Seroprevalence of *Vibrio cholerae* in Adults, Haiti, 2017

Wilfredo R. Matias, Yodeline Guillaume, Gertrude Cene Augustin, Kenia Vissieres, Ralph Ternier, Richelle C. Charles, Jason B. Harris, Molly F. Franke, Louise C. Ivers

In Haiti in 2017, the prevalence of serum vibriocidal antibody titers against *Vibrio cholerae* serogroup O1 among adults was 12.4% in Cerca-la-Source and 9.54% in Mirebalais, suggesting a high recent prevalence of infection. Improved surveillance programs to monitor cholera and guide public health interventions in Haiti are necessary.

In 2010, cholera, caused by the bacterium *Vibrio cholerae*, was introduced into Haiti, resulting in >800,000 cases and >10,000 deaths (*1*,*2*). Case incidence peaked in 2012, then decreased, and the last case of confirmed cholera was reported in February 2019 (*3*). More than 3 years later, in October 2022, cholera was again detected in Haiti, and that outbreak is ongoing (*4*,*5*).

The response to cholera in Haiti and globally has been hampered by inaccuracies in estimating the actual prevalence of disease (*6*). In resource-limited settings where infectious diseases surveillance systems and laboratory capacity are limited, clinical case count–guided public health interventions can be suboptimal because of limitations in the accuracy of clinical case definitions (*7*). More accurate estimates of cholera disease prevalence and transmission dynamics are key for guiding and monitoring control efforts. Serosurveillance represents a promising tool to address the limitations of clinical surveillance (*8*,*9*). However, seroepidemiologic data are lacking from settings like Haiti where cholera has resurged.

Author affiliations: Brigham and Women's Hospital Division of Infectious Diseases, Boston, Massachusetts, USA (W.R. Matias); Massachusetts General Hospital Center for Global Health, Boston (W.R. Matias, Y. Guillaume); Massachusetts General Hospital Division of Infectious Diseases, Boston (W.R. Matias, R.C. Charles, J.B. Harris, L.C. Ivers); Zanmi Lasante, Croix-des-Bouquets, Haiti (G. Cene Augustin, K. Vissieres, R. Ternier); Harvard Medical School, Boston (R.C. Charles, J.B. Harris, M.F. Franke, L.C. Ivers); Harvard School of Public Health, Boston (R.C. Charles); Harvard Global Health Institute, Cambridge, Massachusetts, USA (L.C. Ivers)

DOI: https://doi.org/10.3201/eid2909.230401

In 2017, we conducted a seroepidemiologic survey to measure the prevalence of cholera in Haiti during the waning phase of the first cholera epidemic in that country.

The Study

This study was conducted as part of a campaign to control and eliminate cholera transmission in 2 communities in Haiti. The first, Cerca-la-Source, is a rural, mountainous community of ≈50,000 persons. The second, Mirebalais, is an urban commune of ≈100,000 persons. Both communities are located in the Centre Department of Haiti, a historically underserved and particularly impoverished region of the country.

We conducted a census of both communities. During the census, a subset of households was invited to participate in a household survey and a serologic survey at fixed sampling intervals during March–August 2017 (Appendix Table 1, https://wwwnc.cdc.gov/EID/article/29/9/23-0401-App1.pdf). Trained study enumerators implemented study procedures in their native language of Haitian Creole; the procedures included surveys to measure self-reported sociodemographic and cholera risk factors.

We obtained dried blood spots from consenting adults ≥18 years of age and shipped them to a laboratory in Boston, Massachusetts, USA, where we performed vibriocidal assays by using a drop-plate method from dried blood spots specimens, as described previously (*10*), except we used Advance Dx100 Serum Separator cards (Advance Dx, Inc., https://adx100.com) instead of the cards used in that study. We used target *V. cholerae* strains 19479 El Tor Inaba and X25049 El Tor Ogawa.

To ensure estimates were representative of the populations of Mirebalais and Cerca-la-Source, we used a raking procedure to apply survey weights on the basis of the population distribution of age, sex, and communal sections from the census in those regions. We used a random intercept to account for clustering by household. The primary outcome was

Table 1. Unweighted demographic characteristics of *Vibrio cholerae* serosurvey participants compared with census participants in 2 communities, Centre Department, Haiti, March–August 2017*

	Cerca-la-Source		Mirebalais	
Characteristic	Census†	Serosurvey	Census†	Serosurvey
Total no.	24,500	156	45,365	121
Sex				
M	12,157 (49.6)	74 (47.4)	21,397 (47.2)	56 (46.3)
F	12,343 (50.4)	82 (52.6)	23,968 (52.8)	65 (53.7)
Mean age (SD)	37.1 (16.4)	42.3 (16.1)	37.1 (16.3)	44.6 (16.8)
Age group, y				
18–30	11,162 (45.6)	47 (30.1)	20,700 (45.6)	31 (25.6)
31–40	4,899 (20.0)	29 (18.6)	9,214 (20.3)	25 (20.7)
41–50	3,728 (15.2)	32 (20.5)	6,519 (14.4)	25 (20.7)
>50	4,711 (19.2)	48 (30.8)	8,932 (19.7)	40 (33.1)
Communal section				
1st Acajou Bruler	9,298 (38.0)	51 (32.7)	NA	NA
2nd Acajou Bruler	7,952 (32.5)	59 (37.8)	NA	NA
3rd Lamielle (Cerca-la-Source)	7,250 (29.6)	46 (29.5)	NA	NA
3rd Grand Boucan	NA	NA	26,202 (57.8)	67 (55.4)
6th Sarazin	NA	NA	19,163 (42.2)	54 (44.6)

*Values are no. (%) except as indicated. NA, data not applicable for this category.
†Census only includes persons ≥18 years of age because that was the population included in the serosurvey.

the overall seroprevalence (either Ogawa or Inaba) of vibriocidal antibody responses against *V. cholerae* for each community. We defined seropositivity as a vibriocidal antibody response titer threshold of ≥320 on the basis of the best available evidence, a recent study in Bangladesh that estimated that a vibriocidal modal titer of 320 had a sensitivity of 80.6% and specificity of 83.0% for infections within the preceding year (*9*). We also calculated serotype-specific seroprevalence estimates for each region. For potential risk factors for seropositivity, we provided descriptive statistics, weighted seroprevalence estimates, and 95% CIs (for categorical variables) and odds ratios (ORs) with 95% CIs. We calculated ORs by using univariable logistic regression followed by multivariable logistic regression analysis, including only those risk factors associated with cholera at a significance level of p<0.20 in univariable analysis. We conducted analyses using the survey package in R 4.2.2 (The R Project for Statistical Computing, https://cran.r-project.org) (*11*).

The study was approved by the Partners Healthcare Institutional Review Board (protocol 2016P002781) and the Zanmi Lasante Institutional Review Board (protocol ZL IRB ID AK). All study participants provided written informed consent.

Overall, we enrolled 265 (27.6%) of 960 invited households in the study. Samples from 48 households were lost during tumultuous sociopolitical events, resulting in samples from 217 households available for analysis: 99 households with 156 persons in Cerca-la-Source and 118 households with 121 persons in Mirebalais.

We analyzed unweighted demographic characteristics for the census population and for serosurvey participants (Table 1). Serosurvey participants were representative of the census population. The weighted seroprevalence of *V. cholerae* was 12.4% (95% CI 6.76%–20.0%) in Cerca-la-Source and 9.54% (95% CI 4.91%–16.0%) in Mirebalais (Table 2). We analyzed the frequency distribution of vibriocidal antibody titers for both serotypes (Figure). Only 4 of 277 persons reported having received oral cholera vaccine, consistent with the fact that no major public health oral cholera vaccine campaign had been undertaken in those regions before sample collection.

We calculated seroprevalence estimates for potential risk factors for cholera (Appendix Table 2). Seropositivity varied across multiple subgroups; however, 95% CIs were wide. Only the poverty likelihood index (OR 2.33, 95% CI 0.93–5.84) and reporting having an unimproved toilet compared with

Table 2. Weighted seroprevalence based on vibriocidal antibody titers in *Vibrio cholerae* serosurvey participants in 2 communities, Centre Department, Haiti, March–August 2017*

	Cerca-la-Source			Mirebalais		
Strain	No. tested	No. positive	% Seroprevalence (95% CI)	No. tested	No. positive	% Seroprevalence (95% CI)
Either Ogawa or Inaba	156	16	12.4 (6.76–20.0)	121	12	9.54 (4.91–16.0)
Ogawa only	156	14	9.73 (5.38–16.0)	121	11	8.75 (4.28–15.0)
Inaba only	156	2	2.69 (0.49–8.00)	121	3	2.73 (0.57–7.00)

*Based on a vibriocidal antibody assay positivity threshold titer of 320. Weights were computed as the inverse probability of selection and adjusted so that the marginal distribution of age group, sex, and communal section agreed with those from census estimates.

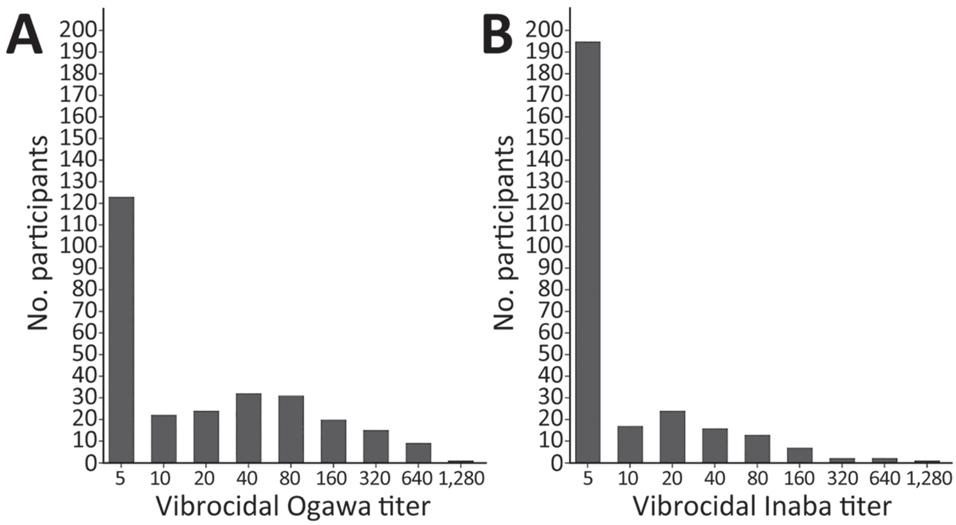

Figure. Serosurvey participants with vibriocidal antibody titers for Ogawa (A) and Inaba (B) *Vibrio cholerae* serotypes in 2 communities, Centre Department, Haiti, March–August 2017. Samples came from 217 total households, 99 (156 persons) in Cerca-la-Source and 118 (121 persons) in Mirebalais. All participants were adults ≥18 years of age.

open defecation (OR 0.26, 95% CI 0.04–1.53) met our predetermined p value threshold for inclusion into a multivariable model, so we did not perform multivariable analysis.

Conclusions

The vibriocidal antibody is a complement-dependent, bactericidal antibody directed against the lipopolysaccharide O-antigen of *V. cholerae* and is the best characterized immunologic marker of recent exposure to cholera. However, there is no widely agreed-upon threshold to quantify exposure over a given period, and our understanding of the relationship between symptom severity and antibody kinetics is limited. In the study from Bangladesh, a vibriocidal titer of ≥320 was the best marker of infection in the preceding year (*9*).

Limited serologic data on *V. cholerae* are available from Haiti. One prior serosurvey, conducted during March–April 2011, within the first 6 months of the onset of the epidemic in the Artibonite Department of Haiti, estimated that 39% of persons had a vibriocidal titer ≥320, whereas 64% had titers ≥80, which suggested extensive infection and was consistent with high early case counts (*12*).

The findings from this study should be interpreted considering several limitations. Only adults ≥18 years of age in 1 department of Haiti participated, so the data cannot be directly extrapolated to younger age groups and other regions; however; during 2017–2018, that department was the most affected according to case counts (*13*). We were unable to account for uncertainty in vibriocidal assay performance characteristics. Ideally, seroprevalence estimates should integrate data on the local sensitivity and specificity of a serologic assay, which are not available for Haiti (*14*). Last, the survey was cross-sectional and did not account for temporal waning of serologic markers.

In summary, in 2017, the seroprevalence of *V. cholerae* vibriocidal antibodies was 12.4% in Cerca-la-Source and 9.54% in Mirebalais in Haiti, suggesting a high rate of recent infection even at a time when case incidence was declining. Although commune-level incidence data were not available for direct comparison, in 2017, the reported annual incidence for the Centre Department, where Cerca-la-Source and Mirebalais are located, was 4.3 cases/1,000 inhabitants, which offers a general frame of reference (*13*,*15*). Those findings inform our understanding of cholera epidemic dynamics in Haiti, which is now experiencing a resurgence of cholera after nearly 3 years without a confirmed case. Our results demonstrate a higher-than-expected disease prevalence and suggest the need for improved surveillance to monitor cholera and guide public health interventions, especially during the waning phase of outbreaks.

Acknowledgments

We thank all the study participants and Zanmi Lasante staff for supporting this work.

This work was supported by the US National Institutes of Allergy and Infectious Diseases (grant no. T32 AI007433, awarded to W.R.M., and grant no. AI099243, awarded to L.C.I. and J.B.H.) and the Bill and Melinda Gates Foundation (grant no. OPP1148213, awarded to L.C.I. and R.T.). Funding sources played no role in study design; in the collection, analysis, and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

About the Author

Dr. Matias is an infectious diseases fellow at Massachusetts General Hospital and Brigham and Women's Hospital and a global health fellow at the Massachusetts General Hospital's Center for Global Health. His research focuses on epidemic disease response and global health equity.

References

1. Chin CS, Sorenson J, Harris JB, Robins WP, Charles RC, Jean-Charles RR, et al. The origin of the Haitian cholera outbreak strain. N Engl J Med. 2011;364:33–42. https://doi.org/10.1056/NEJMoa1012928
2. World Health Organization. Cholera—Haiti. 2022 Dec 22 [cited 2023 Jan 4]. https://www.who.int/emergencies/disease-outbreak-news/item/2022-DON415
3. Rebaudet S, Dély P, Boncy J, Henrys JH, Piarroux R. Toward cholera elimination, Haiti. Emerg Infect Dis. 2021;27:2932–6. https://doi.org/10.3201/eid2711.203372
4. Rubin DHF, Zingl FG, Leitner DR, et al. Reemergence of cholera in Haiti. N Engl J Med. 2022;387:2387–9. https://doi.org/10.1056/NEJMc2213908
5. Vega Ocasio D, Juin S, Berendes D, Heitzinger K, Prentice-Mott G, Desormeaux AM, et al.; CDC Haiti Cholera Response Group. Cholera outbreak—Haiti, September 2022–January 2023. MMWR Morb Mortal Wkly Rep. 2023;72:21–5. https://doi.org/10.15585/mmwr.mm7202a1
6. Luquero FJ, Rondy M, Boncy J, Munger A, Mekaoui H, Rymshaw E, et al. Mortality rates during cholera epidemic, Haiti, 2010–2011. Emerg Infect Dis. 2016;22:410–6. https://doi.org/10.3201/eid2203.141970
7. Nadri J, Sauvageot D, Njanpop-Lafourcade BM, Baltazar CS, Banla Kere A, Bwire G, et al. Sensitivity, specificity, and public-health utility of clinical case definitions based on the signs and symptoms of cholera in Africa. Am J Trop Med Hyg. 2018;98:1021–30. https://doi.org/10.4269/ajtmh.16-0523
8. Azman AS, Moore SM, Lessler J. Surveillance and the global fight against cholera: setting priorities and tracking progress. Vaccine. 2020;38(Suppl 1):A28–30. https://doi.org/10.1016/j.vaccine.2019.06.037
9. Azman AS, Lessler J, Luquero FJ, Bhuiyan TR, Khan AI, Chowdhury F, et al. Estimating cholera incidence with cross-sectional serology. Sci Transl Med. 2019;11:eaau6242. https://doi.org/10.1126/scitranslmed.aau6242
10. Iyer AS, Azman AS, Bouhenia M, Deng LO, Anderson CP, Graves M, et al. Dried blood spots for measuring *Vibrio cholerae*–specific immune responses. PLoS Negl Trop Dis. 2018;12:e0006196. https://doi.org/10.1371/journal.pntd.0006196
11. Lumley T. survey: analysis of complex survey samples. 2020 Apr 3 [cited 2021 May 6]. https://CRAN.R-project.org/package=survey
12. Jackson BR, Talkington DF, Pruckler JM, Fouché MDB, Lafosse E, Nygren B, et al.; The Cholera Serosurvey Working Group. Seroepidemiologic survey of epidemic cholera in Haiti to assess spectrum of illness and risk factors for severe disease. Am J Trop Med Hyg. 2013;89:654–64. https://doi.org/10.4269/ajtmh.13-0208
13. Lee EC, Chao DL, Lemaitre JC, Matrajt L, Pasetto D, Perez-Saez J, et al. Achieving coordinated national immunity and cholera elimination in Haiti through vaccination: a modelling study. Lancet Glob Health. 2020;8:e1081–9. https://doi.org/10.1016/S2214-109X(20)30310-7
14. Azman AS, Lauer SA, Bhuiyan TR, Luquero FJ, Leung DT, Hegde ST, et al. *Vibrio cholerae* O1 transmission in Bangladesh: insights from a nationally representative serosurvey. Lancet Microbe. 2020;1:e336–43. https://doi.org/10.1016/S2666-5247(20)30141-5
15. Haiti Ministry of Health and Population. Report of the National Surveillance Network: cholera. 52nd epidemiologic week, 2017 [in French]. 2017 [cited 2023 Jan 25]. https://mspp.gouv.ht/site/downloads/Profil%20statistique%20Cholera%2052eme%20SE2017version%20finale.pdf

Address for correspondence: Wilfredo R. Matias, Massachusetts General Hospital, Division of Infectious Diseases, 55 Fruit St, BUL-130, Boston, MA 02114, USA; email: wmatias@bwh.harvard.edu

Article DOI: https://doi.org/10.3201/eid2909.230401

Seroprevalence of *Vibrio cholerae* in Adults, Haiti, 2017

Appendix

Appendix Table 1. Study population, date, and sampling intervals (*1*)

Characteristic	Cerca-la-Source	Mirebalais
Census – number of households	9,497	23,194
Census – number of individuals	48,799	97,755
Date of census and household survey	April 6 – May 23, 2017	March 24 – June 9, 2017
Interval for inclusion into household survey	Every 18th household in the census	Every 11th household in the census
Date of serosurvey	August 8 – August 17, 2017	May 22 – June 16, 2017
Interval for inclusion into serosurvey	Every 3rd household in household survey	Every 2nd household in household survey

Appendix Table 2. Seroprevalence by household-level risk factors and associations with seropositivity[a]

Characteristics (N, if not 277)	Total (N = 277)	Unweighted Seropositive (N = 28)	Unweighted Seronegative (N = 249)	Weighted Seroprevalence % (95% CI)	Weighted Odds Ratio (95% CI)	p-value
Sociodemographic characteristics						
Age						
18 - 30	78	10 (12.8)	68	10.7 (4.96 - 19.1)	Ref	Ref
31 - 40	54	7	47	15.9 (6.83 - 29.1)	1.58 (0.55 - 4.57)	0.4
41 - 50	57	4	53	5.94 (1.44 - 15.0)	0.53 (0.13 - 2.08)	0.36
>50	88	7	81	8.24 (3.14 - 16.6)	0.75 (0.24 - 2.31)	0.62
Gender						
Man	130	10	120	8.17 (3.98 - 14.3)	Ref	Ref
Woman	147	18	129	12.7 (7.15 - 20.3)	1.64 (0.68 - 3.94)	0.27
No. people living in household[b, c]		5 (3 - 7)	4 (3 - 6)		1.09 (0.89 - 1.34)	0.39
Children under 5 in household[b]		0 (0 - 2)	0 (0 - 1)		1.30 (0.75 - 2.25)	0.34
Likelihood of Poverty[b,] (*2*)		10.4 (2.2 - 54)	10.4 (2.2 - 35.6)		1.01 (0.99 - 1.03)	0.24
Likelihood of Poverty (Percentile)						
0 – 49	201	17	184	8.85 (4.96 – 14.2)	Ref	Ref
50 – 100	76	11	65	18.5 (9.18 – 31.1)	2.33 (0.93 – 5.84)	0.07
Household Hunger Scale (*3*)						
Little to no hunger	116	12	104	11.6 (5.80 - 19.8)	Ref	Ref
Moderate hunger	113	9	104	6.44 (2.78 - 12.2)	0.53 (0.19 - 1.45)	0.22
Severe hunger	48	7	41	18.1 (6.80 - 35.1)	1.68 (0.53 - 5.36)	0.38
Water and Hygiene						
Water source						
Unimproved	80	8	72	9.25 (3.57 - 18.4)	Ref	Ref
Improved	197	20	177	10.9 (6.51 - 16.6)	1.19 (0.04 - 1.20)	0.73

Characteristics (N, if not 277)	Total (N = 277)	Unweighted Seropositive (N = 28)	Unweighted Seronegative (N = 249)	Weighted Seroprevalence % (95% CI)	Weighted Odds Ratio (95% CI)	p-value
Time to retrieve water and return to house on foot (minutes)						
<15	167	15	152	9.23 (4.93 - 15.2)	Ref	Ref
> = 15 < = 30	71	10	61	15.1 (6.58 - 27.7)	1.75 90.63 - 4.90)	0.28
>30 to < = 60	30	2	28	4.86 (0.64 - 15.5)	0.5 (0.10 - 2.42)	0.39
>60	9	1	8	12.9 (0.14 - 62.6)	1.45 (0.19 - 11.0)	0.72
Money spent on water daily for household						
0 HTG[d]	198	19	179	9.56 (5.39 - 15.2)	Ref	Ref
Less than 15 HTG	25	1	24	6.28 (0.26 - 26.7)	0.63 (0.08 - 5.08)	0.67
15 - 30 HTG	34	4	30	11.7 (3.55 - 25.9)	1.25 (0.39 - 4.08)	0.71
More than 30 HTG	20	4	16	18.6 (4.01 - 44.7)	2.17 (0.53 - 8.79)	0.28
Water from the water source unavailable for at least 1 whole day in last 1 month						
No	123	12	111	8.56 (3.96 - 15.5)	Ref	Ref
Yes	154	16	138	11.9 (6.67 - 18.9)	1.44 (0.56 - 3.68)	0.44
Frequency of treating water						
Not always	135	9	126	7.87 (3.56 - 14.4)	Ref	Ref
Always or almost always	142	19	123	13.5 (7.59 - 21.4)	1.83 (0.70 - 4.76)	0.22
Household exposures						
Respondent had diarrhea in the last 2 weeks						
No	227	24	203	10.0 (6.19 - 15.0)	Ref	Ref
Yes	50	4	46	13.3 (3.67 - 30.4)	1.38 (0.40 - 4.73)	0.61
Respondent had diarrhea requiring stay overnight in a cholera treatment unit or hospital since 2010?						
No	228	23	205	10.6 (6.48 - 16.0)	Ref	Ref
Yes	49	5	44	10.3 (2.90 - 23.5)	0.96 (0.29 - 3.20)	0.95
Anyone in your household (besides respondent) had diarrhea in the last two weeks? (N = 271)						
No	197	18	179	9.89 (5.57 - 15.8)	Ref	Ref
Yes	74	10	64	13.7 (6.18 - 24.6)	1.44 (0.55 - 3.77)	0.45
Anyone in household (besides respondent) been diagnosed with cholera by a doctor in the last two weeks? (If diarrhea in last 2 weeks = Yes. N = 77)						
No	60	6	54	10.5 (3.52 - 22.2)	Ref	Ref
Yes	17	3	14	15.1 (2.28 - 41.7)	1.53 (0.27 - 8.72)	0.63
Anyone in your household (besides respondent) ever spent the night in a cholera treatment unit?						
No	218	21	197	10.2 (6.06 - 15.7)	Ref	Ref
Yes	59	7	52	12.2 (4.82 - 23.6)	1.22 (0.45 - 3.32)	0.69
Observation questions						
Water storage vessel coverage (N = 243)						
Partially or not covered	27	1	26	4.24 (0.18 - 18.7)	Ref	Ref
Fully covered	216	23	193	10.6 (6.51 - 15.9)	2.67 (0.35 - 20.53)	0.34
Type of water storage vessel opening (N = 243)						
Narrow-mouthed	100	10	90	9.79 (4.54 - 17.6)	Ref	Ref
Wide-mouthed	143	14	129	10.3 (5.42 - 17.0)	1.05 (0.41 - 2.74)	0.91
Spigot or tap on water storage vessel (N = 243)						
No	166	18	148	10.9 (6.29 - 17.2)	Ref	Ref

Characteristics (N, if not 277)	Total (N = 277)	Unweighted Seropositive (N = 28)	Unweighted Seronegative (N = 249)	Weighted Seroprevalence % (95% CI)	Weighted Odds Ratio (95% CI)	p-value
Yes	77	6	71	7.31 (2.53 - 15.5)	0.64 (0.22 - 1.91)	0.42
Chlorine level (Parts per million[mg/L]) (N = 217)[e]						
0.1	152	16	136	9.38 (5.32 - 14.9)	Ref	Ref
0.2 - 2	43	2	41	9.05 (1.13 - 28.1)	0.96 (0.18 - 4.99)	0.96
2.1 - 6	22	2	20	10.2 (1.45 - 30.1)	1.09 (0.24 - 4.91)	0.91
Toilet type (N = 219)						
Open defecation	26	6	20	16.1 (4.52 - 35.8)	Ref	Ref
Unimproved	57	2	55	4.79 (0.85 - 13.8)	0.26 (0.04 - 1.53)	0.14
Improved	136	15	121	9.99 (5.55 - 16.0)	0.58 (0.16 - 2.03)	0.39

[a]Data are presented as the number (%) unless stated otherwise.
[b]These data are presented as the weighted median (Interquartile range). For this analysis, likelihood of poverty was calculated based on the $1.25 2005 purchasing power parity poverty line.
[c]We defined a household as an individual or group of related or unrelated individuals sleeping or staying under the same roof and sharing resources for at least half the week.
[d]HTG = Haitian Gourdes.
[e]Chlorine levels (based on chlorine free residual) of the household water supply was tested using a diethyl paraphenylene diamine (DPD) colorimetric indicator test (LaMotte, Chestertown, MD, USA).

References

1. Institut Haitiën de Statistiques et d'Informatiques. Population totale, population de 18 ans et plus, ménages et densités estimés en 2015. Port-au- Prince, Haiti: Ministère de l'Économie et des Finances; 2015 [cited 2023 Jan 5]. https://www.humanitarianresponse.info/sites/www.humanitarianresponse.info/files/documents/files/estimat_poptotal_18ans_menag2015.pdf

2. Schreiner M. Simple Poverty Scorecard poverty-assessment tool, Haiti [cited 2023 Feb 5]. https://www.simplepovertyscorecard.com/HTI_2012_ENG.pdf

3. Ballard T, Coates J, Swindale A, Deitchler M. Household hunger scale: indicator definition and measurement guide [cited 2023 Feb 5]. https://www.fantaproject.org/monitoring-and-evaluation/household-hunger-scale-hhs