

Bangladesh surveillance greyspots

Elonia

Contents

Notes	1
Identifying the cholera surveillance zone	1
Mapping infections with serological data	4
Determining infection risk categories	5
Intersecting infections and the cholera surveillance zone	8
Populations in the cholera surveillance zone	14
Populations at different levels of infection risk in Bangladesh	15

Notes

The goal of this study is to identify how well the Bangladesh national cholera surveillance system captures:

1. the Bangladeshi population
2. the Bangladeshi population living in high, medium, and low risk cholera areas

We define cholera surveillance zones as geographies surrounding one of the 22 cholera sentinel hospitals. Surveillance zones are defined as the area enclosed within a circular buffer with a radius of 10 km, 30 km, or 50 km surrounding the coordinates of a given sentinel hospital.

The values we want to estimate include:

1. percentage of the population living in cholera surveillance zones
2. number and percentage of infections residing in cholera surveillance zones within the last year
3. number and percentage of infections residing in cholera surveillance zones that are in high, medium, and low infection risk areas
4. number and percentage of people living in high, medium, and low infection risk areas that would be captured by cholera surveillance zones

We use the following threshold for defining high, medium, and low risk infection areas:

- RR ≥ 1.5 is high risk
- $0.5 < RR < 1.5$ is medium risk
- $RR \leq 0.5$ is low risk

Identifying the cholera surveillance zone

There are 22 sentinel hospital sites (Table 1).

Table 1: Sentinel hospital IDs and locations.

ID	Hospital	Division	Latitude	Longitude
1	District Hospital Norshingdi	Dhaka	23.92022	90.71846
2	Adhunik Sadar Hospital Habiganj	Sylhet	24.37346	91.41769
3	District Sadar Hospital Cox's Bazar	Chittagong	21.44159	91.97683
4	Adhunik Sadar Hospital Naogaon	Rajshahi	24.82262	88.93793
5	General Hospital Patuakhali	Barisal	22.35885	90.32737
6	Adhunik Sadar Hospital Thakurgaon	Rangpur	26.02952	88.47657
7	District Sadar Hospital Satkhira	Khulna	22.69032	89.04679
8	Dhaka Medical College Dhaka	Dhaka	23.72539	90.39701
9	Uttara Adhunik Medical College Hospital	Dhaka	23.87482	90.39675

ID	Hospital	Division	Latitude	Longitude
10	Bangladesh Institute of Tropical and Infectious Diseases Chittagong	Chittagong	22.39274	91.75855
11	General Hospital Tangail	Dhaka	24.26432	89.92484
12	General Hospital Narayanganj	Dhaka	23.62455	90.50121
13	Sadar Hospital Chuadanga	Khulna	23.63517	88.84640
14	General Hospital Meherpur	Khulna	23.77835	88.64240
15	General Hospital Comilla	Chittagong	23.45596	91.18204
16	Upazila Health Complex Chaugachha Jessore	Khulna	23.25958	89.02446
17	General Hospital Kusthia	Khulna	23.90120	89.12426
18	Upazila Health Complex Madan	Mymensingh	24.71669	90.94530
19	Upazila Health Complex Chhatak Sunamganj	Sylhet	25.03337	91.66869
20	Upazila Health Complex Mathbariya	Barisal	22.28575	89.95365
21	Upazila Health Complex Bakerganj	Barisal	22.53881	90.34633
22	Health Complex Shibganj	Rajshahi	24.68770	88.15844

This is a summary of the populations living within buffers of varying sizes around hospital sentinel surveillance sites (Table 2, Figure 1).

Table 2: **Proportion of population living within sentinel hospital buffers.**

Buffer (km)	Pop	Proportion
5	10257070	0.0636291
10	24058768	0.1492471
15	33610307	0.2084995
20	44334392	0.2750257
25	55775932	0.3460026
30	68500637	0.4249396
35	81380194	0.5048371
40	93446497	0.5796897
45	105029955	0.6515470
50	115339020	0.7154987
55	125593872	0.7791140
60	134413475	0.8338259

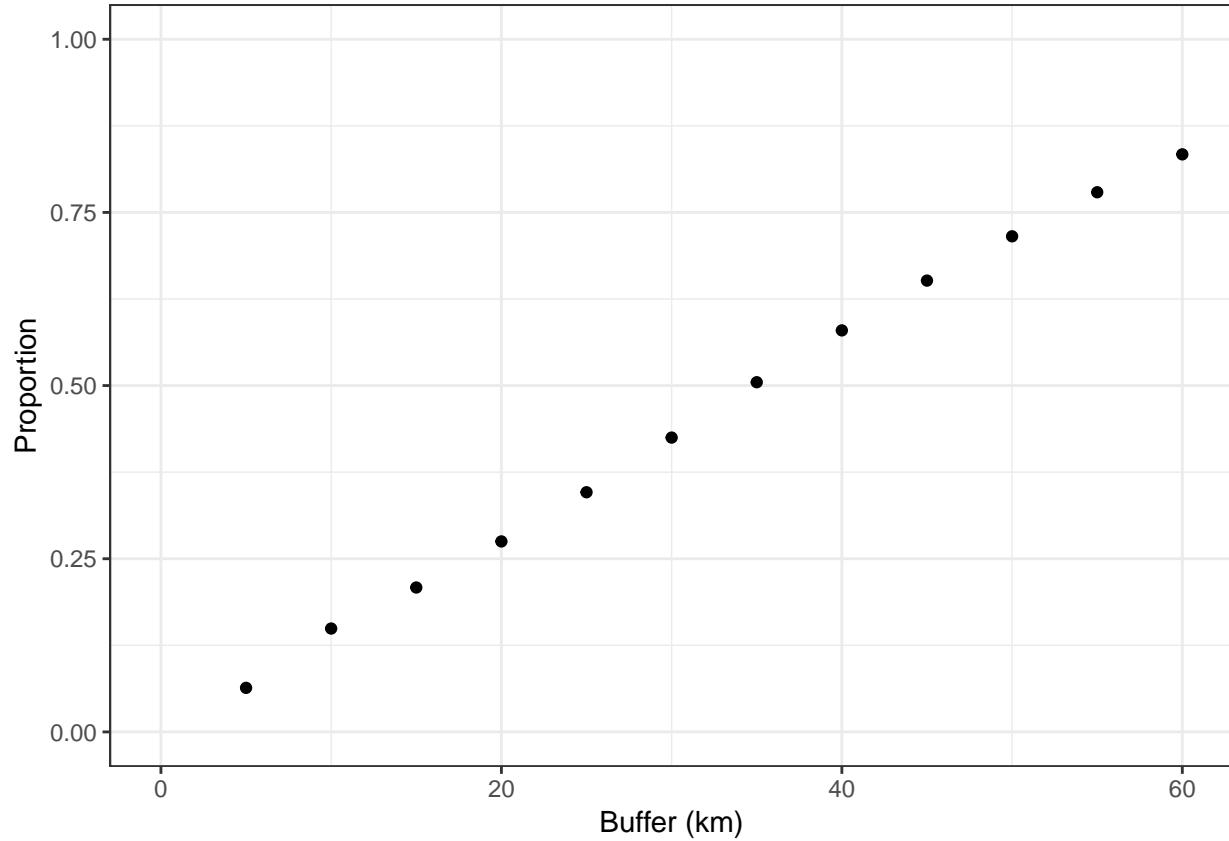


Figure 1: **Proportion of total population captured in cholera surveillance zone, by buffer radius size**

In the absence of better data on health care utilization around the hospital sentinel surveillance sites, we assumed that buffers with radii of 10km, 20km, 30km, 40km, 50km, 60km around the hospital could serve as proxies for potential hospital catchment areas (Figure 2). We refer to the joint buffer areas as the “cholera surveillance zone” for the national cholera sentinel surveillance system.

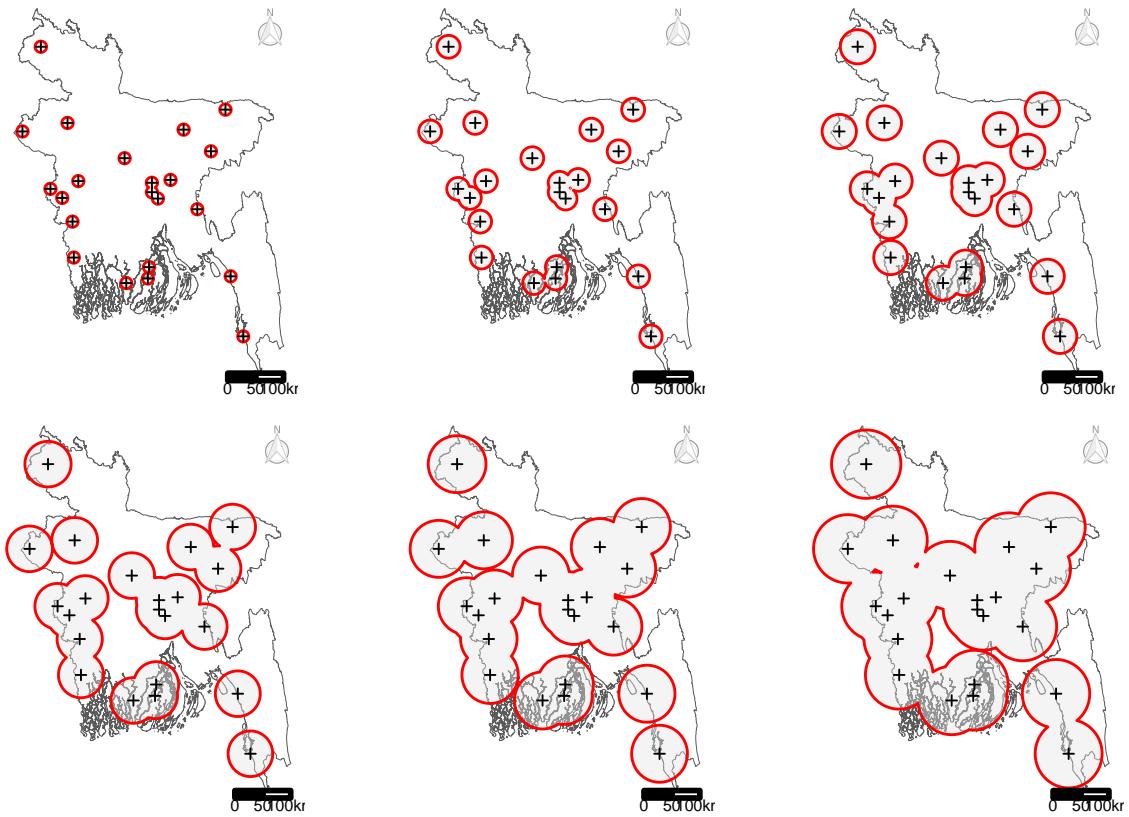


Figure 3: Map of 10km, 20km, 30km, 40km, 50km, 60km buffers around sentinel hospital sites (left to right, top row to bottom row, respectively).

Mapping infections with serological data

Using data from a nationally-representative survey across Bangladesh, we developed maps of infection across 5 km x 5km cells in Bangladesh. This map suggests that 4.1837155×10^7 infections occurred in Bangladesh over the past year (estimated population size ###) [NEED TO ADD DETAILS ON TIME PERIOD FOR THESE ESTIMATES]. We standardized the infection rate estimates in each cell by the population-weighted mean of the Bangladesh infection rate in that cell. This yielded a relative risk of infection for each grid cell (Figure 4).

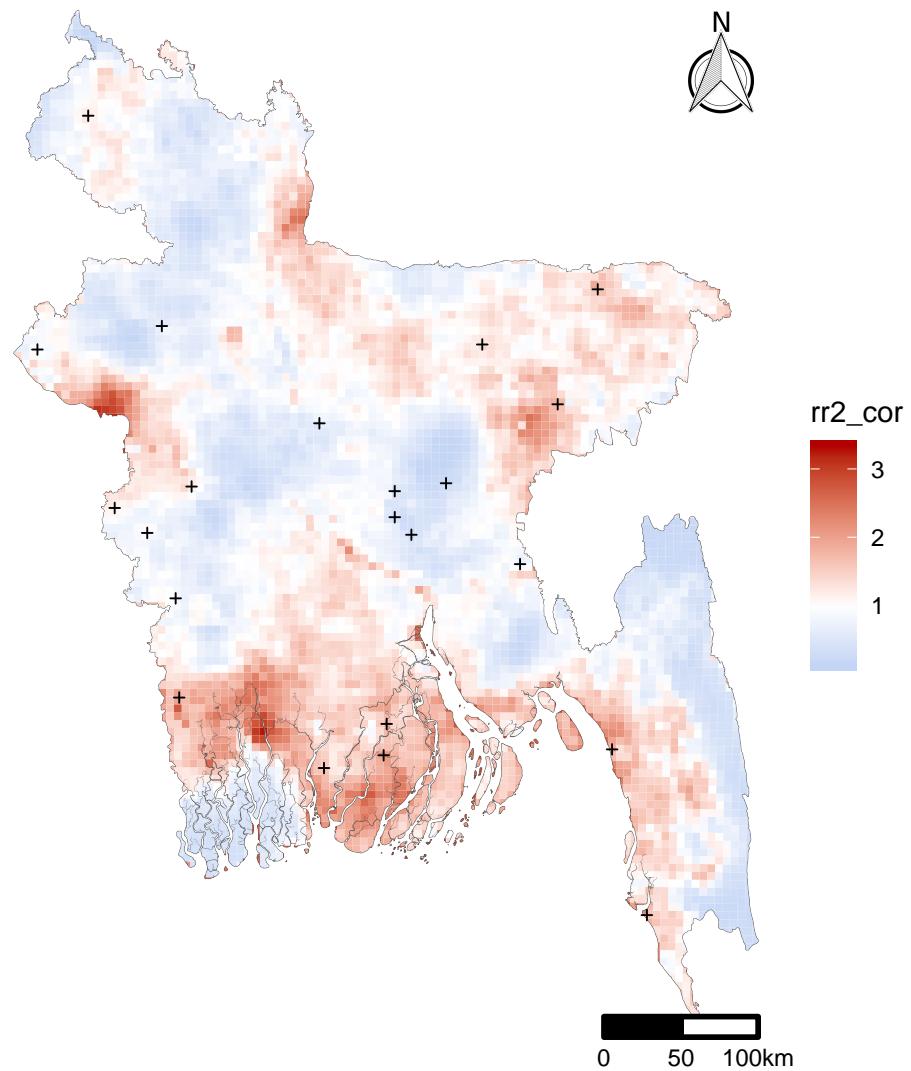


Figure 4: Risk of infection relative to population-weighted mean

Determining infection risk categories

We examined the distribution of relative risks (Figure 5) and estimated infections (Figure 6) by grid cell in order to identify thresholds for binning infection risk into categories .

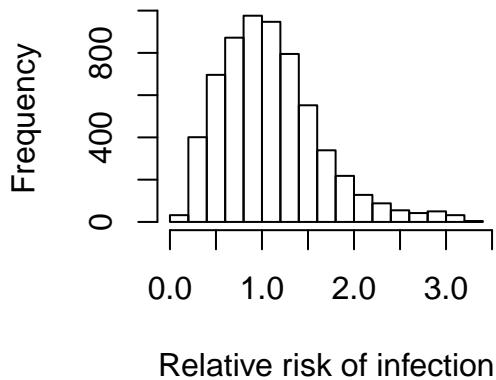


Figure 5: **Histogram of the risk of infection relative to population-weighted mean**

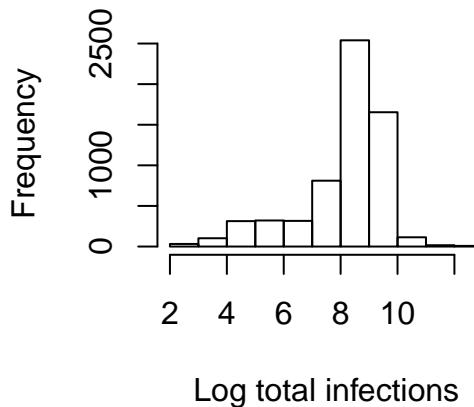


Figure 6: **Histogram of the log total number of infections**

We used two sets of fixed thresholds to delineate areas with high, moderate, and low infection risk. The first set of thresholds was based on low, moderate, and high risk (RR) of infection relative to the mean infection rate across Bangladesh adjusted by the population of each cell (i.e. the expected infection rate in the cell). 5 km x 5km grid cells were categorized as low risk if RR < 0.5, moderate risk if RR >= 0.5 and RR < 1.5, and high risk if RR >= 1.5 (Figure 7). The second set of threshold was based on absolute case counts, where grid cells were categorized as low risk if infections < 2000, moderate risk if infections >= 2000 and infections < 5000, and high risk if infections >= 5000 (Figure 8). The number of infection thresholds were based on the 20th and 80th percentiles from the distribution of the relative risk of infection.

```
## [1] "Distribution of relative risk across by 5 km x 5 km cell"
## 0.1328026 0.6989712 1.026415 1.097483 1.385071 3.336598
## [1] "Distribution of number of infections by 5 km x 5 km cell"
```

```
## 8.390758 2260.931 5155.061 6718.67 8748.352 319525.5
```

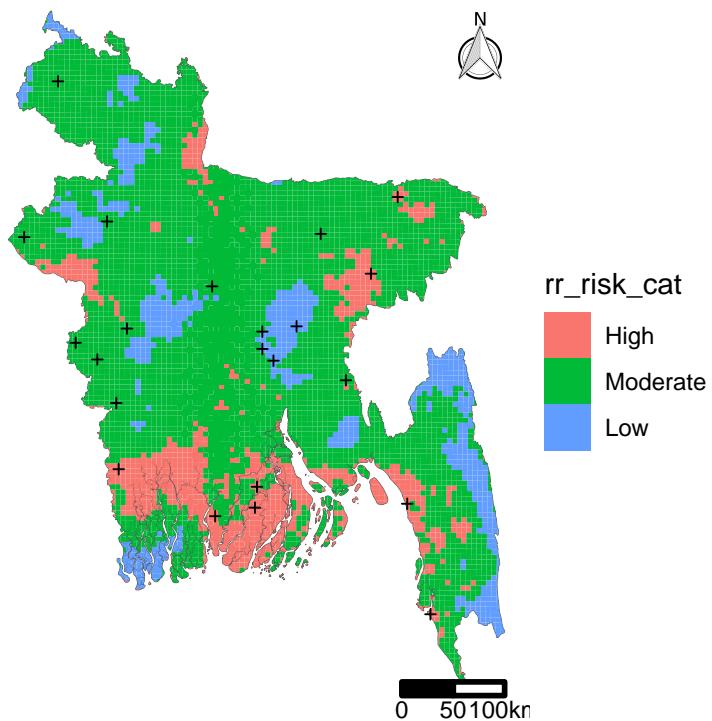


Figure 7: Cholera risk map as categorized by the risk of infection relative to a population-weighted mean

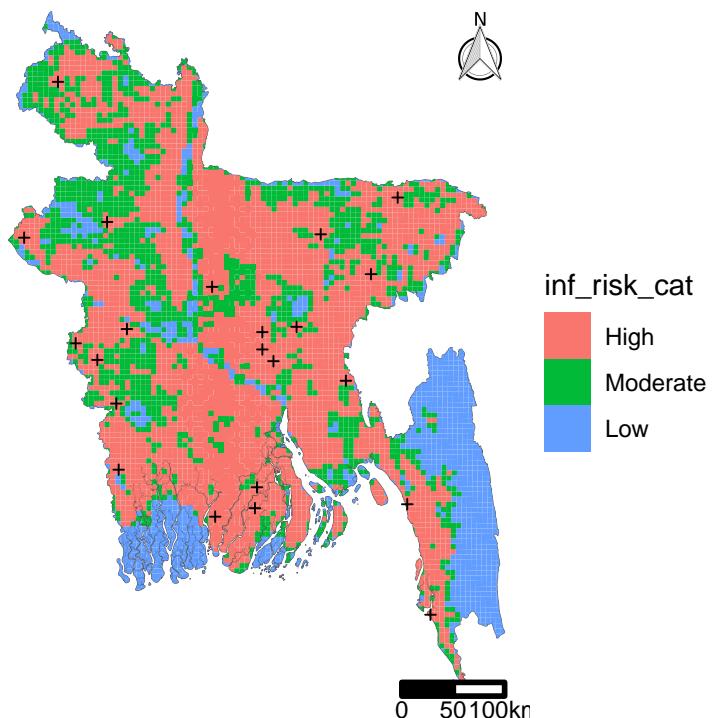


Figure 8: Cholera risk map as categorized by number of infections

Intersecting infections and the cholera surveillance zone

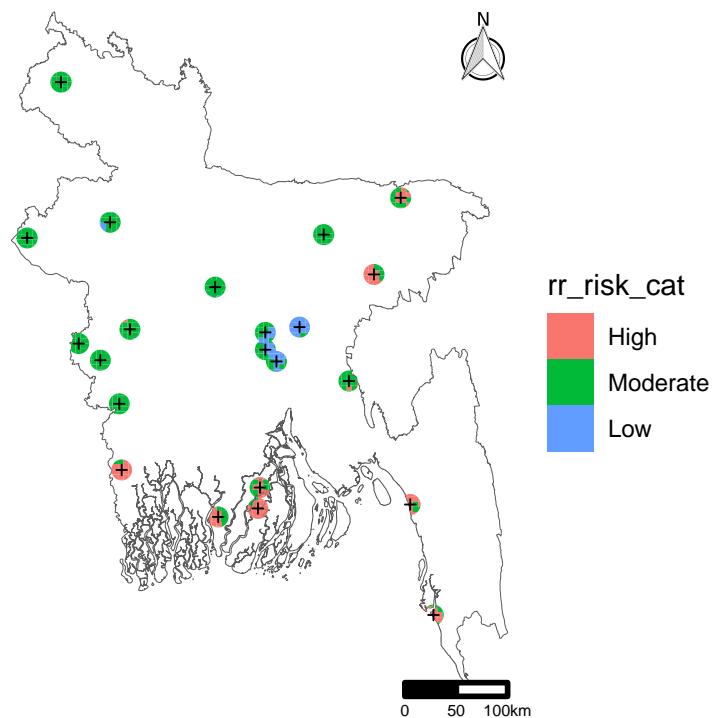


Figure 9: Infection risk, as categorized by relative risk, within cholera surveillance zones (10km)

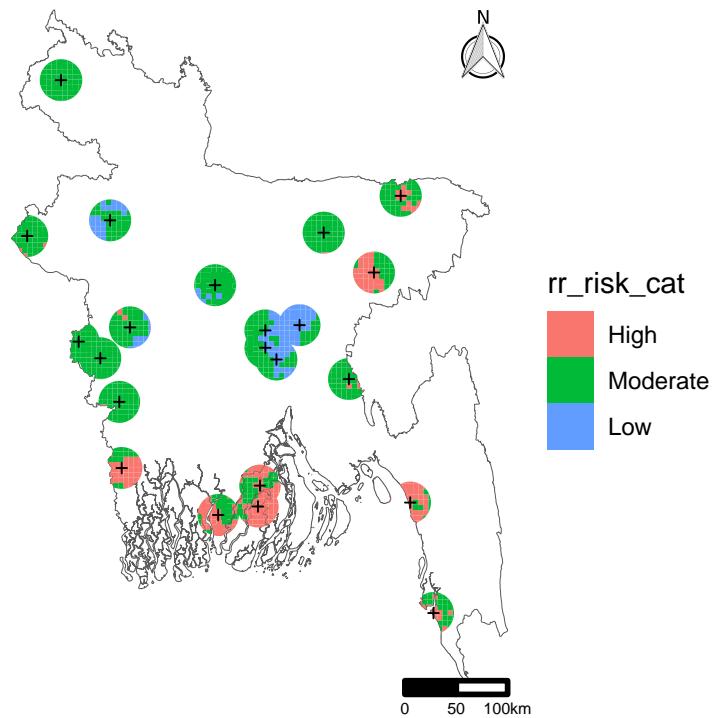


Figure 10: Infection risk, as categorized by relative risk, within cholera surveillance zones (20km)

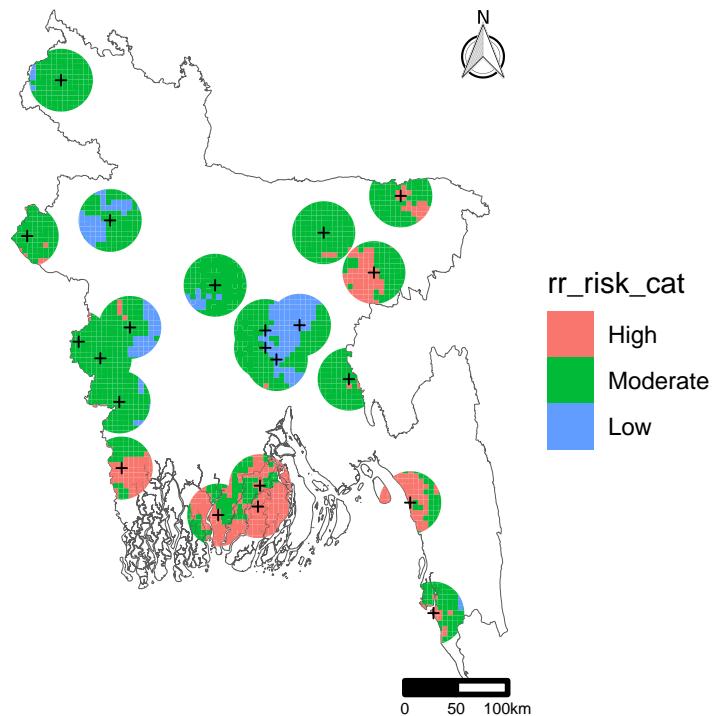


Figure 11: Infection risk, as categorized by relative risk, within cholera surveillance zones (30km)

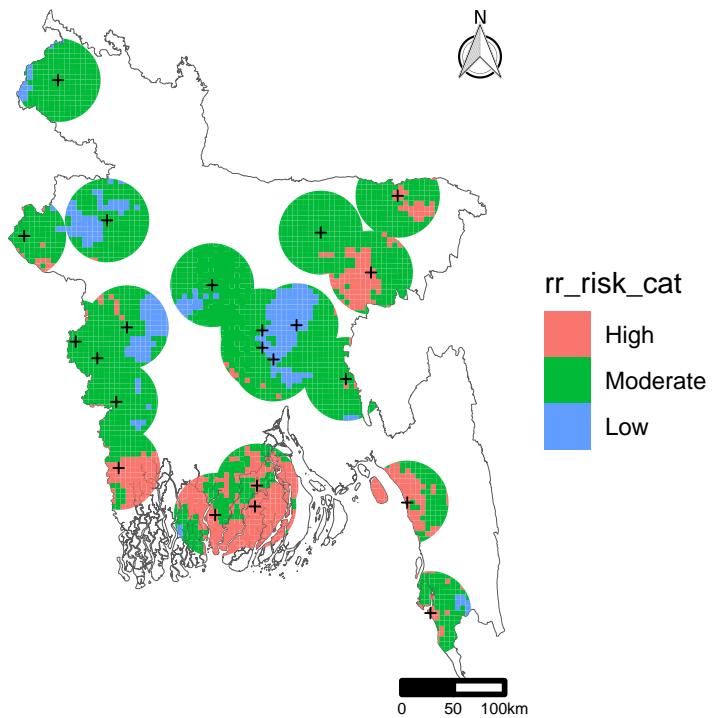


Figure 12: Infection risk, as categorized by relative risk, within cholera surveillance zones (40km)

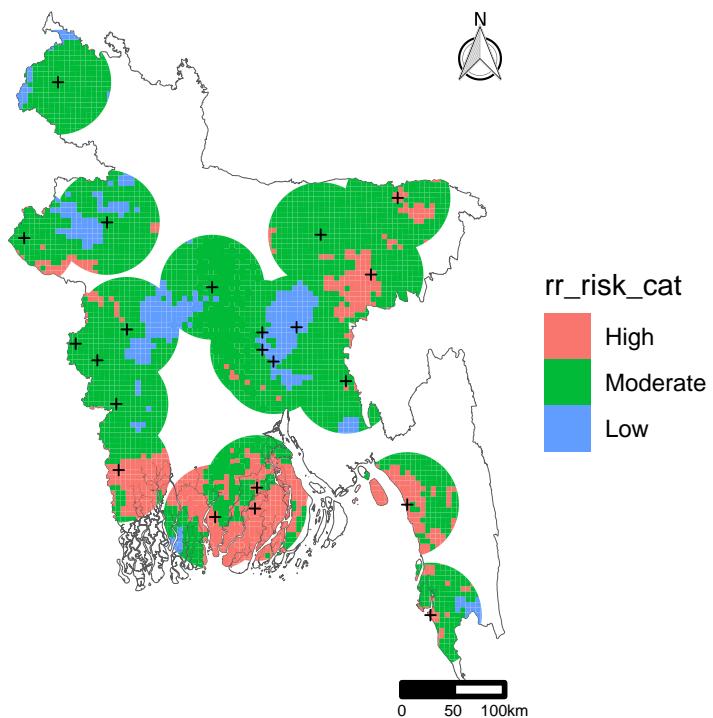


Figure 13: Infection risk, as categorized by relative risk, within cholera surveillance zones (50km)

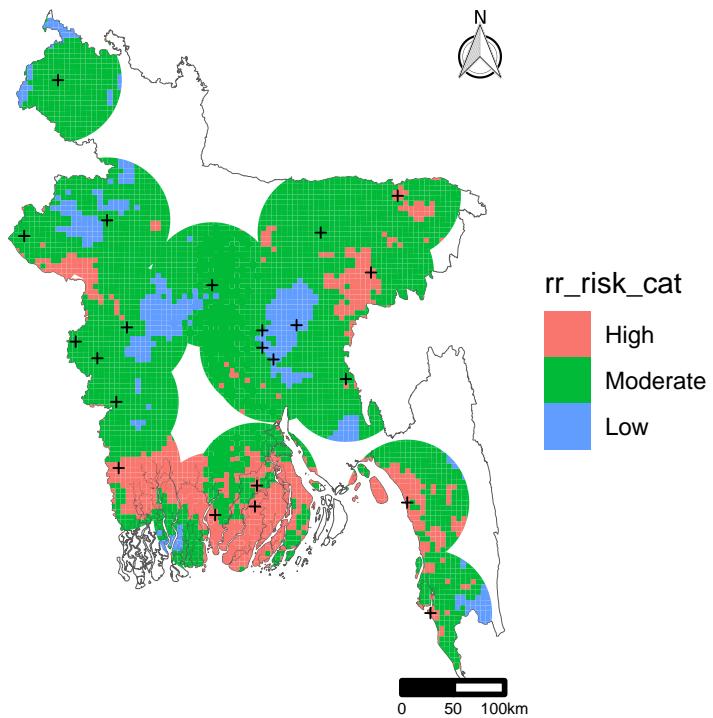


Figure 14: Infection risk, as categorized by relative risk, within cholera surveillance zones (60km)

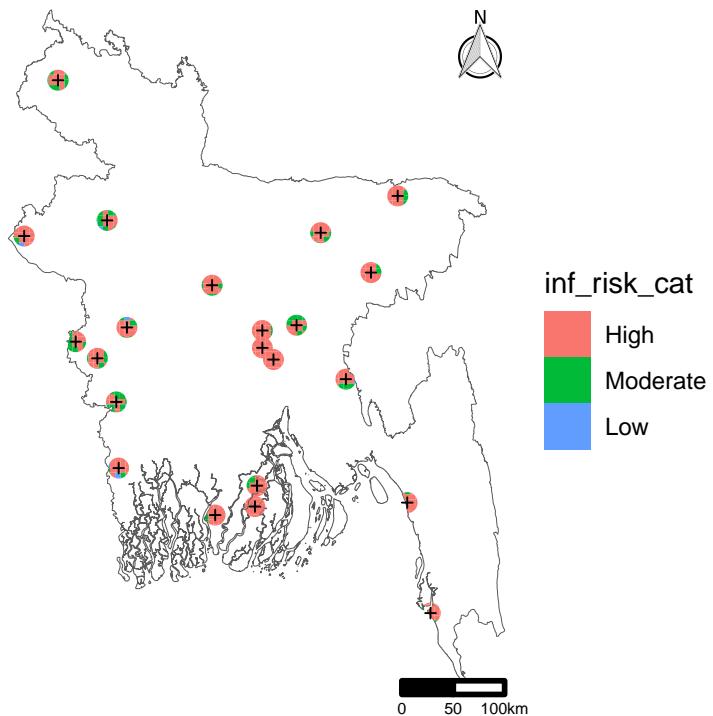


Figure 15: Infection risk, as categorized by number of infections, within cholera surveillance zones (10km)

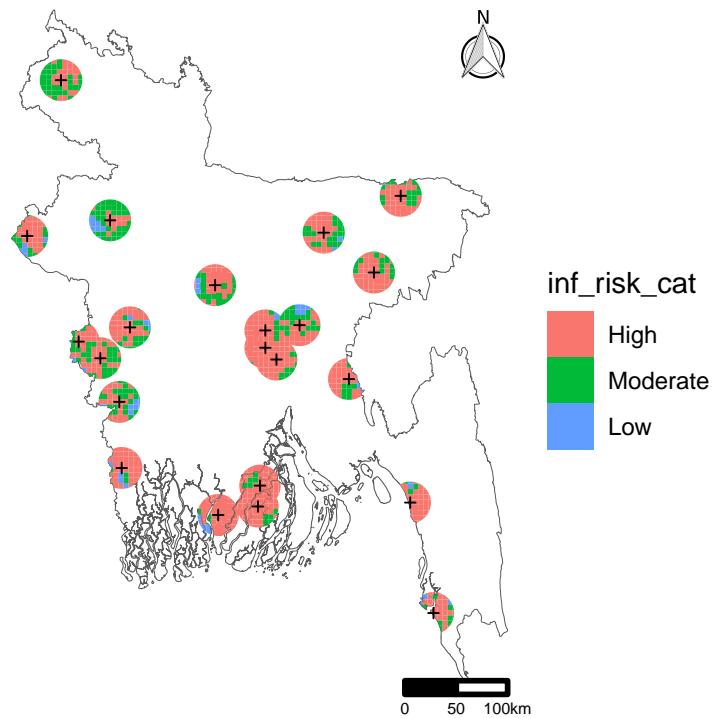


Figure 16: Infection risk, as categorized by number of infections, within cholera surveillance zones (20km)

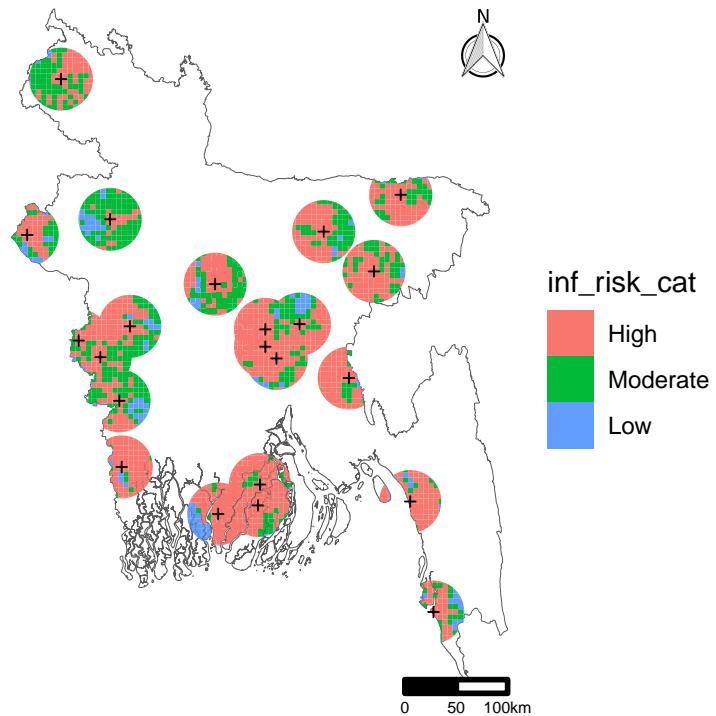


Figure 17: Infection risk, as categorized by number of infections, within cholera surveillance zones (30km)

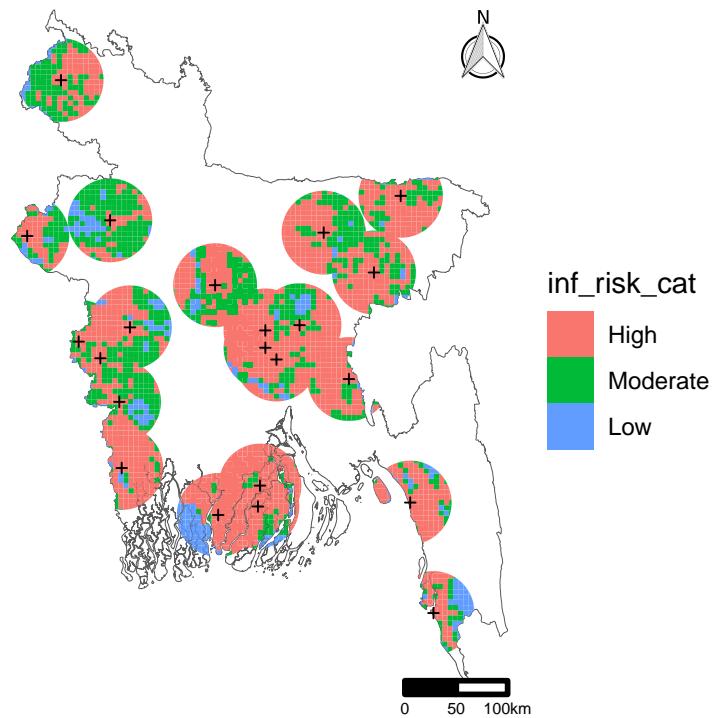


Figure 18: Infection risk, as categorized by number of infections, within cholera surveillance zones (40km)

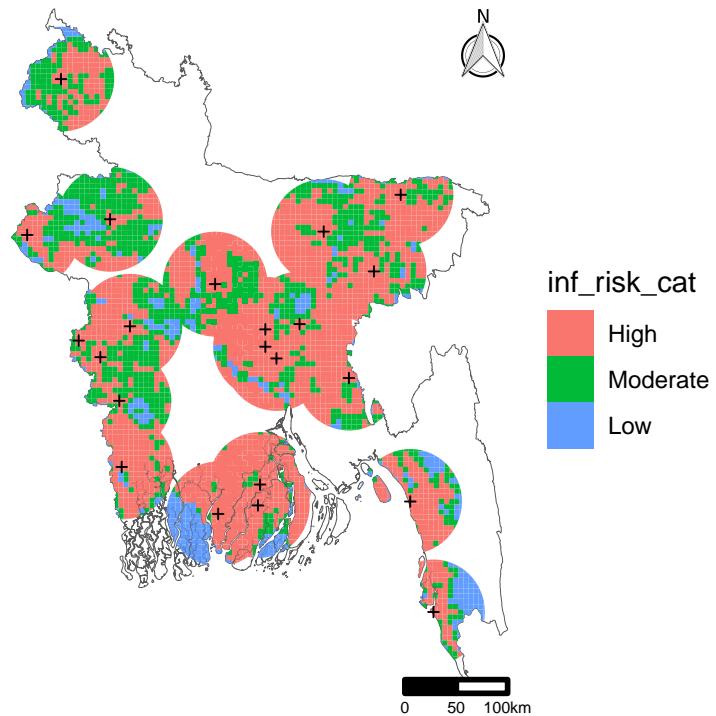


Figure 19: Infection risk, as categorized by number of infections, within cholera surveillance zones (50km)

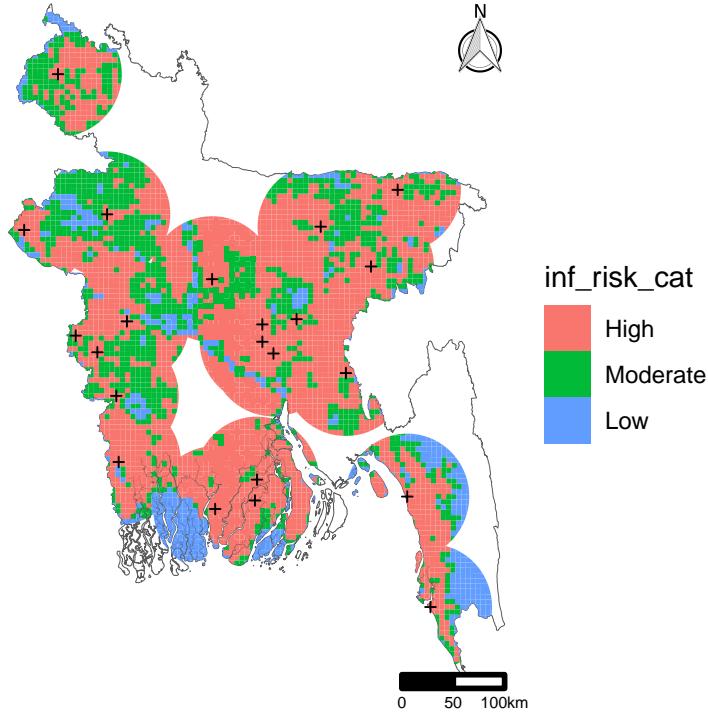


Figure 20: Infection risk, as categorized by number of infections, within cholera surveillance zones (60km)

We overlaid the cholera surveillance zone with the binned infection risk maps to examine the distribution of risks in the surveilled areas. This was done for infection risk as categorized by relative risk (Figure 9 - Figure 14) and by the total number of infections (Figure 15 - Figure 20).

Populations in the cholera surveillance zone

We examined the number and percentage of total infections falling within each buffer distance (Table 3).

Table 3: Number and percent infections that may be captured in cholera surveillance zones

Buffer size	Population size	Number infected	Percent infected
10km	30134592	6093858	14.57
20km	52328179	11800079	28.20
30km	77537043	18375410	43.92
40km	101944116	24999745	59.75
50km	122978702	31017097	74.14
60km	139891837	36032952	86.13

We then examined the distribution of relative-risk-based categories (Table 4) and number-of-infection-based categories (Table 5) within the cholera surveillance zone, for each buffer distance.

Table 4: Number and percent infections that may be captured in cholera surveillance zones, categorized by relative risk

Buffer size	Risk Category	Number Infected	Percent in Surveillance Zone
10km	High	1523171	4.49

Buffer size	Risk Category	Number Infected	Percent in Surveillance Zone
10km	Moderate	3328188	3.99
10km	Low	1242499	11.25
20km	High	3312093	9.76
20km	Moderate	6943890	8.33
20km	Low	1544096	13.98
30km	High	4909857	14.46
30km	Moderate	11657102	13.99
30km	Low	1808451	16.37
40km	High	6520605	19.21
40km	Moderate	16462828	19.76
40km	Low	2016312	18.25
50km	High	8096871	23.85
50km	Moderate	20769015	24.93
50km	Low	2151211	19.47
60km	High	9587473	28.24
60km	Moderate	24161998	29.00
60km	Low	2283481	20.67

Table 5: Number and percent infections that may be captured in cholera surveillance zones, categorized by number of infections

Buffer size	Risk Category	Number Infected	Percent in Surveillance Zone
10km	High	5684690.94	5.17
10km	Moderate	395466.35	2.37
10km	Low	13700.99	0.77
20km	High	10440950.49	9.50
20km	Moderate	1271549.68	7.63
20km	Low	87578.56	4.95
30km	High	15756166.74	14.34
30km	Moderate	2410624.73	14.47
30km	Low	208618.63	11.78
40km	High	21190965.42	19.28
40km	Moderate	3470523.19	20.84
40km	Low	338256.15	19.10
50km	High	26245441.83	23.88
50km	Moderate	4281547.68	25.70
50km	Low	490107.01	27.68
60km	High	30573253.89	27.82
60km	Moderate	4827058.37	28.98
60km	Low	632639.63	35.72

Populations at different levels of infection risk in Bangladesh

We sought to describe how well the cholera surveillance zones capture High, Moderate, Low risk categories of populations in Bangladesh.

We summarized the percentage of high, moderate, and low infection risk populations in Bangladesh that would be captured by cholera surveillance zones at different buffer sizes when risk was categorized both by relative risk (Table 6) and by the number of infections (Table 7).

Table 6: Number and percent infections that may be captured in Bangladesh, categorized by

relative risk

Buffer size	Risk Category	Population	Number Infected	Percent in Risk Category
10km	High	3375395	1523171	2.08
10km	Moderate	14276501	3328188	8.78
10km	Low	12482697	1242499	7.68
20km	High	7244221	3312093	4.45
20km	Moderate	29256548	6943890	17.99
20km	Low	15827410	1544096	9.73
30km	High	10674150	4909857	6.56
30km	Moderate	48245464	11657102	29.67
30km	Low	18617428	1808451	11.45
40km	High	14219731	6520605	8.74
40km	Moderate	67048360	16462828	41.23
40km	Low	20676025	2016312	12.72
50km	High	17512789	8096871	10.77
50km	Moderate	83382686	20769015	51.28
50km	Low	22083226	2151211	13.58
60km	High	20269968	9587473	12.47
60km	Moderate	96093020	24161998	59.09
60km	Low	23528850	2283481	14.47

Table 7: Number and percent infections that may be captured in Bangladesh, categorized by number of infections

Buffer size	Risk Category	Population	Number Infected	Percent in Risk Category
10km	High	27874283.4	5684690.94	17.14
10km	Moderate	2136431.6	395466.35	1.31
10km	Low	123877.1	13700.99	0.08
20km	High	44559249.7	10440950.49	27.40
20km	Moderate	6979272.8	1271549.68	4.29
20km	Low	789656.7	87578.56	0.49
30km	High	62870285.6	15756166.74	38.66
30km	Moderate	13058998.0	2410624.73	8.03
30km	Low	1607759.1	208618.63	0.99
40km	High	81147694.6	21190965.42	49.90
40km	Moderate	18479056.2	3470523.19	11.36
40km	Low	2317364.9	338256.15	1.43
50km	High	97229697.6	26245441.83	59.79
50km	Moderate	22701586.6	4281547.68	13.96
50km	Low	3047417.3	490107.01	1.87
60km	High	110830945.6	30573253.89	68.16
60km	Moderate	25396739.9	4827058.37	15.62
60km	Low	3664152.0	632639.63	2.25