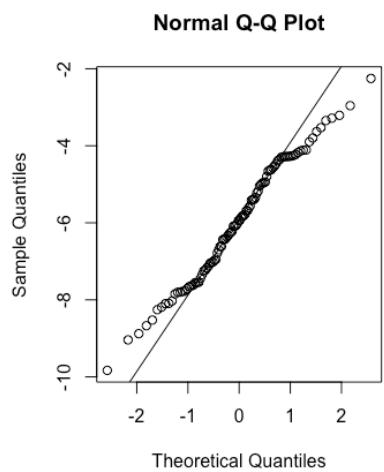
SW test: W = 0.93737, p-value = 0.01288

Region-B

Histogram:



QQ-plot:

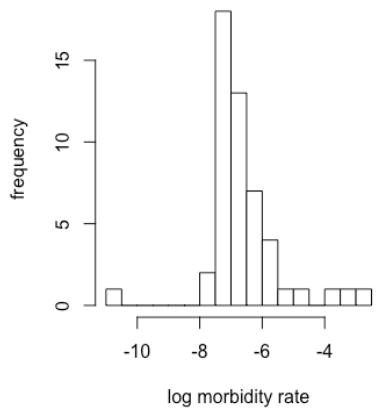


KS test: D = 0.079999, p-value = 0.5442

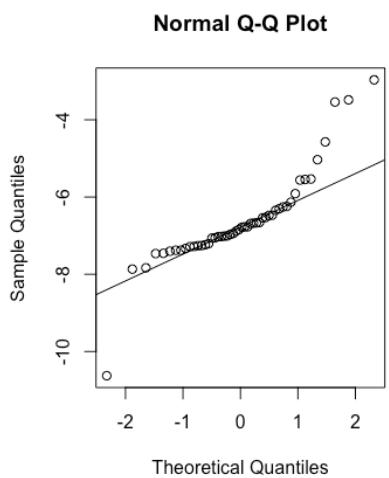
Region G

Histogram:

region G log morbidity rate Histogram



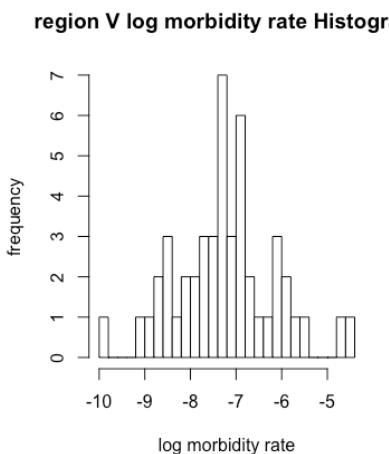
QQ-plot:



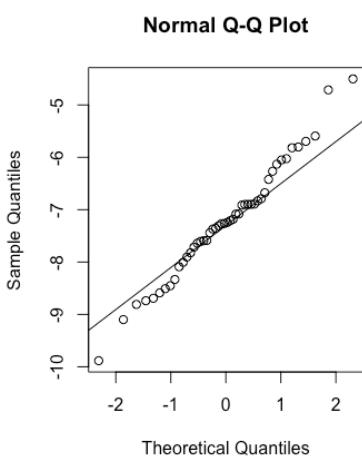
SW test: W = 0.84226, p-value = 9.611e-06

Region-V

Histogram:



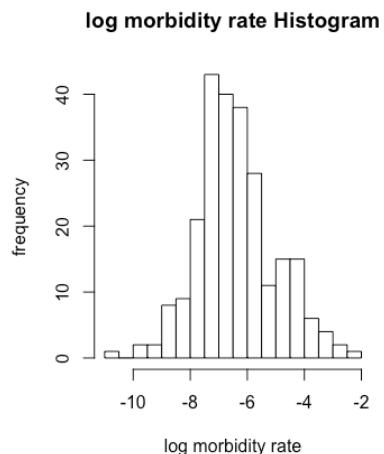
QQ-plot:



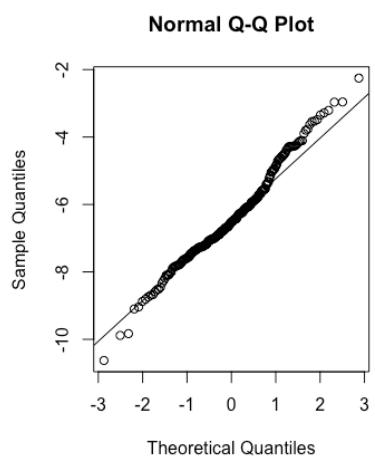
SW test: $W = 0.98586$, p-value = 0.8252

Overall

Histogram:



QQ-plot:



KS test: p-value = 0.1021

- Univariable linear regression results of Morbidity rate, Mortality rate - by site & overall

1. P<0.0001

	site	Variable	coefficie-t	P	
Log morbidity rate	all	additives_99	1.52201	8.26E-05	Variable additives answer: Other
Log morbidity rate	B	additives_5	3.8729	4.31E-05	Variable additives answer: Vitamins
Log mortality rate	B	additives_5	3.3256	1.24E-05	Variable additives answer: Vitamins

2. 0.0001<P<0.001

	site	Variable	coefficient	P	
Log morbidity rate	all	planning_99	0.9535	0.000186	Variable planning answer: Yes, other drugs
Log morbidity rate	all	capital_1	0.9094	0.000678	Variable capital answer: Inherited farm/capital
Log morbidity rate	all	capital_4	1.2654	0.000112	Variable capital answer: Bank
Log morbidity rate	all	capital_99	0.9887	0.000205	Variable capital answer: Other
Log morbidity rate	B	sources_1	1.5232	0.00093	Variable sources answer: Poultry farming
Log morbidity rate	B	capital_4	1.9752	0.000146	Variable capital answer: Bank
Log mortality rate	all	capital_99	0.7972	0.000471	Variable capital answer: Other

3. 0.001<P<0.05

	site	Variable	coefficient	P	
Log morbidity rate	B	water_additives_99	3.9582	0.0138	Variable water_additives answer: Other
Log morbidity rate	B	planning_0	1.8781	0.0243	Variable planning answer: No
Log morbidity rate	V	water_additives_6	1.73933	0.0127	Variable water_additives answer: Antibiotics
Log morbidity rate	B	capital_5	1.592	0.002975	Variable capital answer: Relatives
Log mortality rate	B	workers_2	1.54312	0.0172	Variable workers answer: Manager
Log mortality rate	G	workers_3	1.3904	0.0159	Variable workers answer: Permanent employees
Log morbidity rate	B	planning_1	1.2935	0.0252	Variable planning answer: Yes, antibiotics
Log mortality rate	B	capital_4	1.2742	0.00124	Variable capital answer: Bank
Log morbidity rate	B	capital_1	1.2594	0.017196	Variable capital answer: Inherited farm/capital
Log morbidity rate	all	additives_7	1.23667	0.0143	Variable additives answer: Don't know
Log morbidity rate	all	planning_0	1.2046	0.002126	Variable planning answer: No
Log mortality rate	V	water_additives_6	1.1709	0.0329	Variable water_additives answer: Antibiotics
Log mortality rate	B	capital_5	1.0795	0.00836	Variable capital answer: Relatives
Log morbidity rate	B	water_additives_1	1.0632	0.022	Variable water_additives answer: Acidifiers
Log mortality rate	all	additives_7	0.9811	0.02137	Variable additives answer: Don't know
Log mortality rate	B	workers_1	0.97213	0.0332	Variable workers answer: Owner
Log morbidity rate	V	sources_5	0.9547	0.0377	Variable sources answer: Crop farming
Log morbidity rate	all	additives_0	0.9414	0.0031	Variable additives answer: None
Log morbidity rate	all	sources_10	0.934298	0.01852	Variable sources answer: Own business
Log morbidity rate	B	water_additives_6	0.9329	0.0377	Variable water_additives answer: Antibiotics
Log morbidity rate	all	capital_5	0.9208	0.006452	Variable capital answer: Relatives
Log morbidity rate	B	water_additives_5	0.9014	0.0236	Variable water_additives answer: Vitamins
Log mortality rate	V	additives_1	0.8983	0.00825	Variable additives answer: Acidifiers
Log mortality rate	T	water_additives_5	0.8682	0.00904	Variable water_additives answer: Vitamins
Log morbidity rate	B	income	0.8444	0.0216	Does your household have other sources of income?
Log mortality rate	all	adders_99	0.833	0.0141	Variable adders answer: Other
Log mortality rate	all	capital_4	0.8018	0.004033	Variable capital answer: Bank
Log mortality rate	T	water_additives_3	0.7726	0.00723	Variable water_additives answer: Probiotics
Log mortality rate	all	additives_99	0.7268	0.02437	Variable additives answer: Other

Log morbidity rate	all	sources_11	0.723133	0.00386	Variable sources answer: Other 1
Log mortality rate	all	planning_99	0.69887	0.00154	Variable planning answer: Yes, other drugs
Log morbidity rate	all	water_additives_6	0.694	0.00436	Variable water_additives answer: Antibiotics
Log mortality rate	all	workers_99	0.64255	0.00907	Variable workers answer: Other
Log mortality rate	all	additives_2	0.6139	0.00781	Variable additives answer: Minerals
Log mortality rate	T	presentation_1	0.607	0.0394	Variable presentation answer: Pellet
Log mortality rate	T	water_additives_99	0.5854	0.04153	Variable water_additives answer: Other
Log mortality rate	all	additives_0	0.5467	0.04094	Variable additives answer: None
Log mortality rate	all	additives_5	0.54	0.02473	Variable additives answer: Vitamins
Log mortality rate	all	water_additives_4	0.53326	0.00482	Variable water_additives answer: Sanitisers
Log mortality rate	all	additives_1	0.516	0.00763	Variable additives answer: Acidifiers
Log mortality rate	all	adders_3	0.5095	0.0015	Variable adders answer: By feed company
Log morbidity rate	all	workers_5	0.44957	0.0459	Variable workers answer: Relatives
Log mortality rate	T	water_additives_1	0.37	0.04761	Variable water_additives answer: Acidifiers
Log mortality rate	B	num	-8.13E-05	0.04181	What is the maximum number of birds you can have?
Log mortality rate	T	income	-0.3934	0.0215	Does your household have other sources of income?
Log mortality rate	all	sources_2	-0.45013	0.0324	Variable sources answer: Other livestock farming
Log mortality rate	all	additives_3	-0.5004	0.02071	Variable additives answer: Probiotics
Log mortality rate	B	populated	-0.511	0.00778	How many sheds/enclosures are currently populated?
Log morbidity rate	B	populated	-0.6656	0.00889	How many sheds/enclosures are currently populated?
Log mortality rate	all	education_4	-0.779	0.0222	Higher secondary
Log mortality rate	all	workers_1	-0.80917	0.01117	Variable workers answer: Owner
Log mortality rate	all	sources_3	-0.96682	0.0434	Variable sources answer: Employee salary
Log morbidity rate	T	water_additives_5	-1.02013	0.0275	Variable water_additives answer: Vitamins
Log morbidity rate	B	adders_3	-1.0326	0.0123	Variable adders answer: By feed company
Log mortality rate	B	additives_3	-1.1466	0.0132	Variable additives answer: Probiotics
Log morbidity rate	all	workers_2	-1.1683	0.0491	Variable workers answer: Manager
Log morbidity rate	V	presentation_2	-1.2301	0.0235	Variable presentation answer: Crumb
Log mortality rate	all	workers_2	-1.39581	0.00514	Variable workers answer: Manager
Log morbidity rate	G	workers_3	-1.4133	0.0146	Variable workers answer: Permanent employees
Log morbidity rate	all	adders_2	-1.4716	0.0166	Variable adders answer: By the feed dealer

Log morbidity rate	B	adders_2	-1.849	0.0179	Variable adders answer: By the feed dealer
Log morbidity rate	B	presentation_1	-1.8572	0.0457	Variable presentation answer: Pellet
Log morbidity rate	G	education_99	-2.8091	0.0496	Other
Log mortality rate	G	education_99	-2.8381	0.0447	Other

- Description of mortality rate and morbidity rate with pathogen occurrence (summary table & boxplot)

Description of the outcome(mortality rate / morbidity rate) with pathogens occurrence

1. Mortality rate

$$\text{Mortality rate} = 1000 \times \frac{\text{number of death}(n)}{\text{total number of chicken}(N) \times \text{age}(days)}, \text{ unit: / 1000 days}$$

Table1. Summary table of mortality rate with pathogen occurrence

Region	Pathogen	Test result	Obs.	Mean	Sd.	min	max	Total ob s.
Bangladesh	aiv	m	+	3	0.955	0.864	0.061	1.786
			-	97	1.821	4.487	0.054	38.462
		H9	+	3	0.955	0.864	0.061	1.786
			-	97	1.821	4.487	0.054	38.462
		H5	+	1	0.061	-	0.061	0.061
			-	99	1.812	4.442	0.054	38.462
	campy	ccoli	+	36	1.382	1.161	0.061	4.167
			-	64	2.027	5.462	0.054	38.462
		cjejuni	+	6	1.148	0.79	0.326	2.438
			-	94	1.84	4.56	0.05	38.46
	ecoli		+	88	1.955	4.69	0.054	38.462
			-	12	0.619	0.558	0.061	1.786
		nts	+	5	1.703	1.331	0.452	3.448
			-	95	1.8	4.53	0.054	38.462
Gajurat	campy	ccoli	+	6	1.116	0.395	0.658	1.72
			-	44	3.55	8.461	0.019	47.04
		cjejuni	+	6	1.612	1.422	0.427	0.815
			-	44	3.482	8.466	0.019	47.04
		ecoli	+	27	3.308	6.444	0.427	28.822
			-	23	3.198	9.607	0.019	47.04
	nts		+	0	-	-	-	-
			-	50	3.257	7.967	0.019	47.04
Tamil Nadu	campy		+	27	1.93	1.632	0.594	9.231
			-	22	1.832	1.27	0.675	6.393
	ecoli		+	46	1.868	1.483	0.594	9.231
			-	3	2.167	1.41	0.712	3.526
	nts		+	23	1.856	1.249	0.594	6.393
			-	26	1.912	1.66	0.712	9.231
Viet Nam	aiv	m	+	7	0.793	1.079	0.168	3.191

100

50

49

		-	42	0.458	0.423	0	2.358	
H9		+	5	0.9	1.01	0.17	2.66	
		-	44	0.44	0.41	0	2.36	
		H5	+ 0	-	-	-	-	
			- 49	0.49	0.5	0	2.66	
campy	ccoli	+ 37	0.51	0.57	0	2.66		
		- 12	0.42	0.18	0.15	0.72		
	cjejuni	+ 28	0.49	0.52	0.05	2.66		
		- 21	0.48	0.49	0	2.36		
	ecoli	+ 49	0.506	0.559	0	3.191		
		- 0	-	-	-	-		
	nts	+ 9	0.303	0.146	0.067	0.562		
		- 40	0.551	0.607	0	3.191		

Table2. Summary table of mortality rate with pathogen occurrence (all regions)

Pathogen	Test result	Obs.	Mean	Std. dev.	Min	Max	Total Obs.
nts	+	37	1.458	1.264	0.067	6.393	248
	-	211	1.922	5.018	0	47.04	
ecoli	+	210	1.772	3.945	0	38.462	
	-	38	2.302	7.517	0.019	47.04	
campy	+	122	1.165	1.223	0	9.231	
	-	126	2.519	6.361	0.019	47.04	
aiv	+	10	0.841	0.973	0.061	3.191	149(only V&B)
	-	139	1.458	1.264	0.067	6.393	

Table3. Summary table of mortality rate with different types of aiv and Campy (all regions)

pathogen		Test result	Obs.	Mean	Std. dev.	Min	max	Total obs.
campy	ccoli	+	79	0.95	0.97	0	4.17	200(only B, G&V)
		-	121	2.42	6.53	0.02	47.04	
	cjejuni	+	40	0.76	0.84	0.05	4.29	
		-	160	2.11	5.72	0	47.04	
aiv	m	+	10	0.79	0.84	0.06	2.66	149(only B&V)
		-	139	1.41	3.8	0	38.46	
	H9	+	8	0.92	0.89	0.06	2.66	
		-	141	1.39	3.78	0	38.46	
	H5	+	1	0.06	-	-	-	
		-	148	1.37	3.69	0	38.46	

2. Morbidity rate

Morbidity rate=1000 × $\frac{\text{number of real sick}(n)}{\text{total number of chicken}(N) \times \text{age}(day)}$, unit: / 1000 days

Table1. Summary table of morbidity rate with pathogen occurrence

Region	Pathogen	Test result	Obs.	Mean	Sd.	min	max	Total obs.	
Bangladesh	aiv	m	+	3	4.05	4.74	0.87	9.49	100
			-	97	7.91	13.88	0.05	105.07	
		H9	+	3	4.05	4.74	0.87	9.49	
			-	97	7.91	13.88	0.05	105.07	
		H5	+	1	0.87	-	0.87	0.87	
			-	99	7.87	13.75	0.05	105.07	
	campy	ccoli	+	36	8.8	9.97	0.2	40.34	
			-	64	7.23	15.45	0.05	105.07	
		cjejuni	+	6	5.62	5.18	0.33	13.88	
			-	94	7.94	14.07	0.05	105.13	
		ecoli	+	88	8.6	14.41	0.05	105.13	
			-	12	1.93	1.96	0.17	6.46	
		nts	+	5	15.16	16.96	0.71	37.49	
			-	95	7.41	13.5	0.05	105.13	
Gajurat	campy	ccoli	+	6	1.18	0.43	0.72	1.92	50
			-	44	4.04	9.6	0.02	51.52	
		cjejuni	+	6	2.08	2.24	0.61	6.52	
			-	44	3.91	9.61	0.02	51.52	
	ecoli	-	+	27	3.81	7.76	0.38	30.7	
			-	23	3.56	10.54	0.02	51.52	
		nts	+	0	-	-	-	-	
			-	50	3.69	9.05	0.02	51.52	
Tamil Nadu	campy	-	+	27	2.23	1.76	0.75	9.23	49
			-	22	3.6	4.79	0.67	23.08	
		ecoli	+	46	2.78	3.54	0.67	23.08	
			-	3	4.11	3.41	0.87	7.67	
	nts	-	+	23	3.57	4.67	0.75	23.08	
			-	26	2.21	1.80	0.67	9.23	
		m	+	7	1.13	1.18	0.33	3.72	
			-	42	1.37	2.15	0	11.08	
Viet Nam	aiv	H9	+	5	1.3	1.37	0.33	3.72	49
			-	44	1.33	2.11	0	11.8	

campy	H5		+	0	-	-	-	
			-	49	1.33	2.04	0	11.08
	ccoli		+	37	1.47	2.31	0	11.08
			-	12	0.91	0.64	0.15	2.17
	cjejuni		+	28	1.11	0.98	0.05	3.72
			-	21	1.63	2.91	0	11.08
	ecoli		+	49	1.33	2.04	0	11.08
			-	0	-	-	-	-
	nts		+	9	1.66	2.77	0.16	8.99
			-	40	1.26	1.87	0	11.08

Pathogen	Test result	Obs.	Mean	Std. dev.	Min	Max	Total Obs.
nts	+	37	4.57	8.08	0.16	37.49	248
	-	211	4.75	10.43	0	105.13	
ecoli	+	210	5.02	10.39	0	105.13	
	-	38	3.09	8.28	0.02	51.52	
campy	+	122	3.92	6.56	0	40.34	
	-	126	5.49	12.58	0.02	105.13	
aiv	+	10	2	2.81	0.33	9.94	149(only V&B)
	-	139	5.93	12.02	0	105.13	

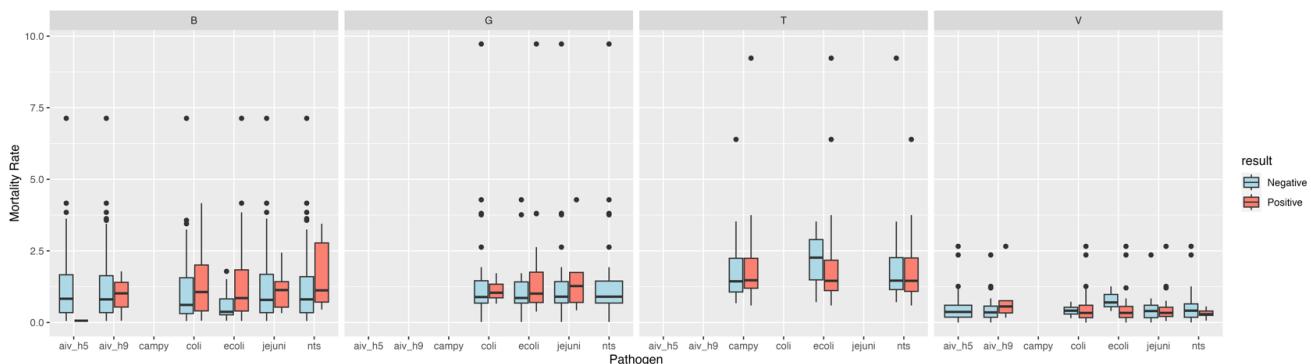
Table2. Summary table of morbidity rate with pathogen occurrence(all regions)

Table3. Summary table of morbidity rate with different types of aiv and Campy (all regions)

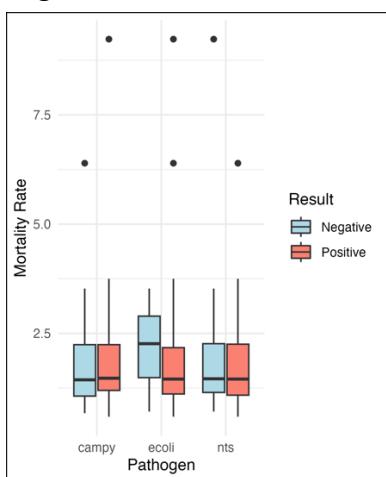
pathogen		Test result	Obs.	Mean	Std. dev.	Min	max	Total obs.
campy	ccoli	+	79	4.79	7.79	0	40.34	200(only B, G&V)
		-	121	5.43	12.82	0.02	105.13	
	cjejuni	+	40	1.93	2.71	0.05	13.88	
		-	160	5.99	12.19	0	105.13	
aiv	m	+	10	2	2.81	0.33	9.49	149(only B&V)
		-	139	5.93	2.02	0	105.13	
	H9	+	8	2.33	3.08	0.33	9.49	
		-	141	5.86	11.95	0	105.13	
	H5	+	1	0.87	-	-	-	
		-	148	5.7	11.7	0	105.13	

Boxplots for pathogen occurrence and mortality rate(1000/day)

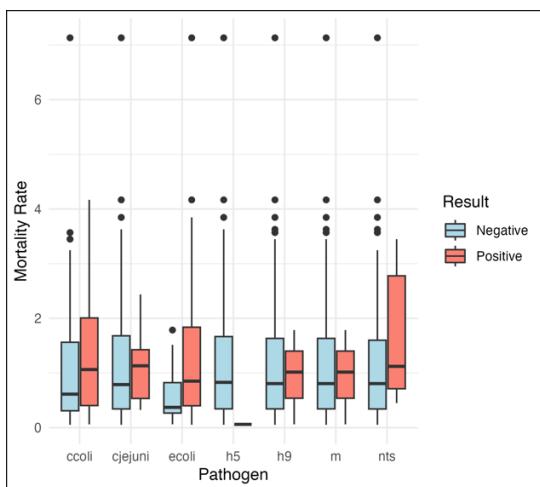
Comparing on the same scale:



Region T:

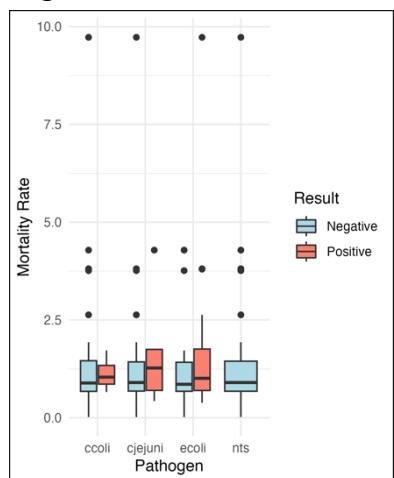


Region B: There are two farms' mortality rate greater than 10, to better use boxplot show the overall situation of the data, these two farms are temporarily deleted.
(Farm id: 517, 562)



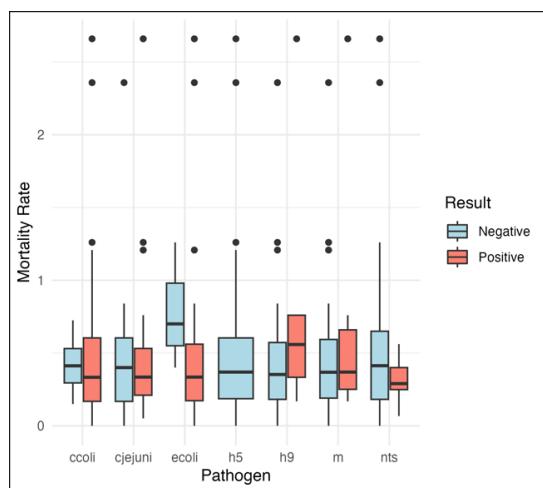
Farm id	Mortality rate (1000/day)
517	22.22
562	38.46

Region G: Delete three farms with mortality rate > 10 (Farm id: 124, 126, 133)

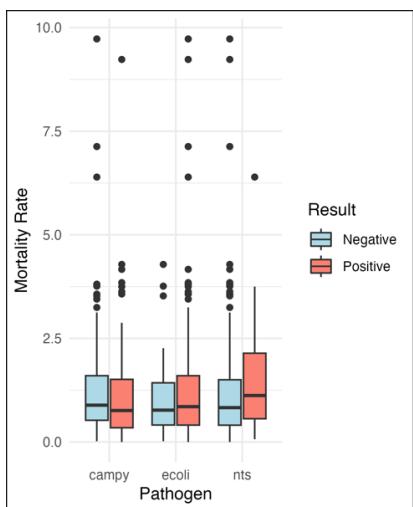


Farm id	Mortality rate (1000/day)
124	19.74
126	28.82
133	47.04

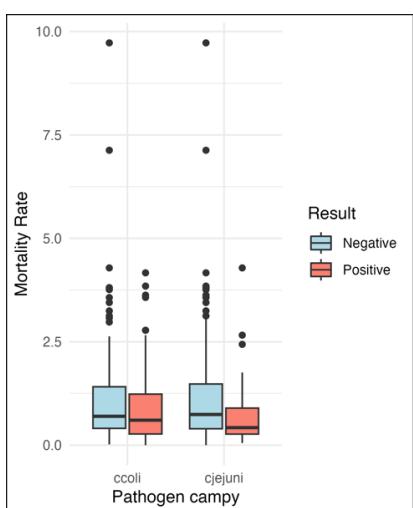
Region V



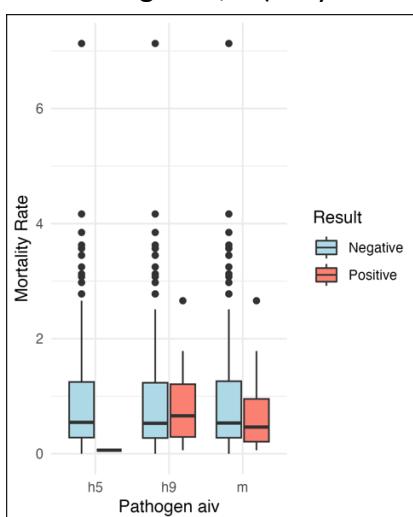
Overall: region T, B, G, V (Also drop the farms with mortality rate >10)



Overall: region B, G, V (There is no specific classification data of campy pathogens in region T)

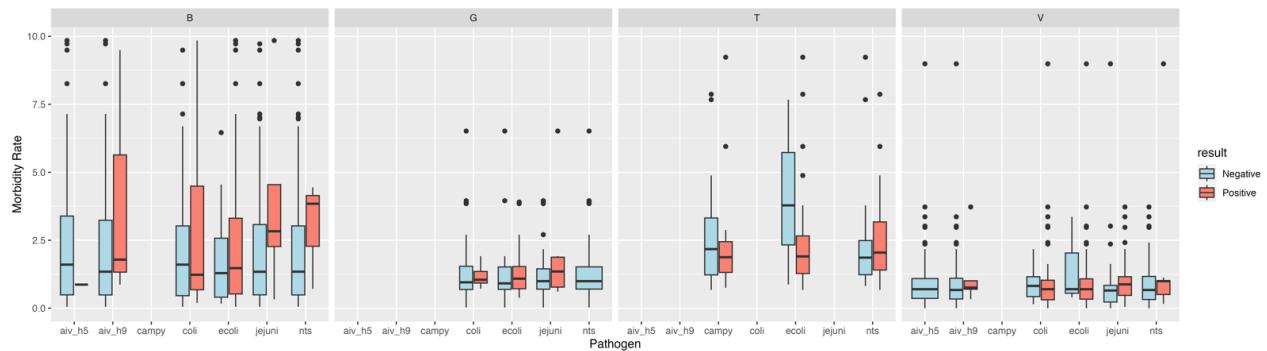


Overall: region B, V (Only these two regions have the av recordings)

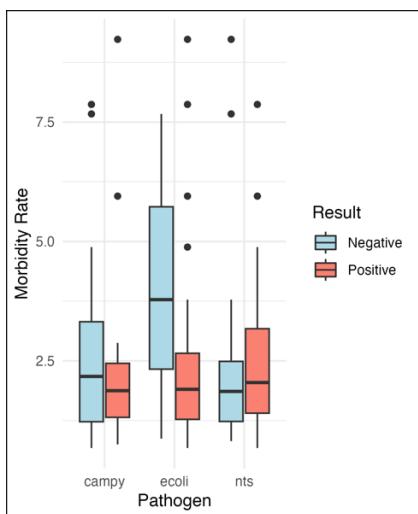


Boxplot for pathogens occurrence and morbidity rate(1000/day)

Comparing on the same scale:

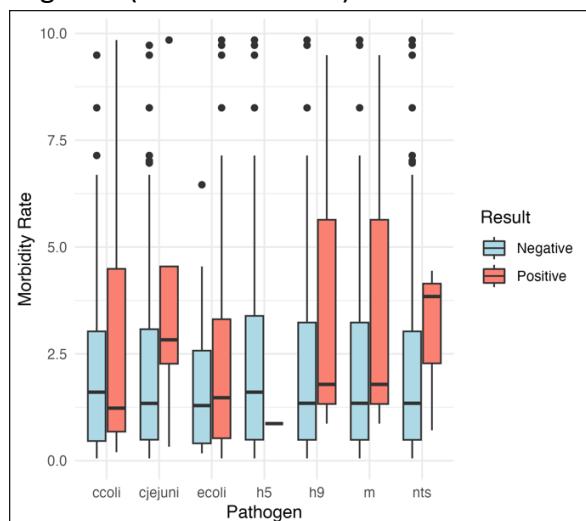


Region T (delete one farm)



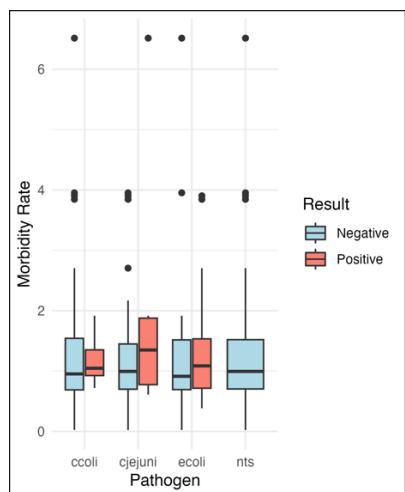
Farm id	Morbidity rate (1000/day)
541	23.08

Region B (delete 26 farms)



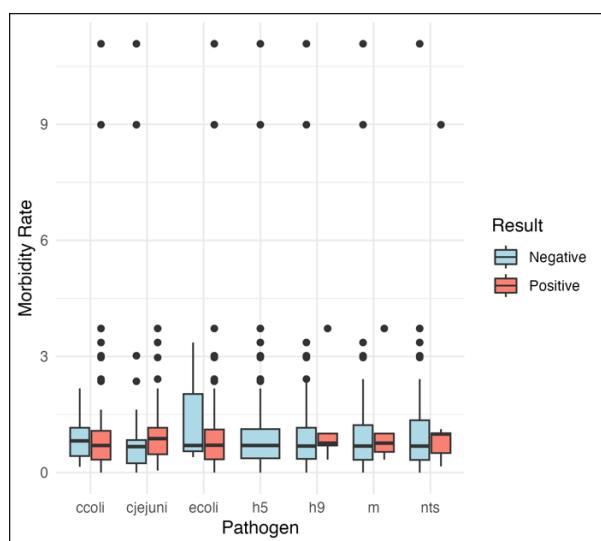
Farm id	Morbidity rate	Farm id	Morbidity rate
501	13.60544	531	11.48325
517	51.85185	542	13.82479
521	37.48597	543	16.45465
522	20.3125	562	105.1282
523	40.34286	564	14.58333
525	10.34483	565	29.31034
526	22.4	602	13.75
529	12.76667	611	10.83333
622	14.18386	645	26.48571
623	12.44131	663	13.85965
625	14.0024	665	13.88046
628	16.34615	666	15.34598
630	35.23809	681	16.04278

Region G (delete 4 farms)



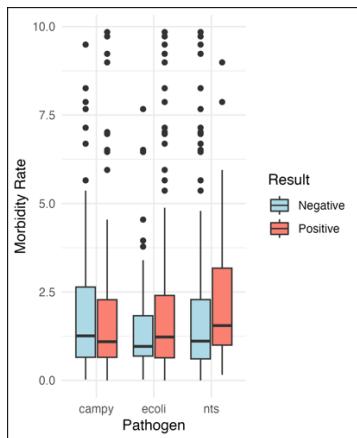
Farm id	Morbidity rate (1000/day)
124	30.70
126	29.01
133	51.52
136	10.33

Region V (delete 1 farm)

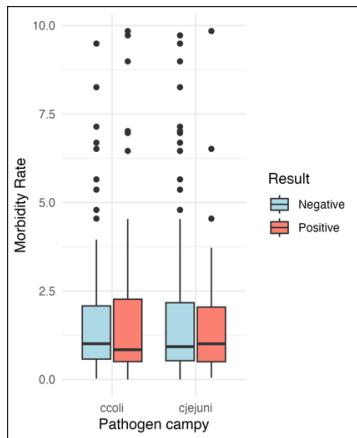


Farm id	Morbidity rate (1000/day)
568	11.08

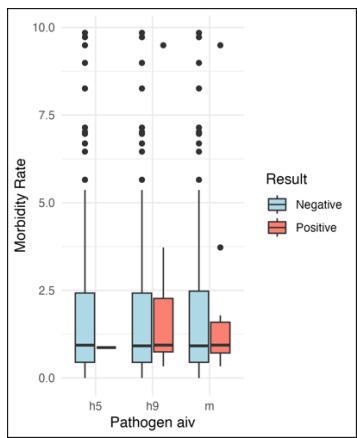
Overall: region T, B, G, V (Also drop the farms with mortality rate >10)



Overall: region B, G, V (There is no specific classification data of campy pathogens in region T)



Overall: region B, V (Only these two regions have the aiv recordings)



Clinical signs

- Summary of the clinical signs and grouped clinical signs

Summary of clinical signs

Table. Summary table of clinical signs 1

Signs in variables	Number of farms			
	T	V	G	B
None	18(21.2%)	21(29.2%)	8(7.1%)	27(10.7%)
Ruffled feathers	1(1.2%)	3(4.2%)	1(0.9%)	8(3.2%)
Prostration	0	0	0	1(0.4%)
Does not move	0	0	5(4.5%)	10(4.0%)
Loss of coordination	0	0	3(2.7%)	5(2.0%)
Circling	1(1.2%)	0	0	0
Coughing	4(4.7%)	2(2.8%)	12(10.7%)	28(11.1%)
Sneezing	9(10.6%)	1(1.4%)	9(8.0%)	29(11.5%)
Nasal/ocular discharge	14(16.5%)	1(1.4%)	4(3.6%)	9(3.6%)
Abnormal head position	0	0	1(0.9%)	5(2.0%)
Twisted neck	0	0	1(0.9%)	4(1.6%)
Swollen head	2(2.4%)	0	2(1.8%)	2(0.8%)
Swollen wattle/comb	1(1.2%)	0	1(0.9%)	2(0.8%)
Difficult breathing	5(5.9%)	19(26.4%)	11(9.8%)	12(4.7%)
Diarrhoea	9(10.6%)	21(29.2%)	12(10.7%)	36(14.2%)
Blood in faeces	1(1.2%)	2(2.8%)	2(1.8%)	31(12.3%)
Leg lesions/lameness	2(2.4%)	2(2.8%)	26(23.2%)	18(7.1%)
Haemorrhage on leg(s)	0	0	0	3(1.2%)
Drop in egg yield	0	0	0	0
Sudden death	7(8.2%)	0	6(5.4%)	9(3.6%)
Heat stroke	5(5.9%)		Stunted growth	2(1.8%)
Distended abdomen	1(1.2%)	0	PM lesions showing E. coli infection	Liver cirrhosis
Gout	1(1.2%)		Ascites	1(0.4%)
Other supply of	1(1.2%)		Summer	Overcrowding
				Fever
				2(0.8%)
				2(0.8%)

	weak		stress	
	chicks			
Kidney		Depressed		
Swelling	1(1.2%)	feed	1(0.9%)	Conjunctivitis
		consumption		1(0.4%)
E.coli	1(1.2%)			Ascites, off-fed 1(0.4%)
				Eye lesions 1(0.4%)
				Swollen abdomen 1(0.4%)
IBD at				Fever, Head
Young age	1(1.2%)	Growth low	1(0.9%)	twisted, Watery 1(0.4%)
(14 - 17 days)				Fever, white
				watery diarrhoea,off fed 1(0.4%)
				Overcrowding, Cannibalism 1(0.4%)
				Anorexia 1(0.4%)
Total	85(100%)	72(100%)	112(100%)	253(100%)
Number of farms	50	51	50	100

Table Summary table of clinical signs 2

Number of signs	Signs	Number of farms
2	Abnormal head position, Sudden death	1
2	Blood in faeces, Diarrhoea	1
2	Blood in faeces, Sudden death	1
2	Coughing, Blood in faeces	1
2	Coughing, Difficult breathing	1
2	Coughing, Sneezing	1
2	Diarrhoea, Anorexia	1
2	Diarrhoea, Blood in faeces	3
2	Diarrhoea, Distended abdomen	1
2	Diarrhoea, Leg lesions/lameness	3
2	Difficult breathing, Diarrhoea	8
2	Difficult breathing, Leg lesions/lameness	1
2	Does not move, Leg lesions/lameness	1

2	Does not move, Leg lesions/lameness	1
2	Does not move, Sudden death	1
2	Leg lesions/lameness, Growth low	1
2	Leg lesions/lameness, Sudden death	1
2	Nasal/ocular discharge, Diarrhoea	1
2	Nasal/ocular discharge, Difficult breathing	1
2	Ruffled feathers, Circling	1
2	Ruffled feathers, Coughing	1
2	Ruffled feathers, Diarrhoea	1
2	Ruffled feathers, Sudden death	1
2	Sneezing, Difficult breathing	1
2	Sneezing, E.coli	1
2	Sneezing, Nasal/ocular discharge	1
2	Sneezing, Sudden death	1
2	Sudden death, Heat stroke	1
2	Sudden death, Liver cirrhosis	1
3	Abnormal head position, Leg lesions/lameness, Sudden death	1
3	Coughing, Abnormal head position, Diarrhoea	1
3	Coughing, Diarrhoea, Leg lesions/lameness	2
3	Coughing, Difficult breathing, Leg lesions/lameness	1
3	Coughing, Sneezing, Difficult breathing	1
3	Coughing, Sneezing, Nasal/ocular discharge	2
3	Coughing, Sneezing, Swollen abdomen	1
3	Coughing, Sneezing, Twisted neck	1
3	Diarrhoea, Blood in faeces, Leg lesions/lameness	1
3	Diarrhoea, Blood in faeces, Leg lesions/lameness	1
3	Diarrhoea, Haemorrhage on leg(s), Sudden death	1
3	Diarrhoea, Leg lesions/lameness, Ascites	1
3	Diarrhoea, Leg lesions/lameness, Stunted growth	1
3	Diarrhoea, overcrowding, Cannibalism	1
3	Difficult breathing, Diarrhoea, Blood in faeces	1
3	Difficult breathing, Diarrhoea, Leg lesions/lameness	1
3	Difficult breathing, Leg lesions/lameness, Depressed feed consumption	1
3	Does not move, Diarrhoea, Blood in faeces	1
3	Does not move, Difficult breathing, Leg lesions/lameness	1
3	Does not move, Difficult breathing, Sudden death	1

3	Does not move, Leg lesions/lameness, Stunted growth	1
3	Does not move, Nasal/ocular discharge, Leg lesions/lameness	1
3	Fever, Head twisted, Watery diarrhoea	1
3	Nasal/ocular discharge, Blood in faeces, Heat stroke	1
3	Nasal/ocular discharge, Diarrhoea, Leg lesions/lameness	1
3	Nasal/ocular discharge, Difficult breathing, Diarrhoea	1
3	Nasal/ocular discharge, Leg lesions/lameness, supply of weak chicks	1
3	Ruffled feathers, Coughing, Difficult breathing	1
3	Ruffled feathers, Does not move, Leg lesions/lameness	2
3	Ruffled feathers, Leg lesions/lameness, Eye lesions	1
3	Ruffled feathers, Loss of coordination, Sudden death	1
3	Sneezing, Coughing, Leg lesions/lameness	1
3	Sneezing, Diarrhoea,	2
3	Sneezing, Difficult breathing, Diarrhoea	1
3	Sneezing, Leg lesions/lameness,	1
3	Sneezing, Nasal/ocular discharge, Leg lesions/lameness	1
3	Sneezing, Nasal/ocular discharge, Swollen head	1
4	Coughing, Diarrhoea, Blood in faeces, Leg lesions/lameness	1
4	Coughing, Nasal/ocular discharge, Blood in faeces, Leg lesions/lameness	1
4	Coughing, Sneezing, Blood in faeces, Leg lesions/lameness	1
4	Coughing, Sneezing, Blood in faeces, Sudden death	1
4	Coughing, Sneezing, Diarrhoea, Blood in faeces	2
4	Coughing, Sneezing, Diarrhoea, Fever	1
4	Coughing, Sneezing, Difficult breathing, Blood in faeces	1
4	Coughing, Sneezing, Difficult breathing, Diarrhoea	1
4	Coughing, Sneezing, Difficult breathing, Leg lesions/lameness	1
4	Coughing, Sneezing, Leg lesions/lameness, Ascites	1
4	Coughing, Sneezing, Nasal/ocular discharge, Blood in faeces	1
4	Coughing, Sneezing, Nasal/ocular discharge, Diarrhoea	1
4	Coughing, Swollen head, Diarrhoea, Blood in faeces	1
4	Does not move, Difficult breathing, Diarrhoea, Blood in faeces	1
4	Loss of coordination, Abnormal head position, Diarrhoea, Haemorrhage on leg(s)	1
4	Nasal/ocular discharge, Diarrhoea, Sudden death, Kidney Swelling	1
4	Ruffled feathers, Coughing, Difficult breathing, Diarrhoea	1
4	Sneezing, Twisted neck, Diarrhoea, Blood in faeces	1
5	Coughing, Sneezing, Diarrhoea, Blood in faeces, Conjunctivitis	1
5	Coughing, Sneezing, Diarrhoea, Blood in faeces, Leg lesions/lameness	1
5	Coughing, Sneezing, Difficult breathing, Diarrhoea, Blood in faeces	1
5	Coughing, Sneezing, Nasal/ocular discharge, Diarrhoea, Blood in faeces	1
5	Coughing, Sneezing, Nasal/ocular discharge, Difficult breathing, Leg lesions/lameness	1
5	Coughing, Sneezing, Twisted neck, Diarrhoea, Blood in faeces	1

5	Does not move, Nasal/ocular discharge, Difficult breathing, Diarrhoea, Leg lesions/lameness	1
5	Does not move, Twisted neck, Swollen head, Ascites, off-fed	1
5	Nasal/ocular discharge, Blood in faeces, Leg lesions/lameness, Sudden death, Ascites	1
5	Nasal/ocular discharge, Diarrhoea, IBD at Young age (Diarrhoea, - Haemorrhage on leg(s), days)	1
5	Sneezing, Nasal/ocular discharge, Swollen wattle/comb, Difficult breathing, Blood in faeces	1
5	Twisted neck, Swollen wattle/comb, Difficult breathing, Diarrhoea, Blood in faeces	1
6	Coughing, Sneezing, Diarrhoea, Blood in faeces, Leg lesions/lameness, Ascites	1
6	Coughing, Sneezing, Nasal/ocular discharge, Diarrhoea, Haemorrhage on leg(s), Fever	1
6	Coughing, Sneezing, Nasal/ocular discharge, Swollen head, Swollen wattle/comb, Difficult breathing	1
6	Does not move, Coughing, Sneezing, Nasal/ocular discharge, Diarrhoea, Leg lesions/lameness	1
6	Does not move, Loss of coordination, Sneezing, Abnormal head position, Diarrhoea, Leg lesions/lameness	1
6	Loss of coordination, Coughing, Sneezing, Diarrhoea, Leg lesions/lameness, Sudden death	1
6	Loss of coordination, Coughing, Sneezing, Fever, white watery diarrhoea, off fed	1
6	Loss of coordination, Coughing, Sneezing, Swollen head, Diarrhoea, Leg lesions/lameness	1
6	Prostration, Sneezing, Nasal/ocular discharge, Abnormal head position, Difficult breathing, Blood in faeces	1
7	Loss of coordination, Coughing, Sneezing, Nasal/ocular discharge, Swollen head, Swollen wattle/comb, Diarrhoea	1

Summary of grouped clinical signs.

Clinical signs	Number of clinical signs is reported				
	Tamil Nadu	Bangladesh	Gujarat	Vietnam	Overall
None	18(21.7%)	27(10.7%)	8(7.2%)	21(29.2%)	74(14.3%)
Weakness/anorexia	2(2.4%)	20(7.9%)	7(6.3%)	3(4.2%)	32(6.2%)
Neurological	1(1.2%)	14(5.5%)	5(4.5%)	0	20(3.9%)
Respiratory	32(38.6%)	79(31.2%)	36(32.4%)	23(31.9%)	170(32.8%)
Gastro-intestinal	11(13.3%)	73(28.9%)	16(14.4%)	23(31.9%)	123(23.7%)
Locomotion	2(2.4%)	21(8.3%)	26(23.4%)	2(2.8%)	51(9.8%)
Other lesions	Swollen head	2(2.4%)	2(0.8%)	2(1.8%)	0
	Swollen wattle/comb	1(1.2%)	2(0.8%)	1(0.9%)	0
	Sudden death	7(8.4%)	9(3.6%)	6(5.4%)	0
	Heat stroke	5(6.0%)	0	0	0
	Summer stress	0	0	1(0.9%)	0
	Kidney Swelling	1(1.2%)	0	0	0
	Stunted growth	0	0	3(2.7%)	0
	Gout	1(1.2%)	0	0	0
	Liver cirrhosis	0	1(0.4%)	0	0
	Overcrowding	0	2(0.8%)	0	0
	Fever	0	1(0.4%)	0	0
	Cannibalism	0	1(0.4%)	0	0
	Eye lesions	0	1(0.4%)	0	0
	Overall	83(100%)	253(100%)	111(100%)	72(100%)
Number of farms					
	50	100	50	51	201

#. Three farms that have reported clinical signs of a pathogen or disease are being deleted from the above table. Only G_149 recorded the pathogen information in the next disease variable.

Farm id	Answer of clinical sign	Disease caused these clinical sign
T_541	E.coli	Gnuzing
T_547	IBD	Due to wet litter and continuous sarin
G_149	E.coli	E.coli

- Cross table of grouped clinical signs (Respiratory and Gastro-intestinal) & 4 types of pathogens' occurrence

Cross table of grouped clinical signs (Respiratory & Gastro-intestinal) and pathogen (nts) – by site & overall

Respiratory

Table Region B's cross table of grouped clinical signs (Respiratory) and nts occurrence

Region B		nts		Total count
		+	-	
Respiratory	Yes	2	40	42
	No	3	55	58
Total count		5	95	100

Table Region T's cross table of grouped clinical signs (Respiratory) and nts occurrence

Region T		nts		Total count
		+	-	
Respiratory	Yes	10	10	20
	No	13	17	30
Total count		23	27	50

Table Region V's cross table of grouped clinical signs (Respiratory) and nts occurrence

Region V		nts		Total count
		+	-	
Respiratory	Yes	4	16	20
	No	13	17	30
Total count		17	33	50

Table All regions' cross table of grouped clinical signs (Respiratory) and nts occurrence

All regions		nts		Total count
		+	-	
Respiratory	Yes	16	87	103
	No	22	126	148
Total count		38	213	251

Gastro-intestinal

Table Region B's cross table of grouped clinical signs (Gastro-intestinal) and nts occurrence

Region B		nts		Total count
		+	-	
Gastro-intestinal	Yes	4	51	55
	No	1	44	45
Total count		5	95	100

Table Region T's cross table of grouped clinical signs (Gastro-intestinal) and nts occurrence

Region T		nts		Total
		+	-	
Gastro-intestinal	Yes	6	4	10
	No	17	23	40
Total		23	27	50

Table Region V's cross table of grouped clinical signs (Gastro-intestinal) and nts occurrence

Region V		nts		Total
		+	-	
Gastro-intestinal	Yes	5	16	21
	No	5	25	30
Total		10	41	51

Table All regions' cross table of grouped clinical signs (Gastro-intestinal) and nts occurrence

All regions		nts		Total
		+	-	
Gastro-intestinal	Yes	15	84	99
	No	23	129	152
Total		38	213	251

Cross table and OR value of grouped clinical signs (Respiratory & Gastro-intestinal) and pathogen (salmonella, campylobacter, AI-H5, AI-H9) -overall sites

Table cross table of clinical signs R&G and 4 pathogens

		Respiratory		Total	Gastro-intestinal		Total
		+	-		+	-	
Salmonella	+	16	22	38	15	23	38
	-	87	126	213	84	129	213
Total		103	148	251	99	152	251
Campylobacter	+	49	73	122	54	68	122
	-	54	75	129	45	84	129
Total		103	148	251	99	152	251
AI-H5	+	0	1	1	1	0	1
	-	62	88	150	75	75	150
Total		62	89	151	76	75	151
AI-H9	+	3	5	8	5	3	8
	-	59	84	143	71	72	143
Total		62	89	151	76	75	151

Table Odds Ratio of clinical signs R&G and 4 pathogens

OR (95%CI)			
		Clinical Signs	
		Gastro-intestinal	Respiratory
Pathogens	AI-H5	infinity (0 to infinity)	0 (0)
	AI-H9	1.69 (0.39 to 7.34)	0.85 (0.2 to 3.71)
	Campylobacter	1.48 (0.89 to 2.47)	2.18 (1.35 to 3.49)
	Salmonella	1 (0.49 to 2.03)	1.05 (0.52 to 2.12)

RESULTS- Association

Pathogen occurrence & Clinical signs



- Description of farmers who know the disease, disease name, and farmers' information source (Q 5.1.1 & Q 5.1.1.1) & Description of the way farmers handle sick and dead chickens (Q 5.1.3, Q 5.1.4, Q 5.3, Q 5.4)

Across the four regions, a total of 250 farms were surveyed, and the overall awareness level of farmers regarding the diseases causing the observed clinical signs was found to be 57%. Notably, Gujarat exhibited the highest proportion with 82% awareness, whereas Vietnam had the lowest level at 41%.

Region	Number of farmers	Percentage of farmers
Tamil Nadu	29	58%
Bangladesh	52	52%
Gujarat	41	82%
Vietnam	21	41%
Overall	143	57%

Table 1 Number of farmers who know which disease caused those clinical signs.

In the overall level of the 201 farmers who provided affirmative responses regarding their knowledge of diseases causing clinical signs in farms, Chronic Respiratory Disease (CRD) was identified as the most frequently mentioned disease, accounting for 21% of the responses. Coccidiosis, E. coli, and Infectious Bursal Disease (IBD) had similar levels of occurrence, each accounting for approximately 15% of the responses. When focusing on each region individually, it was found that heat stroke was the most frequently reported disease in Tamil Nadu, IBD in Bangladesh, E. coli in Gujarat, and CRD in Vietnam.

Disease name	Number of diseases is reported				
	Tamil Nadu	Bangladesh	Gujarat	Vietnam	Overall
Chronic Respiratory Disease	9	1	19	13	42
Coccidiosis	1	17	9	5	32
E. coli	0	1	28	1	30
Gumbro/IBD	0	23	6	0	29
Heat stroke	10	0	2	0	12
Newcastle disease	0	9	0	1	10
Lamness	0	0	7	0	7
Gout	1	4	0	0	5
Enteritis	3	2	0	0	5
Pneumonia	0	5	0	0	5
Black head disease	0	0	0	5	5
Nutritional deficiency	0	0	3	0	3
Ascites	0	0	3	0	3
Infectious Bronchitis	2	0	0	0	2
Common flu	0	2	0	0	2
Sudden death syndrome	1	0	0	0	1
Bursa in flame	1	0	0	0	1
Stroke	0	1	0	0	1
Infectious Laryngotracheitis	0	0	0	1	1
Ranikhet disease	0	0	1	0	1

Metabolic disease	0	0	1	0	1
Depressed problem	0	0	1	0	1
Fatty liver haemorrhagic syndrome	0	0	1	0	1
Heart attack	0	0	1	0	1
Overall	28	65	82	26	201

Table 2 Farmers' answer of which disease caused the clinical signs.

In tracing the sources of information regarding the diseases causing the observed clinical signs, it was found that among the total of 162 affirmative responses across the four regions, nearly 50% of farmers relied on their own experience to make determinations. Additionally, 23% of farmers sought consultation from private veterinarians. In Tamil Nadu, contractors' veterinarians also emerged as important sources of information.

Information source of disease	Number of sources of disease is reported				
	Tamil Nadu	Bangladesh	Gujarat	Vietnam	Overall
Owen experience	15	23	40	2	80
Internet search	0	0	0	0	0
Contractor, their vet	13	5	1	0	19
Feed/ drug seller	0	5	0	1	6
Drug company rep	1	2	0	0	3
Private surgeon	2	23	0	13	38
Government vet	0	0	0	0	0
Paravet/ vet field assistant	1	3	1	3	8
Other farms(s)	0	1	0	0	1
Laboratory analyses	1	0	0	0	1
Famer supervisor	4	0	0	0	4
Company vet	0	2	0	0	2
Overall	37	64	42	19	162

Table 3 Farmers' answer of how they know the disease.

Cross table for disease name and information source(overall)

Disease name	Information source of disease			Number of diseases reported
	Own experience	Contractor, their vet	Private surgeon	
CRD	60%	12%	31%	42
Coccidiosis	59%	9%	38%	32
E. coli	9%	3%	3%	30
Gumbro/IBD	55%	3%	31%	29
Heat stroke	83%	8%	8%	12
Newcastle disease	4%	1%	5%	10

For the top six reported diseases, which account for a significant proportion, it is observed that the primary sources of information are personal experience and diagnosis from private surgeon.

Description of question 5.1.3/5.1.4/5.3/5.4

Question 5.1.3 Do you have a separate shed/enclose for sick birds?

Overall, across the four regions, it was reported that 88% of farms did not have a separate shed for sick birds and 34% of farms reported mixing sick birds with healthy ones.

Separate shed for sick birds	Number of farms				
	Tamil Nadu	Bangladesh	Gujarat	Vietnam	Overall
Yes	8(26%)	6(8%)	5(12%)	2(7%)	21(12%)
No, they mix with healthy bird	5(16%)	36(48%)	0	20(69%)	61(34%)
No, but I isolate them in the same shed	18(58%)	33(44%)	37(88%)	7(24%)	95(54%)
Overall	31	75	42	29	177

Question 5.1.4 What did you do with the sick chickens?

Overall, in the reported 271 methods of handling sick birds, it was found that “treated” accounted for 59% of the approaches. A proportion, approximately 24%, involved leaving the sick birds untreated. In Tamil Nadu, burying the sick birds in a death pit was also a relatively common method, accounting for approximately 20% of the responses. In Bangladesh, eating the sick birds was reported in approximately 18% of the cases.

Treatment of sick birds		Number of treatments is reported				
		Tamil Nadu	Bangladesh	Gujarat	Vietnam	Overall
Nothing		16	26	0	22	64
Burnt		0	0	0	0	0
Buried	Death pit	10	9	1	0	12
	Behind farm area		1		1	
Throw away	Nearby Area	4	3	1	1	0
	Garbage		1		0	4
Treated		16	73	41	29	159
Ate		0	23	0	0	23
Fed to animals	Dog	0	1	0	0	1
Sold		0	0	0	0	0
Do the postmortem and disposed to carcass disposal pit		5	0	0	0	5
Give to poor people		0	2	0	0	2
Overall		51	127	42	51	271

Question 5.3 Where do you store the dead birds?

Overall, it was reported that 80% of the farms stored dead birds outside the farm. This trend was consistent in Bangladesh, Gujarat, and Vietnam as well. In Tamil Nadu, storing dead birds in the shed or in the specific room was also the common choices.

Where to store the dead birds	Number of ways is reported				
	Tamil Nadu	Bangladesh	Gujarat	Vietnam	Overall
In the shed	19	3	5	0	27
Outside	15	94	43	51	203
In the specific room	12	0	0	0	12
Death pit	7	0	1	0	8
Throw away	0	3	0	0	3
Buried immediately	0	0	1	0	1
Overall	53	100	50	51	254

Question 5.4 What did you do with the dead birds?

Overall, among the reported 274 methods of handling dead birds, buried accounted for 49% of the approaches, while placing them in dedicated carcass disposal pits represented 26% of the methods. Looking at each specific region, in Gujarat, the use of carcass disposal pits was nearly unanimous. In Bangladesh and Vietnam, throwing away the dead birds or feeding them to animals were also chosen methods.

Treatment of dead birds	Number of treatments is reported							
	Tamil Nadu	Bangladesh		Gujarat	Vietnam		Overall	
Nothing	0	0		0	0		0	
Burnt	2	1		0	3		6	
Buried	Outside farm	28	2	71	4	1	34	6
	Garden		8		2			
	Crop field		0		7			
	Farmyard		0		1			
	Riverside		0		8			
Throw away	Nearby Area	1	1	31	1	0	6	1
	Dustbin		0		2			
	River		0		1			
	Well		0		3			
	Biogas		0		0			
Fed to animals	Fish	0	16	5	0	9	2	25

	Dog		9		6	
	Fox		2		0	
	Eagle		0		1	
Carcass disposal pit		21	0	50	0	71
Ate		0	0	0	0	0
Sold		0	0	0	0	0
Overall		52	119	51	52	274

Summary of grouped clinical signs.

Clinical signs	Number of clinical signs is reported				
	Tamil Nadu	Bangladesh	Gujarat	Vietnam	Overall
None	18(21.7%)	27(10.7%)	8(7.2%)	21(29.2%)	74(14.3%)
Weakness/anorexia	2(2.4%)	20(7.9%)	7(6.3%)	3(4.2%)	32(6.2%)
Neurological	1(1.2%)	14(5.5%)	5(4.5%)	0	20(3.9%)
Respiratory	32(38.6%)	79(31.2%)	36(32.4%)	23(31.9%)	170(32.8%)
Gastro-intestinal	11(13.3%)	73(28.9%)	16(14.4%)	23(31.9%)	123(23.7%)
Locomotion	2(2.4%)	21(8.3%)	26(23.4%)	2(2.8%)	51(9.8%)
Other lesions	Swollen head	2(2.4%)	2(0.8%)	2(1.8%)	6(1.2%)
	Swollen wattle/comb	1(1.2%)	2(0.8%)	1(0.9%)	4(0.8%)
	Sudden death	7(8.4%)	9(3.6%)	6(5.4%)	22(4.2%)
	Heat stroke	5(6.0%)	0	0	5(1.0%)
	Summer stress	0	0	1(0.9%)	1(0.2%)
	Kidney Swelling	1(1.2%)	0	0	1(0.2%)
	Stunted growth	0	0	3(2.7%)	3(0.6%)
	Gout	1(1.2%)	0	0	1(0.2%)
	Liver cirrhosis	0	1(0.4%)	0	1(0.2%)
	Overcrowding	0	2(0.8%)	0	2(0.4%)
	Fever	0	1(0.4%)	0	1(0.2%)
	Cannibalism	0	1(0.4%)	0	1(0.2%)
	Eye lesions	0	1(0.4%)	0	1(0.2%)
Overall		83(100%)	253(100%)	111(100%)	72(100%)
Number of farms		50	100	50	51
519(100%)					

Overall, among the reported clinical signs, respiratory and gastrointestinal are the most frequently mentioned, accounting for 32.8% and 23.7% of the reports respectively. However, in Gujarat, locomotion symptoms replace gastrointestinal symptoms as the second most common category, representing 23.4% of the reports.

Checking for normality:

We present the histogram, normal QQ plot and statistical test to check the normality of the outcome variables. After doing log transformation, the overall level mortality rate and morbidity rate show a normal distribution, and the mortality risk, morbidity risk and lethality do not fit a normal distribution. Therefore, we decided to fit a linear model to the log mortality rate and log morbidity rate.

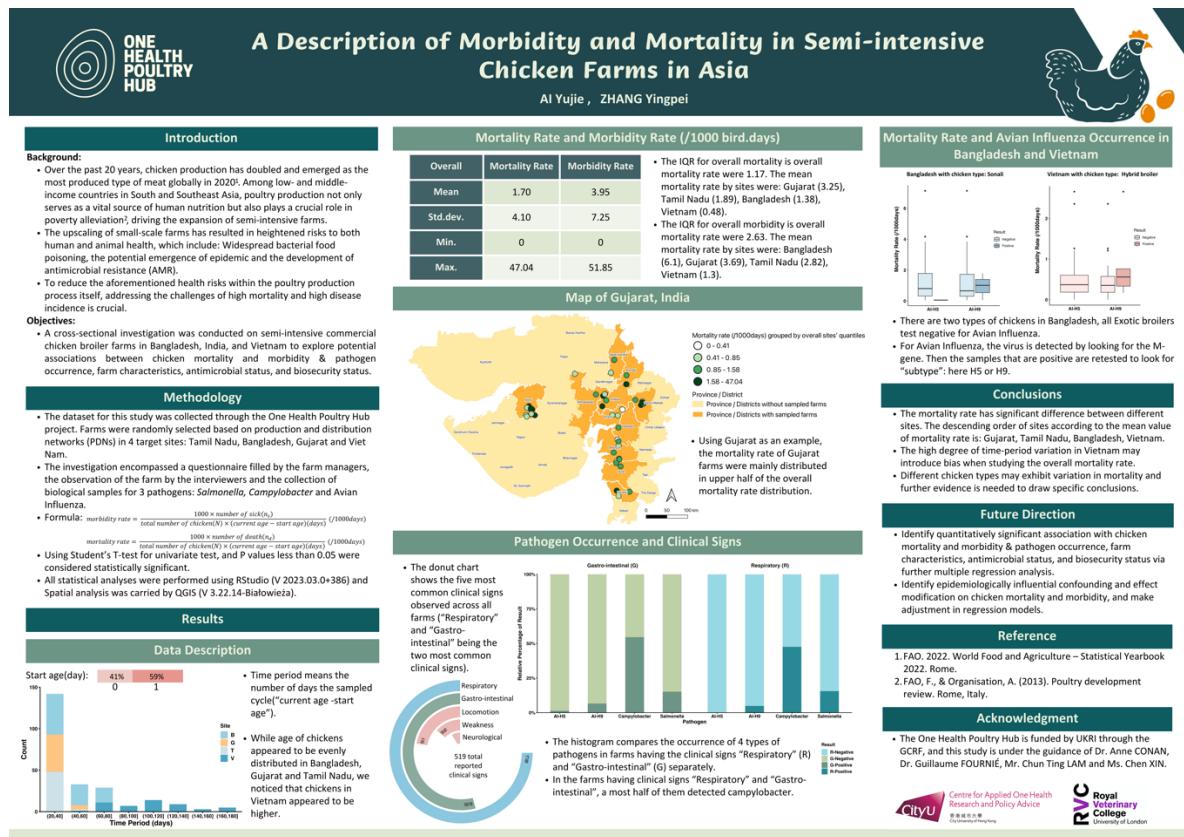
Discussions

1. The mortality rate and morbidity rate have significant difference between different sites. The descending order of sites according to the mean value of mortality rate is: Gujarat, Tamil Nadu, Bangladesh, Vietnam. For morbidity rate, the order is: Bangladesh, Gujarat, Tamil Nadu, Vietnam.
2. The high degree of time-period variation in Vietnam may introduce bias when studying the overall mortality rate and morbidity rate.
3. Respiratory and gastro-intestinal were the 2 most clinical signs in the sampled farms.
4. In the farms having respiratory and gastro-intestinal, a most half of them detected campylobacter. But the association between these 2 clinical signs and 4 types of pathogens was not significant but we need to look further.
5. Different chicken types may exhibit variation in mortality rate and further evidence is needed to draw specific conclusions.

Limitations

1. The cross-sectional study may not be suitable for highly fatal diseases, because the survival status of individuals may influence their exposure status. However, H5 is one of the famous subtypes of highly pathogenic avian influenza, so it may introduce survival bias. Perhaps using other study method would be better to capture the association between this exposure and outcome variables.
2. For the biological sample of pathogens, the data selected 5 chickens for terminal sampling and 10 chickens for live bird sampling in each sample batch. However, the farms vary in batch size, some have one hundred chickens per batch and others may have over twenty thousand chickens. The prevalence for the three pathogens is also different. So more reliable and representative sample will be got after accounting for the variability in prevalence of pathogens and the different batch size.

Poster



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Introduction

- The rapid expansion of semi-intensive poultry production in South and Southeast Asia presents challenges for monitoring due to the lack of data collection and surveillance systems.
- This study aimed to investigate reported disease-associated morbidity and mortality rates on farms in the region.

Materials and Methods

- A cross-sectional study was conducted on 251 semi-intensive broiler chicken farms from Bangladesh, Vietnam, Tamil Nadu (India), and Gujarat (India) between April 2021 and June 2022.
- Farm characteristics were collected through site visits and interviews of the farmers.
- Disease-associated morbidity and mortality rates reported by farmers were summarized and standardized per 1000 chicken-days, and statistical comparisons were carried out using student's t-test.

Results

- The average number of chickens on each farm across all four sites was 3,525 (Interquartile Range (IQR): 1,000 – 4,500; Range: 100 – 27,000).
- A wide range of morbidity and mortality rates was reported, with an overall average of 1.70 (per 1000 chicken-day; IQR: 3.17 – 13.75) and 3.95 (per 1000 chicken-day; IQR: 0.70 – 3.33), respectively.
- Among the sites, Bangladesh exhibited the highest median morbidity rate per 1000 chicken-day, while Tamil Nadu exhibited the highest median mortality rate per 1000 chicken-day. Notably, Vietnam had the lowest morbidity and mortality rate across all four sites.
- In each of the four sites, several potential clusters of farms with high mortality rates per 1000 chicken-day were visually detected (Figure 2).

Figure 2. Spatial distribution of the 251 semi-intensive broiler chicken farms in Bangladesh, Vietnam, Tamil Nadu, and Gujarat with mortality rate per 1000 chicken-day observed between April 2021 and June 2022.

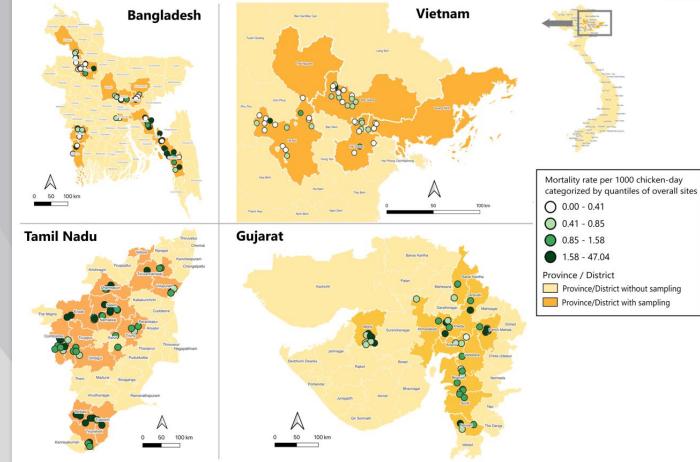
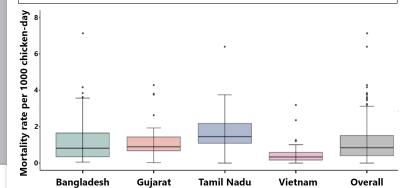
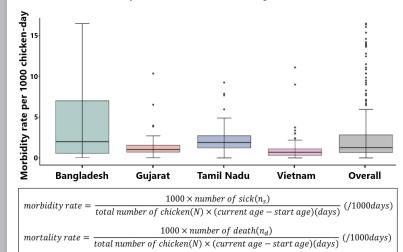


Figure 1. Boxplots of the observed overall and site-level morbidity rate (per 1000 chicken-day) and mortality rate (per 1000 chicken-day) from 251 semi-intensive broiler chicken farms between April 2021 and June 2022 in Bangladesh, India, and Vietnam.



Discussion and Conclusion

- Despite potential survival bias related to highly pathogenic avian influenza, recall bias from farmers, and disparities in farm sizes, this study highlights the variation in disease-associated morbidity and mortality rates within and between all four sites in the region.
- Results of these initial investigations can be used to inform further multivariable regression analysis.

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