



RESEARCH ARTICLE

**REVISED** Paediatric morbidity and mortality in Sierra Leone. Have things changed after the 2014/2015 Ebola outbreak? [version 2; peer review: 5 approved, 1 approved with reservations]

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**Abstract**

**Background:** Sierra Leone was severely affected by the 2014/2015 Ebola outbreak which is likely to have had longer term repercussions on the health system including on paediatric morbidity and mortality. We thus assessed under-five morbidity and mortality for malaria, acute respiratory Infections (ARI)/pneumonia, watery diarrhoea and measles during the post-Ebola period in Sierra Leone and compared this with the pre- and intra-Ebola periods.

**Methods:** This was a retrospective cross-sectional study using program data from the District Health Information system (DHIS2) and sourced from 14 districts in Sierra Leone. It included under-five children from 1,250 health facilities country-wide. Study periods included: before (June 1<sup>st</sup>, 2013-April 30<sup>th</sup>, 2014); during (June 1<sup>st</sup>, 2014-April 30<sup>th</sup>, 2015); and after Ebola (June 1<sup>st</sup>, 2016-April 30<sup>th</sup>, 2017).

**Results:** Malaria, ARI/pneumonia and diarrhoea consultations declined during Ebola but recovered to pre-Ebola levels in the post-Ebola period. During the post-Ebola period, there was a highly significant reduction in case-fatality for the first three morbidities compared to the pre-Ebola period ( $P < 0.0001$ ). Average number of measles cases increased from 48/month in the pre-Ebola period to 568/month (12-fold increase) post-Ebola. Although there was no difference in measles case-fatality between the pre- and post-Ebola periods, case-fatality post-Ebola was significantly lower than during Ebola (Relative Risk: 0.05, 95% confidence interval 0.02-0.15,  $P < 0.0001$ ).

**Conclusions:** Consultations for under-five children at health facilities in Sierra Leone recovered to pre-Ebola levels and case-fatality for common childhood illnesses declined significantly. This is a change for

Open Peer Review

Reviewer Status

	Invited Reviewers					
	1	2	3	4	5	6
<b>version 2</b>						
(revision)						
09 Jan 2020			report	report	report	report
<b>version 1</b>						
06 Jun 2019						
	report	report				

1. Sara Hersey , The World Bank, Washington, USA
2. Justin Lessler , Johns Hopkins Bloomberg School of Public Health, Baltimore, USA
3. Alex Stewart , University of Exeter, Exeter, UK
4. Prajjwal Pyakurel , B.P. Koirala Institute of Health Sciences, Dharan, Nepal
5. Lutgarde Lynen , Institute of Tropical Medicine Antwerp, Antwerp, Belgium
6. Vic Arendt , Centre Hospitalier de

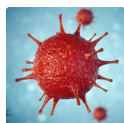
the better. However, the high level of reported measles cases in the post-Ebola period indicates gaps in immune status and needs focused attention.

### Keywords

Sustainable Development Goals, Outbreak response, Universal Health Coverage, Operational Research, SORT IT

Luxembourg, Luxembourg City, Luxembourg

Any reports and responses or comments on the article can be found at the end of the article.



This article is included in the [Disease Outbreaks](#) gateway.



This article is included in the [TDR](#) gateway.

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**Author roles:** **Sesay T:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Denisiuk O:** Data Curation, Formal Analysis, Methodology, Software, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Zachariah R:** Conceptualization, Formal Analysis, Funding Acquisition, Methodology, Resources, Software, Supervision, Validation, Writing – Original Draft Preparation, Writing – Review & Editing

**Competing interests:** No competing interests were disclosed.

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*The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.*

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**First published:** 06 Jun 2019, 8:796 <https://doi.org/10.12688/f1000research.18552.1>

**REVISED Amendments from Version 1**

We have made some minor edits to formatting and grammar. In addition, in response to reviewers, we have added clarifications in the introductory paragraph on recovery or improvement. We added t-tests to the methods description and disaggregated the analysis of monthly consultation trends across time periods by disease condition. Therefore, [Figure 1](#) now has four components, one for each of the conditions. We added in [Table 1](#) which presents the results of the t-tests for differences in mean monthly consultations for the four conditions. Finally, in the discussion section, we added points on lack of representation in our data and findings of longer term changes in the health system; a description of our finding on the reductions in case fatality from malaria, ARI/pneumonia and watery diarrhoea; an elaboration on the possible explanations for the decline in immunization services; as well as recommendations for future research.

**Any further responses from the reviewers can be found at the end of the article**

**Introduction**

In 2017, a cross-sectional study<sup>1</sup> documented country-wide morbidity for four common childhood illnesses: malaria, acute respiratory infections (ARI)/pneumonia, watery diarrhoea and measles. There were two main findings. First, during the Ebola outbreak, health facility visits for malaria, ARI/pneumonia and watery diarrhoea dropped significantly nation-wide, without returning to pre-Ebola levels post-outbreak. As these morbidities have similar symptom patterns as Ebola, people may have avoided accessing formal health services to avoid being considered “an Ebola case”. Second, measles cases increased dramatically by six-fold during Ebola and the immediate post-Ebola periods. This was attributed to cessation of measles vaccination activities during the Ebola outbreak.

The outbreak was declared over in November 2015. Since then, there have been considerable investments into the health system by Government and development partners. One of the limitations of the 2017 study<sup>1</sup> was that it only included the immediate six-month period after the Ebola outbreak, which might have been too early to assess health system recovery or possible improvement. It is now expected that the country would have fully recovered from the outbreak, but there has been no formal evaluation in this regard.

We thus conducted a similar country-wide study assessing morbidity and mortality for the same childhood illnesses using a longer post-Ebola period and compared this data with the pre- and intra Ebola periods.

**Methods**

This was a retrospective analysis using routine program data from the District Health Information system (DHIS2) and sourced from all 14 districts in Sierra Leone (see Underlying data<sup>2</sup>).

The study setting was described in detail before<sup>1</sup>. In brief, the health infrastructure is tiered into tertiary hospitals, district hospitals and Peripheral Health Units (PHUs). PHUs include

Community Health Centres (CHCs), Community Health Posts (CHPs) and Maternal and Child Health Posts (MCHPs). The Ministry of Health and Sanitation provides free primary health care for children under five across 1,250 health facilities nationwide.

The study population included all children under-five years attending public health facilities nationwide. No children were excluded.

Study periods included: before (June 1<sup>st</sup> 2013-April 30<sup>th</sup> 2014); during (June 1<sup>st</sup> 2014-April 30<sup>th</sup> 2015); and after Ebola (June 1<sup>st</sup> 2016-April 30<sup>th</sup> 2017).

We exported data on health facility visits and mortality for malaria, ARI/pneumonia, watery diarrhoea and measles from the DHIS2 to Microsoft excel (2016) for analysis. Differences between groups were assessed using Pearson’s  $\chi^2$  test (Chi square) for the case fatality and t-tests for the average monthly consultations. Levels of significance were set at  $P \leq 0.05$ .

**Ethics and consent**

Ethics approval was obtained from the Sierra Leone Ethics and Scientific Review Board (dated 14 December 2018) and the Union Ethics Advisory Group (International Union against Tuberculosis and Lung Disease, Paris, France; EAG number: 68/18). As the study used anonymous data, there was no need for informed consent.

**Results****Country-wide trend in out-patient consultations for under-five morbidities**

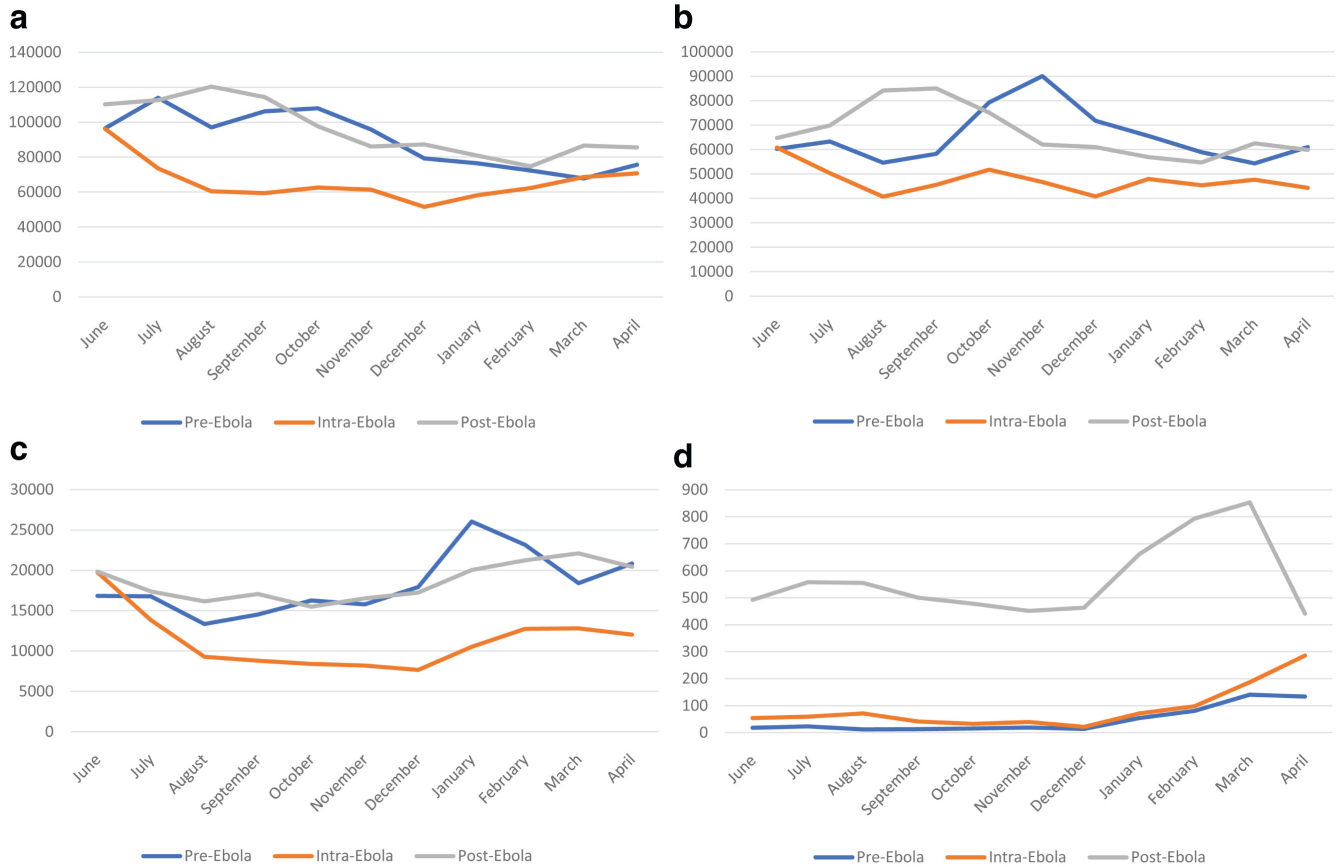
[Figure 1](#) shows country-wide trends in outpatient consultations for malaria, ARI/pneumonia, watery diarrhoea and measles. Consultations followed a seasonal pattern with an overall decline during Ebola. In the post-Ebola period (assessed six months after the end of the outbreak), consultations reached pre-Ebola levels. In contrast, measles increased during the last six months of the Ebola outbreak and this trend continued into the post-Ebola period. Average numbers of measles cases were 48/month in the pre-Ebola period, increasing to 87/month in the Ebola period and 568/month (12-fold increase) post-Ebola. Measles cases peaked in March 2017 with 853 cases.

[Table 1](#) shows that the observed differences of the pre-Ebola period relative to both the intra-Ebola and post-Ebola periods were statistically significant for all morbidities.

**Morbidity and case-fatality for four under-five morbidities**

[Table 2](#) shows numbers of cases, deaths and case-fatality (per 1,000) for malaria, ARI/pneumonia, watery diarrhoea and measles. During the post-Ebola period, there was a highly significant reduction in case-fatality for the first three morbidities compared to the pre-Ebola period ( $P < 0.0001$ ).

For measles, there was a total of 525 cases pre-Ebola, 962 cases during Ebola and 6,245 cases post-Ebola. Although there was



**Figure 1.** Trends in consultations for childhood morbidities in the pre-Ebola (1 June 2013–30 April 2014), intra-Ebola (1 June 2013–30 April 2014), and post-Ebola (1 June 2016–30 April 2017) periods, Sierra Leone. **a)** Malaria consultations in the pre-Ebola, intra-Ebola and post-Ebola periods. **b)** ARI/Pneumonia consultations in the pre-Ebola, intra-Ebola and post-Ebola periods. **c)** Watery diarrhoea consultations in the pre-Ebola, intra-Ebola and post-Ebola periods. **d)** Measles consultations in the pre-Ebola, intra-Ebola and post-Ebola periods.

**Table 1.** Difference in mean monthly consultations for four morbidities between the pre-Ebola (1 June 2013–30 April 2014) period and the intra-Ebola (1 June 2013–30 April 2014) and post-Ebola (1 June 2016–30 April 2017) periods, Sierra Leone.

Condition	Pre/Intra-Ebola			Pre/Post-Ebola		
	Difference	95% CI	P-value	Difference	95% CI	P-value
ARI/Pneumonia	-17,771	(-17,804 to -17,738)	p<0.0001	1,661	(1,628 to 1,693)	p<0.0001
Malaria	-24,071	(-24,060 to -23,973)	p<0.0001	6,117	(6,093 to 6,161)	p<0.0001
Measles	39	(31 to 47)	p<0.0001	520	(508 to 532)	p<0.0001
Watery Diarrhoea	-6,900	(-6,926 to -6,874)	p<0.0001	320	(301 to 339)	p<0.0001

CI: Confidence Interval

no difference in measles case-fatality between the pre- and post-Ebola periods, case-fatality post-Ebola was significantly lower than during Ebola (Relative Risk: 0.05, 95% confidence interval 0.02–0.15,  $P<0.0001$ ).

**Discussion**

This study shows that health facility consultations for malaria, ARI/Pneumonia and watery diarrhoea recovered to pre-Ebola

levels and were accompanied by significant country-wide reductions in case-fatality compared to the pre-Ebola period. Despite a dramatic increase in measles cases post-Ebola, there was a significant mortality reduction, suggesting overall improvements in clinical care.

A study strength is that we included data from 1,250 health facilities and for similar periods before, during and after the

**Table 2. Morbidity and case-fatality for four under five morbidities before, during and after the Ebola outbreak in Sierra Leone<sup>1</sup>.**

	Pre-Ebola n	Ebola n	Post-Ebola n	P-value <sup>2</sup>
<b>Malaria</b>				
Cases	989,068	724,881	1,056,354	
Deaths	2,564	1,205	2,112	
Deaths/1000	2.6	1.7	2.0	<0.0001
<b>ARI/Pneumonia</b>				
Cases	717,345	521,860	735,836	
Deaths	849	794	568	
Deaths/1000	1.2	1.5	0.8	<0.0001
<b>Watery Diarrhoea</b>				
Cases	200,006	124,100	203,520	
Deaths	361	150	242	
Deaths/1000	1.8	1.2	1.2	<0.0001
<b>Measles</b>				
Cases	525	962	6,245	
Deaths	1	16	6	
Deaths/1000	1.9	16.6	1.0	0.5

<sup>1</sup> Pre-Ebola: June 1<sup>st</sup> 2013 – April 30<sup>th</sup> 2014; Ebola: June 1<sup>st</sup> 2014 – April 30<sup>th</sup> 2015; Post-Ebola: June 1<sup>st</sup> 2016 – April 30<sup>th</sup> 2017.

<sup>2</sup> Chi-square comparing the pre-Ebola and post-Ebola periods.

outbreak. A limitation is that our data did not include private health facilities resulting in possible underestimation of disease burden. In addition, our post-Ebola period was limited to 2017, which may not be representative of long-term changes in systems strengthening.

There were two key findings. First, the reductions in case fatality from malaria, ARI/pneumonia and watery diarrhoea could be associated with post-Ebola health system investments with improved health seeking behaviour. The post-Ebola recovery plan<sup>3</sup> of the Government of Sierra Leone with enhanced financial, technical and training support from partners may also have contributed. Furthermore, community health worker activities including early identification and referrals of ill children were promoted which in turn would contribute to reducing mortality.

Second, increased measles cases during and after Ebola could be attributed to vaccination service cessation during Ebola in line with the recommendation to avoid invasive procedures as a way of minimizing Ebola-related occupational risks<sup>4</sup>. Many children would have missed their measles vaccination, resulting in a reduction in herd immunity as well as an accumulation of unvaccinated children. Measles coverage among children under two years in 2017 (post-Ebola) stood at 80%<sup>5</sup> while pre-Ebola this was at a low 78.6%<sup>6</sup>. This implies that measles vaccination coverage was already below the desired level prior to Ebola, worsened during Ebola and remained below desired levels after

Ebola. The decline in immunization services during the Ebola period may have triggered a measles outbreak; however the resumption of immunization services would have contributed to the reduction of the cases in the post-Ebola period. This calls for strategies to increase immunisation coverage to at least 95%<sup>7,8</sup> and to increase in the coverage of the second measles dose taken at 15 months of age.

Future research may consider including additional time periods of 2018-2019 to understand the longer term changes of health systems strengthening efforts on service delivery.

In conclusion, consultations of under-five children at health facilities in Sierra Leone recovered to pre-Ebola levels and case-fatality for common childhood illnesses declined significantly. This is a change for the better. However, the high level of reported measles cases in the post-Ebola period needs focused attention.

## Data availability

### Source data

The Sierra Leone Health Management Information Systems, the District Health Information System 2 (DHIS2), is accessible with a Ministry of Health and Sanitation (MOHS) login through <https://sl.dhis2.org/>. The Directorate of Policy, Planning, and Information (DPPI) can be contacted to arrange access through Dr. Francis Smart ([drfsmart@gmail.com](mailto:drfsmart@gmail.com)), Director, DPPI, MOHS.

### Underlying data

Repository: Dataset 1. Sesay\_Tom\_SORTIT2\_paed\_data. <https://doi.org/10.17605/OSF.IO/SYP7G><sup>2</sup>

This project contains the following underlying data:

- Sesay\_T\_casefatality\_data.xlsx (case fatality data)
- Sesay\_T\_morbidity\_data.xlsx (morbidity data)
- Sesay\_T\_paed\_datadictionary.xlsx (data dictionary)

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

## Acknowledgement

This research was conducted through the Structured Operational Research and Training Initiative (SORT IT), a global partnership coordinated by the Special Programme for Research and Training in Tropical Diseases at the World Health Organization (WHO/TDR) and implemented with partners. The training model is based on a course developed jointly by the International Union Against Tuberculosis and Lung Disease (The Union) and Médecins sans Frontières (MSF). The specific SORT IT programme which resulted in this publication was jointly developed and implemented by: WHO/TDR, the Sierra Leone Ministry of Health and Sanitation, WHO Sierra Leone and the Centre for Operational Research, The Union, Paris, France, Alliance for Public Health, Ukraine; Institute of Tropical Medicine, Antwerp, Belgium; and Sustainable Health Systems, Freetown, Sierra Leone.

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[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)

# Open Peer Review

Current Peer Review Status:      

Version 2

Reviewer Report 15 December 2020

<https://doi.org/10.5256/f1000research.23885.r74704>

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**Vic Arendt** 

Service National des Maladies Infectieuses, Centre Hospitalier de Luxembourg, Luxembourg City, Luxembourg

This article reports the impact of the West African Ebola outbreak in Sierra Leone (from early 2014-late 2015) on the number of consultations for common childhood diseases at 1250 health facilities as well as case fatality rates for these diseases.

The conclusions are highly relevant regarding the recovery of the health system and the attendance to these facilities after the end of the Ebola epidemic.

Regarding the figures of mortality, the conclusion that the case fatality between pre and post-ebola periods decreased significantly is clear.

Strange enough, however, the mortality from malaria and diarrheal diseases from the pre to intra-ebola period also decreased a lot and it would be useful to comment on this. Could this be because of mass drug administration for malaria during the outbreak<sup>1</sup> or could it be due to underreporting fever-related death due to fear of being suspected as Ebola cases or other explanations? Or decreased social contacts during the epidemic leading to a decrease in diarrheal diseases?

## References

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**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Yes

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** infectious diseases

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

Reviewer Report 30 November 2020

<https://doi.org/10.5256/f1000research.23885.r74709>

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**Lutgarde Lynen** 

Department of Clinical Sciences, Institute of Tropical Medicine Antwerp, Antwerp, Belgium

This is a follow-up study on the impact of the West-African Ebola outbreak on health seeking behavior for common childhood illnesses and their case-fatality in Sierra Leone.

It is important to report on these indirect impacts of outbreaks on population health and hopefully lessons can be learnt for future epidemics, in how to mitigate these.

The authors have sufficiently addressed the comments of the reviewers in the first round.

The results are clear and are correctly discussed. I have no further comments.

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**



Yes

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Infectious Diseases

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

Reviewer Report 25 November 2020

<https://doi.org/10.5256/f1000research.23885.r74702>

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**Prajjwal Pyakurel** 

School of Public Health and Community Medicine, B.P. Koirala Institute of Health Sciences, Dharan, Nepal

1. First, during the Ebola outbreak, health facility visits for malaria, ARI/pneumonia and watery diarrhoea dropped significantly nation-wide, without returning to pre-Ebola levels post-outbreak. (Please explain the reason).
2. The outbreak was declared over in November 2015. Since then, there have been considerable investments into the health system by Government and development partners. (In terms of what?)
3. We thus conducted a similar country-wide study assessing morbidity and mortality for the same childhood illnesses using a longer post-Ebola period. (Can you specify what a longer period means?)
4. Is DHIS2 is the latest version? (Has it been upgraded?)
5. Could you discuss the transition period of recovery from Pre-Ebola to Ebola period and how the health system worked during that period so that the reader could correlate with your findings?

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Yes

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Yes

**Competing Interests:** No competing interests were disclosed.

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

Reviewer Report 17 November 2020

<https://doi.org/10.5256/f1000research.23885.r74706>

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✓ **Alex Stewart** 

College of Life and Environmental Science, University of Exeter, Exeter, UK

This is a revised version of a paper examining rates of consultations for childhood illnesses and deaths before, during and after the Ebola outbreak in Sierra Leone. The authors have responded fully to the reviewers' comments on the first submission.

I have no further comment to make. The paper is clear, the results justify the conclusions, and there are considerable implications for health services both in Ebola and other outbreak and pandemic situations.

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Yes

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Yes

**Competing Interests:** I taught with Rony Zachariah in November 2019 in Nepal on a one week SORT IT course. I have not had social contact with him before or after.

**Reviewer Expertise:** Public Health, Health Protection, Environmental public health, Iodine deficiency.

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

Reviewer Report 30 January 2020

<https://doi.org/10.5256/f1000research.23885.r58461>

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**Sara Hersey** 

The World Bank, Washington, DC, USA

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Yes

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Yes

**Competing Interests:** No competing interests were disclosed.

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

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### Version 1

Reviewer Report 28 October 2019

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**Justin Lessler** 

Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA

"Paediatric morbidity and mortality in Sierra Leone. Have things changed after the 2014/2015 Ebola outbreak?" provides a straight forward analysis of changes in reports of, and mortality from, four diseases before, during and after the 2014/2015 Ebola outbreak based on data from DHIS2 in Sierra Leone. The report provides simple, but important, statistics on morbidity and mortality for malaria, ARI/pneumonia, watery diarrhea, and measles. While the data and analysis is important, I have some significant concerns with the statistical analysis and interpretation of the results:

#### **Statistics:**

While the use of chi-squared test to identify that significant differences in mortality exist is appropriate, it only is being used to compare pre- and post Ebola periods and does not help with evaluation of the size of the changes. I would suggest the authors instead select a reference period and report relative rates and confidence intervals, so the data can be better understood. Further, the authors do not perform statistical tests to support some of their statements, some of which are noted below. More tests for differences in reported rates between periods and some analysis of changes in the Ebola period would better support their conclusions.

#### **Interpretation:**

The authors make several statements in the discussion and abstract that do not correspond to the analyses done. For instance, they make statements regarding trends in case reports, but perform no statistical test as to whether between period changes in reports are significant. Further, in some cases they frame speculation as a key finding of the paper, such as when they attribute

changes to community confidence in the health system. Such speculations need to be clearly framed as such.

Overall, this paper could be made far stronger and more valuable with the addition of just a few additional basic statistical analyses that were more aligned with the conclusions the authors which to highlight in the discussion. This analysis could likely be done while preserving the admirable conciseness and brevity of the paper.

**Specific notes:**

- Introduction, "to early to assess...": Could this not just be recovery, but also improvements, as significant investments followed the Ebola outbreak.
- Discussion, "First, the reductions in case fatality...": There is not really any evidence for this association in the paper, it should be, at the very least, more clear this is speculation.
- Discussion, "Second, increased measles cases...": If this is going to be said it needs to be better supported by the statistical analysis in the paper.
- Discussion, "In conclusion, consultations...": This was not explicitly tested in the analysis, so I am not sure it can be concluded.

**Is the work clearly and accurately presented and does it cite the current literature?**

Partly

**Is the study design appropriate and is the work technically sound?**

Partly

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Partly

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

No

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Epidemiology, statistics, infectious disease dynamics

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Author Response 09 Dec 2019

**Tom Sesay**, Ministry of Health and sanitation, Sierra Leone

### **Author Response to Reviewer Report for Version 1 from Justin Lessler 28 Oct 2019**

Thank you for your thoughtful review of the manuscript and your suggestions. We have responded as below.

**1. Reviewer comment:"Paediatric morbidity and mortality in Sierra Leone. Have things changed after the 2014/2015 Ebola outbreak?" provides a straight forward analysis of changes in reports of, and mortality from, four diseases before, during and after the 2014/2015 Ebola outbreak based on data from DHIS2 in Sierra Leone. The report provides simple, but important, statistics on morbidity and mortality for malaria, ARI/pneumonia, watery diarrhea, and measles.**

**Response:**

Thank you for this comment.

**2. Reviewer comment: While the data and analysis is important, I have some significant concerns with the statistical analysis and interpretation of the results. Statistics: While the use of chi-squared test to identify that significant differences in mortality exist is appropriate, it only is being used to compare pre- and post Ebola periods and does not help with evaluation of the size of the changes. I would suggest the authors instead select a reference period and report relative rates and confidence intervals, so the data can be better understood. Further, the authors do not perform statistical tests to support some of their statements, some of which are noted below. More tests for differences in reported rates between periods and some analysis of changes in the Ebola period would better support their conclusions.**

**Response:**

Thank you for this point. We have performed t-tests for the differences in the mean monthly cases of the intra-Ebola and post-Ebola periods relative to the pre-Ebola period at a level of significance of 5%. We have also updated the figures by disease condition, which better displays the differences between the periods.

**3. Reviewer comment:Interpretation: The authors make several statements in the discussion and abstract that do not correspond to the analyses done. For instance, they make statements regarding trends in case reports, but perform no statistical test as to whether between period changes in reports are significant. Further, in some cases they frame speculation as a key finding of the paper, such as when they attribute changes to community confidence in the health system. Such speculations need to be clearly framed as such.**

**Response:**

We have taken note of this comment and, accordingly, removed comments that could be considered as speculations.

**4. Reviewer comment:Overall, this paper could be made far stronger and more valuable with the addition of just a few additional basic statistical analyses that were more aligned with the conclusions the authors which to highlight in the discussion. This analysis could likely be done while preserving the admirable conciseness and brevity of the paper.**

**Response:**

We have included the basic statistical tests to test the statistical significance of differences between periods, as mentioned above.

**5. Reviewer comment:Introduction, "to early to assess...": Could this not just be recovery, but also improvements, as significant investments followed the Ebola outbreak.**

**Response:**

This comment is noted, and we have added in a phrase on possible improvements.

**6. Reviewer comment:Discussion, "First, the reductions in case fatality..." There is not really any evidence for this association in the paper, it should be, at the very least, more clear this is speculation.**

**Response:**

The reductions in case fatality were indicated by a Chi-square test of the difference between the pre-Ebola and the post-Ebola period which showed a significant reduction in case fatality in the post- Ebola period.

**7. Reviewer comment:Discussion, "Second, increased measles cases...": If this is going to be said it needs to be better supported by the statistical analysis in the paper.**

**Response:**

We have included a t-test of the average monthly measles cases, which showed significant increase in the number of measles cases between the pre-Ebola and post-Ebola periods.

**8. Reviewer comment:Discussion, "In conclusion, consultations...": This was not explicitly tested in the analysis, so I am not sure it can be concluded.**

**Response:**

We have ensured that the relevant statistical tests have been completed, with corresponding results to support the conclusions.

**Competing Interests:** No competing interests were disclosed.

Reviewer Report 08 October 2019

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**Sara Hersey** 

The World Bank, Washington, DC, USA

The authors of this paper have looked at trends in the pediatric morbidity and mortality prior to, during and after the 2014-15 Ebola outbreak in West Africa. The impact of large scale outbreaks on health systems remains a critical area of research, and the authors should be congratulated in contributing to this area of work. The comments below are intended to better contextualize the analysis and conclusions proposed by the authors.

- The authors divide the paper into three distinct time periods, with 'post-Ebola' defined as beginning in June 2016 and extending through April 2017. While the end of the Ebola outbreak in Sierra Leone was declared in November 2015, there continued to be additional Ebola clusters in the country and the region into the 'post-Ebola' study period. The policy of mandatory Ebola testing for all deaths also continued until June 2016.
- During the 'post-Ebola' time period in the paper, there was an enormous influx of funding to improve health systems at both the facility and community levels that was organized under the Presidential Recovery Plan. This funding supported the national and sub-national health systems but was also supplemented by NGO and other non-governmental health services. By the end of 2017, there were substantial reductions in the funds available for health systems and service delivery.
- The continued specter of Ebola transmission and the rapid scale-up in health resources likely had both negative and positive impacts on health systems utilization that are difficult to quantify. The authors have documented significantly lower case fatality rates for three diseases than the pre-Ebola time period which would support the conclusion that there was regained community trust in the health services. However, those services were not the same ones available prior to the Ebola outbreak and the services are difficult to maintain with reduced external resources.
- In order to compare the pre and post-Ebola periods, I would recommend that the analysis be extended to the immediate post-Ebola period included in this paper as well as a longer-



term post-Ebola period through 2018 which would better capture the more sustainable health system in Sierra Leone rather than the one served by a short-term, high-volume influx of external funding.

- Aside from the clear spikes in measles consultations, Figure 1 is difficult to interpret when displayed by time period. The differences may be more impactful if compared by disease instead.
- The analysis supports the conclusion that measles surged during and post-Ebola and this is backed up by other research and program documentation. However, it does not necessarily support the recommendation to extend the cut off age for vaccination. The recommendation to conduct laboratory confirmation for measles is also not necessarily supported by the data presented. Is this because a number of the measles outbreaks were determined to be rubella which is currently not on the vaccine schedule? If yes, this should be documented by the data. What would be the impact on measles morbidity if there was increased diagnostic versus syndromic management of measles?

**Is the work clearly and accurately presented and does it cite the current literature?**

Partly

**Is the study design appropriate and is the work technically sound?**

Partly

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Yes

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Infectious disease epidemiology

**I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Author Response 09 Dec 2019

**Tom Sesay**, Ministry of Health and sanitation, Sierra Leone

**Author Response to Reviewer Report for Version 1 from Sara Hersey 08 Oct 2019**

Thank you for your thoughtful review of the manuscript and your insightful suggestions. We have responded as below.

**1. Reviewer comment:**The authors of this paper have looked at trends in the pediatric morbidity and mortality prior to, during and after the 2014-15 Ebola outbreak in West Africa. The impact of large scale outbreaks on health systems remains a critical area of research, and the authors should be congratulated in contributing to this area of work. The comments below are intended to better contextualize the analysis and conclusions proposed by the authors.

**Response:**

Thank you for recognising the importance of this study and its contribution to knowledge about the impact of the 2014/15 Ebola outbreak.

**2. Reviewer comment:**The authors divide the paper into three distinct time periods, with 'post-Ebola' defined as beginning in June 2016 and extending through April 2017. While the end of the Ebola outbreak in Sierra Leone was declared in November 2015, there continued to be additional Ebola clusters in the country and the region into the 'post-Ebola' study period. The policy of mandatory Ebola testing for all deaths also continued until June 2016.

During the 'post-Ebola' time period in the paper, there was an enormous influx of funding to improve health systems at both the facility and community levels that was organized under the Presidential Recovery Plan. This funding supported the national and sub-national health systems but was also supplemented by NGO and other non-governmental health services. By the end of 2017, there were substantial reductions in the funds available for health systems and service delivery.

The continued specter of Ebola transmission and the rapid scale-up in health resources likely had both negative and positive impacts on health systems utilization that are difficult to quantify. The authors have documented significantly lower case fatality rates for three diseases than the pre-Ebola time period which would support the conclusion that there was regained community trust in the health services. However, those services were not the same ones available prior to the Ebola outbreak and the services are difficult to maintain with reduced external resources.

In order to compare the pre and post-Ebola periods, I would recommend that the analysis be extended to the immediate post-Ebola period included in this paper as well as a longer-term post-Ebola period through 2018 which would better capture the more sustainable health system in Sierra Leone rather than the one served by a short-term, high-volume influx of external funding.

**Response:**

Thank you for this recommendation which we do understand and accept. We do

acknowledge the need for further research into the sustainability of the early post-Ebola gains in a much longer post-Ebola period. However, the objective of this study was to assess whether the investments in the health system had an impact on service delivery in the post-Ebola period, as defined in the manuscript. In addition, the ethical approval obtained for this study was only for the periods mentioned in the paper. This, however, is an area we will be interested to investigate in the near future. We have added a recommendation to this effect in the discussion section.

**3. Reviewer comment: Aside from the clear spikes in measles consultations, Figure 1 is difficult to interpret when displayed by time period. The differences may be more impactful if compared by disease instead.**

**Response:**

We agree with your recommendation, and accordingly have completed the analysis separately by the disease conditions. We have amended the Figure 1 based on this.

**4. Reviewer comment: The analysis supports the conclusion that measles surged during and post-Ebola and this is backed up by other research and program documentation. However, it does not necessarily support the recommendation to extend the cut off age for vaccination. The recommendation to conduct laboratory confirmation for measles is also not necessarily supported by the data presented. Is this because a number of the measles outbreaks were determined to be rubella which is currently not on the vaccine schedule? If yes, this should be documented by the data. What would be the impact on measles morbidity if there was increased diagnostic versus syndromic management of measles?**

**Response:**

We do agree with this recommendation. We have removed the recommendation to extend the cut off age for vaccination and added the recommendation to increase the coverage of the second measles dose at 15 months.

**Competing Interests:** No competing interests were disclosed.

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