

Research Article

Impact of the 2018-2020 Democratic Republic of Congo Ebola epidemic on health system utilization and health outcomes

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Keywords: Hemorrhagic fever, Ebola, Outcome assessment, Health Care, Democratic Republic of Congo, Health Facilities, Vaccination

<https://doi.org/10.29392/001c.88108>

Journal of Global Health Reports

Vol. 7, 2023

Background

The 2018-2020 Ebola epidemic in the eastern Democratic Republic of Congo caused 3,481 infections and 2,299 deaths. The broader impact on health system utilization and health outcomes remains unclear.

Methods

From January to March 2020, a cross-sectional survey was administered to 3,631 households in Ebola-affected and non-affected health zones in North Kivu province to collect data on health behaviors and health status. Using linear models, we tested for associations between residence in an Ebola zone and multiple outcomes. Additionally, administrative data from 56 health facilities in Ebola zones was used to test for statistically significant changes in medical procedures (e.g. Cesarean sections) and disease rates before and during the epidemic.

Results

Comparing before the epidemic to during, we found no difference in monthly mean procedures per facility: measles vaccinations -58 (95% confidence interval, CI = -140, 24); Cesarean sections 1.4 (95% CI = -0.8, 3.6); laparotomy 0.2 (95% CI = -0.5, 0.9); open fractures 0.0 (95% CI = -0.1, 0.1); appendectomy 0.0 (95% CI = -0.3, 0.3); inguinal hernia 0.3 (95% CI = 0.0, 0.7). Households in Ebola zones were 16 percentage points (pp) (95% CI = 11, 21) more likely to report going to the hospital more often than normal because of free access, reported fewer measles vaccinations (-10pp 95% CI = -14, -5), and less willingness to vaccinate children (-6pp; 95% CI = -9, -3). However, administrative data showed no change in vaccination before and during Ebola in Ebola zones. Households in Ebola zones were 14pp less likely to report that a child had experienced measles (95% CI = -18, -11) and 8pp less likely to report that a child had experienced diarrhea (95% CI = -12, -4) since 1 Jan 2017. However, administrative data showed no change in either, comparing before-Ebola to during-Ebola in Ebola zones (difference in monthly mean procedures per facility: measles 5.6 (95% CI = -0.8, 12.0); diarrhea 41 (95% CI = -63, 145).

Conclusions

The Ebola epidemic did not have large effects on health system utilization or health outcomes (other than Ebola virus disease). This suggests that the Congolese and international response successfully maintained health system capacity during the epidemic.

In 2014, the Ebola virus emerged in West Africa, which resulted in the death of over 11,000 people, and crippled the health systems of Guinea, Sierra Leone, and Liberia. As healthcare workers were also sick and many died,¹ healthcare utilization plummeted,² primary preventive services came to a halt,³⁻⁵ and chronic disease management and surgery virtually ceased.⁶⁻⁸ Consequently, many West Africans died of other preventable deaths indirectly due

to Ebola.^{5,6} A systematic review of 22 studies comparing healthcare utilization before and after the West African epidemic found a decline of 18% (95% confidence interval: 10-27%). Inpatient care and deliveries showed greater declines than outpatient care. Some evidence suggests that the population-level harms from decreased utilization were greater than those of the direct effect of Ebola virus disease

(EVD) infections.^{9,10} Surprisingly, no studies were found on other Ebola epidemics.

In August 2018, Ebola emerged in the eastern Democratic Republic of Congo (DRC). A region previously Ebola-naïve where health systems had already been weakened by decades of structural adjustment and armed conflict,¹¹ many feared another epidemic on the scale of West Africa 2014–2016. To prevent a country-wide—or worse, regional—health system collapse, a large and robust Ebola Response coalesced in the region shortly after the declaration of the epidemic. User fees for primary health care were eliminated, infection prevention and control practices were augmented, and extensive sensibilization efforts in the community were undertaken. Nonetheless, by the end of the epidemic in June 2020, 3,407 cases of EVD and 2,280 deaths had been recorded.

While there has not been a systematic evaluation of the impact of the eastern Congo epidemic on broader health outcomes or health care utilization, several studies have focused on particular determinants of utilization. Wisniewski and colleagues find that the no-user-fee policy in some parts of the most affected province (North Kivu) resulted in 2.48 times more clinic visits (95% CI = 2.20–2.78), but had no effect on measles vaccination or fourth antenatal care clinic visits.¹² Vinck and colleagues surveyed households in two cities in North Kivu and found that belief in misinformation and low institutional trust were associated with less seeking of formal healthcare (misinformation: odds ratio 0.06, 95% CI = 0.05–0.06; one-point increase in trust score: odds ratio 1.16, 95% CI = 1.15–1.17).¹³ Masumbuko and colleagues interviewed residents in one of the same cities (Butembo); 12% of their respondents believed that Ebola was fabricated; 9% expressed support for overt acts of hostility to the EVD response team.¹⁴ These studies suggest that free care and misinformation were important influences on health care utilization during the Congolese Ebola epidemic, but there is a gap in the literature regarding the overall effects of the epidemic on health care utilization and non-EVD health outcomes.

The primary aim of this study was to evaluate if the eastern Congo Ebola epidemic reduced healthcare utilization and worsened health outcomes other than EVD. To our knowledge, this is the first attempt to do so. Thus, this study contributes to our understanding of how health systems respond to emergencies and how health system strengthening is related to epidemic mitigation, which will inform future mitigation efforts.

METHODS

STUDY DESIGN

This mixed methods study combines ethnographic research with a cross-sectional survey and analysis of administrative data. “Ebola zones” were defined as the six health zones (Beni, Butembo, Katwa, Vuhovi, Kalunguta, and Mabalako) in North Kivu province that recorded over 100 cases of Ebola. Health zones are administrative units of the Congolese health system that typically include about 160,000 inhabitants each. For comparison, “non-Ebola zones” were

defined as four health zones (Kirotshe (0), Masisi (0), Nyiragongo (3), and Rutshuru (0)) in North Kivu that had three or fewer cases.

The ethnographic research began in the Ebola zones in October 2020. A member of the research team conducted open-ended interviews in each health center in the study zones that conducted surgeries during the epidemic (n=11). We also interviewed community leaders in Mangina, the town in North Kivu where the epidemic was first declared. Based on the findings of this research, expert opinion, and relevant scientific literature, a household questionnaire was developed to compare the experiences of those living in health zones with Ebola to those living outside the Ebola-affected area (**Online Supplementary Document**). The questionnaire went through several rounds of reviews by Ebola and health systems experts. The questionnaire was then piloted for one week in Butembo. Several questions were edited to be more understandable. The questionnaire at the beginning of the survey work included items on Ebola, health services utilization, other health practices and outcomes, and overall well-being. Questions about accessing services more due to free care, measles vaccinations, and fear of Ebola treatment centers (ETC) were added after roughly half of the targeted households had been interviewed. Interviewers were recruited from networks of non-profit research in the region. All interviewers had at least a secondary education and were fluent in Swahili and French (and for those working in rural zones, Kinande). All interviewers were trained in survey methodology in a three-day workshop by experts. Interviewers obtained verbal consent from all study participants after providing information about the nature and purpose of the research and making it clear that participation was voluntary and that responses would be anonymized. Questionnaire validity was assessed by descriptive analysis of pilot results and discussion with the interviewers and respondents. Sample size calculations were based on a previous estimate that 3.2% of households in North Kivu province have a handwashing system. To detect an increase as small as 3 percentage points at 80% power with a 5% chance of Type I error, the sample would need to include at least 1,368 households in Ebola zones and 500 outside of Ebola zones. We oversampled Ebola zones because we suspected there would be a higher variance in outcomes within Ebola zones. Within each health zone, we randomly sampled from a comprehensive list of neighborhoods (quartiers). The probability of selection was proportional to the relative population of the neighborhood relative to all neighborhoods in the study zones. Within each neighborhood, sampling began at the local administrator’s residence (chef de quartier). From there, the research team spun a pen to randomly select a direction, and the fifth household in that direction was interviewed. Interviews with every fifth household continued until the target number was met for that neighborhood.

Administrative data on medical procedures was collected from 56 health facilities that practice surgery. One of the authors travelled to each health zone covered by the household survey, and then to the individual health centers practicing surgery. They transposed paper files into digital

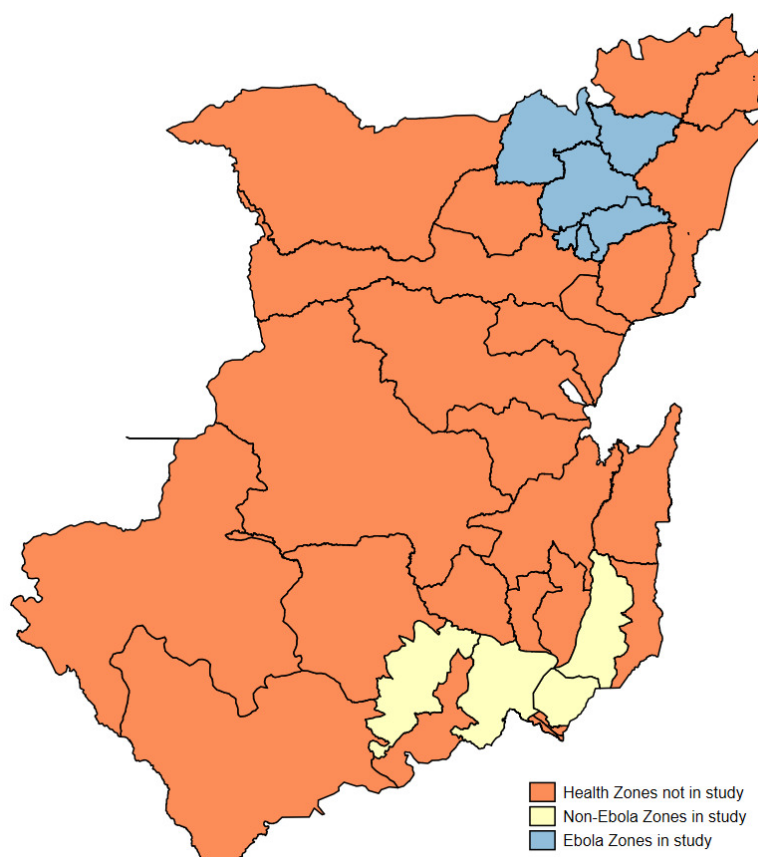


Figure 1. Map of North Kivu Province, DRC, showing health zones included in the study

spreadsheets. They verified with health zone authorities that they went to all the individual health centers that were practicing surgery in those zones. A retrospective chart analysis of operative procedures was conducted to measure utilization of health services at facilities in Ebola zones. The Congolese government authorized the performance of surgery during the epidemic in the six Ebola-affected health zones in North Kivu selected as defined above. The number of operations performed during the periods January 1, 2016-July 31, 2017 (hereafter discussed as the “before Ebola” period) and August 1, 2018-December 31, 2019 (hereafter discussed as the “during Ebola” period) was tallied for each of the following procedures: Cesarean sections, laparotomy, open fracture repairs, inguinal hernia, and appendectomy. In addition to operative volume, characteristics of the facilities were recorded, including whether the facility offered free care during the epidemic had an Ebola transit or treatment center.

Finally, the offices of the six Ebola-affected health zones were visited by a member of the research team, and zone-level health data were extracted on diarrhea case counts, measles case counts, and rates of measles vaccination during the same before- and after-Ebola periods (January 1, 2016-July 31, 2017 and August 1, 2018-December 31, 2019).

STATISTICAL ANALYSIS

For outcomes comparing residents of Ebola zones to residents of non-Ebola zones, we fit linear regression models in

Stata version 17.0. We present crude and adjusted mean differences with 95% confidence intervals using control variables for household characteristics that are unlikely to have changed due to the Ebola epidemic: occupation of the household head and urban/rural residence.

For outcomes comparing procedure rates in health facilities during Ebola to the same facilities before Ebola, we compared the mean number of monthly procedures in each hospital before and during Ebola. We used paired t-tests to assess if there was a statistically significant difference (using $P=0.05$ as a cut-off) between the two time periods.

RESULTS

POPULATION CHARACTERISTICS

From 13 January 2020 to 24 March 2020, 3,102 households in Ebola zones and 529 households outside of Ebola zones were interviewed. We found no systematic difference in the occupation of the household head between Ebola and non-Ebola zones; overall, 49% were farmers (95% confidence interval, CI = 48-51%), 18% were small-scale merchants (95% CI = 17-19%), 11% were government employees (95% CI = 10-12%), and 4% were unemployed (95% CI = 3-4%), with the remaining 18% in other occupations. In the following analyses, we control for rural/urban residence and occupation of household head to reduce confounding of the estimated associations. Households in Ebola zones were 54 percentage points less likely to be in rural areas. House-

holds in Ebola zones were also slightly larger: 6.8 members vs 6.5 in non-Ebola zones.

ASSOCIATIONS BETWEEN LIVING IN AN EBOLA ZONE AND EBOLA EXPOSURE, PERCEPTIONS, AND PREVENTION

Less than one percent of households outside of Ebola zones reported knowing someone who has had Ebola, compared to 28 percent in Ebola zones ([Table 1](#)). Respondents in Ebola zones were 20 percentage points (95% CI = 16, 25) more likely to report that they had had Ebola at some point during the epidemic. They were also 58 percentage points (95% CI = 54, 63) more likely to have had at least one household member vaccinated against Ebola: on average, Ebola zone households reported that 2.3 people (95% CI = 2.2, 2.4) were vaccinated against Ebola; 41% (95% CI = 40, 43) reported no vaccinations, and 28% (95% CI = 26, 29) reported that 4 or more people were vaccinated. Finally, Ebola zone households were 11 percentage points (95% CI = 8, 15) more likely to have found work related to Ebola.

Households in the Ebola zones were more likely to distrust the 'Ebola Response'. They were 10 percentage points (95% CI = 7, 12) more likely to report that someone in the area under surveillance by The Response had fled. Households in Ebola zones were 6 percentage points (95% CI = 0-12) more likely to answer the question "Why do people sometimes die in Ebola Treatment Centers?" in a way that suggests they were afraid. At the same time, households in Ebola zones were more likely to adopt health practices that curb Ebola transmission. They were 37 percentage points (95% CI = 33, 42) more likely to report that they would like to be treated in an ETC if they were diagnosed with Ebola and 22 percentage points (95% CI = 18, 26) more likely to use soap every day.

ASSOCIATIONS BETWEEN LIVING IN AN EBOLA ZONE AND HEALTHCARE UTILIZATION

The associations between Ebola and healthcare utilization appear to be mixed ([Tables 1 & 2](#)). Households in Ebola zones were 16 percentage points (95% CI = 11, 21) more likely to report that they went to the hospital more often since the epidemic began because of the elimination of user fees by the response. At the same time, households in Ebola zones were 6 percentage points less likely to report that they would vaccinate their children during the epidemic, and, consistent with that, households in Ebola zones were 10 percentage points less likely to report having vaccinated at least one child against measles. However, we did not find a statistically significant difference (-0.02, 95% CI = -0.05, 0.01) between households inside and outside of Ebola zones regarding the proportion of children vaccinated against measles, nor in the proportion reporting that they could access treatment for a child with measles. Furthermore, data from the six health zones affected by Ebola show no significant differences (-58, 95% CI = -140, 24) in the monthly average of measles vaccinations when comparing the 19 months before the epidemic to the first 17 months of the epidemic ([Table 2](#)).

ASSOCIATIONS BETWEEN LIVING IN AN EBOLA ZONE AND HEALTH OUTCOMES

Returning to the household data, we found evidence that non-Ebola infectious disease outcomes were better inside the Ebola zone than outside, while injury mortality was worse ([Table 3](#)). Households in Ebola zones were 14 percentage points less likely to report having a child contract measles between 1 Jan 2017 and early 2020. Households in Ebola zones were also 8 percentage points (95% CI = 4, 12) less likely to report any child having diarrhea between 1 January 2017 and early 2020. In contrast to these household-level results, data from the six health zones affected by Ebola show no significant differences in the monthly average of diarrhea cases or measles cases when comparing the 19 months before the epidemic to the first 17 months of the epidemic ([Table 2](#)). Maternal deaths and deaths due to lack of surgical care were only reported in 1% of households outside of the Ebola zone, and we found no statistically significant difference from households in the Ebola zone ([table 3](#)). Finally, deaths from injury were 4 percentage points (95% CI = 1, 6) more likely in the Ebola zone.

ASSOCIATIONS BETWEEN LIVING IN AN EBOLA ZONE, URBAN/RURAL RESIDENCE, AND HEALTH PRACTICES

Regarding health practices, when asked how else the Ebola virus had changed the health of their household, the most frequent response was that handwashing hygiene had improved, although households in rural areas outside of Ebola zones were less likely to report this ([table 4](#)). Households in rural areas outside of Ebola zones were the least likely to report going to the hospital if sick and most likely to report no changes. Households in both urban and rural areas in Ebola zones were more likely to report not sharing beds with visitors (a normalized hosting practice in the region).

ASSOCIATIONS BETWEEN LIVING IN AN EBOLA ZONE, URBAN/RURAL RESIDENCE, AND PRIORITIES

When asked which problems among Ebola, insecurity, and food should be prioritized, insecurity was the most frequent response by all households, except those in urban areas outside Ebola zones, who chose Ebola ([table 4](#)). Ebola was much less likely to be named by households in rural areas outside of Ebola zones. Food was much less likely to be prioritized inside Ebola zones compared to outside of Ebola zones.

DISCUSSION

MAIN FINDINGS OF THIS STUDY

The primary aim of this study was to evaluate if the 2018-2020 eastern Congo Ebola epidemic reduced health-care utilization and worsened health outcomes other than EVD. Contrary to what was initially feared, the epidemic did not cause major decreases in health system utilization. Households in Ebola zones reported going to the hospital more due to free care, and we did not observe a change in the volume of surgical procedures performed before and

Table 1. Associations between living in an Ebola zone and Ebola exposure, perceptions, and prevention*

Outcomes	<u>No Ebola Zone</u>		Mean	SD	<u>Ebola Zone</u>		Mean	SD	Unadj. diff.	Adj. diff.	<u>95% Conf. Int.</u>		Missing
	N, total	N, "yes"			N, total	N, "yes"					Lower Bound	Upper Bound	
Believed had Ebola	501	14	0.03	0.16	3102	818	0.26	0.44	0.24	0.20	0.16	0.25	28
Know someone infected with Ebola	518	1	0.00	0.04	3101	872	0.28	0.45	0.28	0.25	0.21	0.29	12
Any HH member vaccinated with Ebola	529	20	0.04	0.19	3102	1823	0.59	0.49	0.55	0.58	0.54	0.63	0
Know someone who fled Response	516	2	0.00	0.06	3101	264	0.09	0.28	0.08	0.10	0.07	0.12	14
Fear of Ebola Treatment Center (ETC)	383	196	0.51	0.50	1474	764	0.52	0.50	0.01	0.06	0.00	0.12	1774
Prefer ETC for treatment	529	85	0.16	0.37	3102	1652	0.53	0.50	0.37	0.37	0.33	0.42	0
Found work thanks to Ebola	521	2	0.00	0.06	3099	385	0.12	0.33	0.12	0.11	0.08	0.15	11
Use soap every day	529	264	0.50	0.50	3102	2457	0.79	0.41	0.29	0.22	0.18	0.26	0
Would access vaccines for children	529	518	0.98	0.14	3099	2755	0.89	0.31	-0.09	-0.06	-0.09	-0.03	3
Any child vaccinated against measles	529	450	0.85	0.36	3102	2223	0.72	0.45	-0.13	-0.10	-0.14	-0.05	0
Proportion of children vaccinated measles	461	432	0.94	0.20	1879	1699	0.90	0.27	-0.03	-0.02	-0.05	0.01	1291
Could access treatment for measles	529	488	0.92	0.27	3099	2691	0.87	0.34	-0.05	-0.02	-0.05	0.01	3
Attend hospital more because its free	529	276	0.52	0.50	1541	1012	0.66	0.47	0.13	0.16	0.11	0.21	1561

*Data are from a cross-sectional household survey. Outcomes are binary. Unadjusted differences (Unadj. diff.) contain the coefficient on 'living in an Ebola zone' from a linear regression model with no control variables. Adjusted differences (Adj. diff.) contain the coefficient on 'living in Ebola zone' from linear regression models with controls for urban/rural residence and occupation of the household head. SD = standard deviation. HH = household.

Table 2. Comparison of health system utilization and health outcomes before Ebola vs during Ebola*

Outcomes	Before (mean)	Before (SD)	During (mean)	During (SD)	Difference in means		95% CI =	p-value
<i>Medical procedure</i>								
Measles vaccinations	688	409	631	390	-58	-140	24	0.234
Cesarean	16.3	17.8	17.7	20.9	1.4	-0.8	3.6	0.214
Laparotomy	2.4	4.0	2.6	5.9	0.2	-0.5	0.9	0.531
Open fractures	0.2	0.6	0.2	0.9	0.0	-0.1	0.1	0.628
Appendectomy	1.1	1.3	1.1	1.5	0.0	-0.3	0.3	0.956
Inguinal hernia	1.1	1.7	1.5	2.7	0.3	0.0	0.7	0.081
<i>Health outcomes</i>								
Measles cases	0.5	0.5	6.1	8.1	5.6	-0.8	12.0	0.150
Diarrhea cases	427	257	468	258	41	-63	145	0.485

* Before = monthly mean number of medical procedures or cases from Jan 1, 2017–July 31, 2018; During = monthly mean number of medical procedures or cases from Aug 1, 2018–Dec 31, 2019. Data are from 56 health facilities across six North Kivu, DRC health zones. Measles cases include suspected and confirmed cases. Diarrhea cases include simple and dehydrated. SD = standard deviation.

during the epidemic. While, in the survey, households in Ebola zones voiced reticence to bring their children in for measles vaccination, the vaccination rates reported by the health facilities in Ebola zones did not change with the Ebola epidemic. Thus, we conclude that, like surgical volume, measles vaccination likely remained constant despite the epidemic. The response's elimination of the user fees in targeted health facilities and the response's efforts to improve infection prevention and control in all health facilities in Ebola zones, likely played a critical role in the continued functioning of the health system.

Nor did the epidemic cause a considerable deterioration in health outcomes beyond the direct effects of Ebola. In the household survey data, we observed lower prevalence of self-reported measles and diarrhea in Ebola zones compared to outside of Ebola zones. However, health zone administrative records did not show a similar trend; measles and diarrhea rates did not change during Ebola. One possible explanation for this divergence, which is supported by our ethnographic data, is that, in the absence of Ebola, measles and diarrhea are often treated in the informal health system, in pharmacies and by traditional practitioners that do not report directly to the health zone (see [11] for a discussion of the formal and informal health care systems in Congo). With the elimination of user fees in some formal structures, healthcare utilization likely shifted from informal structures (which still charged fees) to formal structures (which became temporarily free). This would explain why the overall incidence of measles and diarrhea could have decreased in the Ebola zones, while the health zones continued to record similar numbers of cases. Two contributing factors to decreased measles and diarrhea cases in Ebola zones include the improved health practices that were noted in the survey—increased household soap use, improved handwashing, and decreased bed sharing—as well as social and physical distancing between households, which we observed ethnographically.

Finally, in this study, we observed that households in Ebola zones reported more injury deaths than households outside of Ebola zones. This is consistent with our finding that insecurity was reported as a higher priority than Ebola among households in Ebola zones. This finding was confirmed in the ethnographic arm of the study, wherein people often spoke of their fear of being massacred by the armed groups active in the region.¹¹

WHAT WAS ALREADY KNOWN ON THIS TOPIC

A systematic review of 22 health care utilization studies during the West African Ebola epidemic found, across 235 estimates of relative utilization, a mean decline of 18% (95% CI =: 10–27%).¹⁵ Inpatient care and deliveries showed greater declines than outpatient care. No studies were found on other Ebola epidemics.

In DRC's North Kivu province, using national health information system data from 81 to 156 facilities (depending on the outcome), Wisniewski and colleagues found that the no-user-fee policy resulted in 2.48 times more clinic visits (95% CI = 2.20–2.78).¹² Unlike our study, they did not statistically test for differences in utilization before and after the epidemic, or between affected and unaffected areas. However, their data, as presented in Figures 3–7, suggest that utilization of most services did not change from before to during the epidemic, consistent with our findings. Their data is limited to public facilities, had high rates of missingness, and missingness was indistinguishable from true zeroes. Our household survey data thus provides a valuable complementary set of information on utilization.

Another study in North Kivu, by Vinck and colleagues, interviewed a random sample of residents in two cities. Of the 961 interviewees, only 349 (31.9%, 95% CI = 27.4–36.9) trusted that local authorities represent their interest.¹³ Belief in misinformation was widespread, with 230 (25.5%, 21.7–29.6) respondents believing that the Ebola outbreak

Table 3. Association between living in an Ebola zone and non-Ebola health outcomes*

Outcomes	No Ebola Zone		Mean	SD	Ebola Zone		Mean	SD	Unadj. diff.	Adj. diff.	95% Conf. Int.		Missing
	N, total	N, "yes"			N, total	N, "yes"					Lower Bound	Upper Bound	
Any child infected with measles	529	135	0.26	0.44	3102	363	0.12	0.32	-0.14	-0.14	-0.18	-0.11	0
Any child that had diarrhea	529	159	0.30	0.46	3102	717	0.23	0.42	-0.07	-0.08	-0.12	-0.04	0
Proportion of children with diarrhea	483	-	0.19	0.31	2678	-	0.38	0.46	0.19	0.02	-0.03	0.06	470
Death during labor	527	7	0.01	0.11	3099	45	0.01	0.12	0.00	0.00	-0.01	0.02	5
Death, lack of surgery	526	7	0.01	0.11	3101	27	0.01	0.09	0.00	0.00	-0.01	0.01	4
Death, injury	526	19	0.04	0.19	3096	155	0.05	0.22	0.01	0.04	0.01	0.06	9

* Data are from a cross-sectional household survey. Outcomes are binary. Unadjusted differences (Unadj. diff.) contain the coefficient on 'living in an Ebola zone' from a linear regression model with no control variables. Adjusted differences (Adj. diff.) contain the coefficient on 'living in Ebola zone' from linear regression models with controls for urban/rural residence and occupation of the household head. SD = standard deviation.

Table 4. Health behavior change and priorities by Ebola zone and Urban/Rural*

Question and responses	Ebola Zone, Urban (N=1979)		Ebola Zone, Rural (N=1123)		Non-Ebola Zone, Urban (N=51)		Non-Ebola Zone, Rural (N=478)	
	Proportion	N, "yes"	Proportion	N, "yes"	Proportion	N, "yes"	Proportion	N, "yes"
<i>How did Ebola change the health of households?</i>								
Handwashing hygiene has improved	0.89	1761	0.84	943	0.96	49	0.60	287
We are more likely to go to the hospital if sick	0.22	435	0.15	168	0.24	12	0.06	29
We don't share beds with visitors	0.23	455	0.16	180	0.02	1	0.02	10
No changes	0.08	158	0.13	146	0.04	2	0.38	182
<i>Which of the following should be prioritized?</i>								
Ebola	0.49	970	0.53	595	0.45	23	0.17	81
Insecurity	0.66	1306	0.83	932	0.41	21	0.83	397
Food	0.05	99	0.04	45	0.14	7	0.16	76

* Data are from a cross-sectional household survey. Variables are binary. Numbers in the table are the proportions of respondents that reported the behavior change or priority. The proportions do not sum to one because respondents could choose multiple options. Total observations = 3,631.

was not real. Masumbuko and colleagues interviewed a convenience sample of residents in one of the same cities (Butembo).¹⁴ Of the 630 interviewees, 78 (12%) believed that Ebola was fabricated, and 60 (9%) expressed support for overt acts of hostility to the EVD response team. These results are more or less consistent with our finding that 52% of respondents feared the Ebola Treatment Center, and 10% of respondents in Ebola zones knew someone who had fled the Ebola response.

Regarding health outcomes other than Ebola, a study in Sierra Leone combining facility data and data from safe burial teams found that all-cause mortality during the epidemic was 3.4 times higher than the four years before the epidemic – a much higher increase than could be accounted for by EVD.⁹ A study that attempts to capture all social and economic costs of the West African epidemic estimates that deaths from causes other than Ebola constitute roughly 36% of total costs.¹⁰

WHAT THIS STUDY ADDS

This study combines household surveys with administrative records for a multifaceted assessment of the overall impact of the 2018–2020 Congolese Ebola epidemic on the affected region's health system. It shows that health systems in low-resource, high-disease-burden settings can avoid collapse during an infectious disease epidemic with thousands of cases and deaths. Surgical procedure and vaccination rates appear to have remained constant. More households in the epidemic zone reported higher than usual hospital visitation than households outside of the zone, and households in the epidemic zone reported lower rates of diarrhea and measles. Additional research should investigate the reasons for this success and their applications to other settings.

LIMITATIONS

This study has several limitations. First, some of our analysis compares households in Ebola zones to households outside of Ebola zones. This relies on the assumption that, in the absence of Ebola, there was, on average, no difference between these two groups of households. To make these two groups more comparable, we controlled for urban or rural residence and occupation of the household head. We also presented some results disaggregated by urban or rural residence. Nonetheless, there may still be unknown confounders in the absence of randomization. Second, the household data come from a single cross-sectional survey. Reverse causality is a concern if any of the variables conceptualized as outcomes might have instead been causes. A priori, we do not see any such variables among the outcomes we analyzed. Third, like all self-reported data, social desirability bias may affect our household data. However, we believe this would affect Ebola and non-Ebola zones equally. Fourth, the administrative data used in the study is limited in that it does not include non-Ebola zones as a comparison group. The key assumption here is that surgical procedures and infectious disease rates would have remained constant in the absence of Ebola. Fifth, we did not calculate kappa or intraclass correlation coefficients for our

questionnaire. For our conclusions to be valid, we must assume that any variation across respondents or interviewers is balanced across comparison groups. Sixth, some of our outcome variables have high proportions of missingness, because they were added to the questionnaire after the survey work began. If households surveyed later were systematically different from households surveyed earlier, this would introduce bias. We have no reason to believe this is the case.

CONCLUSIONS

The Ebola epidemic in eastern DRC does not appear to have caused a health system collapse like that observed in the earlier West African epidemic. Thus, we may cautiously consider the response successful and look for lessons to apply to other areas at risk. However, moving forward, given predictions of increased frequency and severity of zoonotic epidemics in the future,^{16,17} the barometer by which we measure success in epidemic management will likely need to change. Instead of supporting a health system just enough to prevent its collapse—for, with more frequent and more massive epidemics, this will become increasingly expensive and difficult—the international community needs to move toward more comprehensive health-systems strengthening; that is, toward the construction of resilient health systems. Such an approach would mitigate the effects of epidemics when they emerge and improve health outcomes between epidemics. Improving health in eastern Congo will also require reducing violence, which our respondents judged to be an even higher priority than Ebola, despite the on-going epidemic.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the talented team of researchers in North Kivu who administered the household surveys, collected the hospital data, and provided invaluable expertise to the project.

ETHICS STATEMENT

Ethics committee approval was obtained from Emory University in Atlanta, GA (IRB00116917), and le Comité d'Éthique de la Santé in Kinshasa, DRC (154/CNES/BN/PMM/2019). all interviewers were vaccinated with Merck's Ervebo before beginning research, to minimize their risk of contracting Ebola. Due to concerns about data security in a conflict zone, and low literacy levels among study participants, interviewers obtained verbal rather than written consent, after providing information about the nature and purpose of the research, and making it clear that participation was voluntary and that responses would be anonymized. Both IRBs approved this.

DATA AVAILABILITY

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

FUNDING

This work was supported by a grant from the European Union Instrument contributing to Stability and Peace [IcSP, grant no. 2019/409-434] and conducted on behalf of the Congo Research Group, a project of the Center on International Cooperation at New York University. The APC was funded by Georgetown University.

AUTHORSHIP CONTRIBUTIONS

RN and LM conceived of the study and led data collection. RN and JQ analyzed the data. RN and JQ wrote the manuscript. RN, LM, and JQ edited the manuscript.

DISCLOSURE OF INTEREST

The authors completed the ICMJE Disclosure of Interest Form (available upon request from the corresponding author) and disclose no relevant interests.

ADDITIONAL MATERIAL

This article contains additional information as an Online Supplementary Document: the STROBE protocol checklist and the study's questionnaire.

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Submitted: July 12, 2023 GMT, Accepted: August 15, 2023 GMT



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SUPPLEMENTARY MATERIALS

Online Supplementary Document

Download: <https://www.joghr.org/article/88108-impact-of-the-2018-2020-democratic-republic-of-congo-ebola-epidemic-on-health-system-utilization-and-health-outcomes/attachment/181425.docx>
