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Has Ebola delayed progress on access to routine care and financial protection in Sierra Leone? Evidence from a difference-in-differences analysis with propensity score weighting

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ABSTRACT

Introduction: Covid-19 has highlighted the need to understand the long-term impact of epidemics on health systems. There is extensive evidence that the Ebola epidemic of 2014-16 dramatically reduced coverage of key reproductive, maternal, newborn, child and adolescent health (RMNCAH) indicators during the period of acute crisis in Sierra Leone. However, less is known about the longer lasting effects, and whether patients continue to be deterred from seeking care either through fear or cost some years after the end of the epidemic

Methods: We analysed nationally representative household surveys from before (2011) and after (2018) the Ebola epidemic to estimate the coverage of 11 indicators of access to RMNCAH, and affordability of care. We used a differences-in-differences analysis, exploiting the variation in epidemic intensity across chiefdoms, to identify the effect of epidemic intensity on access and affordability outcomes, with propensity score weighting to adjust for differences in underlying characteristics between chiefdoms.

Results: 13537 households were included across both datasets. Epidemic intensity was associated with a significant stalling in progress (−12.2 percentage points, 95% CI: 23.2 to −1.3, p = 0.029) in the proportion of births attended by a skilled provider. Epidemic intensity did not have a significant impact on any other indicator.

Conclusion: While there is evidence that chiefdoms which experienced worse Ebola outbreaks had poorer coverage of attendance of skilled providers at birth than would have otherwise been expected, more broadly the intensity of the epidemic did not impact on most indicators. This suggests the measures to restore both staffing and trust were effective in supporting the health system to recover from Ebola.

1. Introduction

The Covid-19 pandemic has renewed interest and discussion around the long term impact of epidemics on access to and affordability of healthcare. There are concerns that epidemics can impact health systems both directly through undermining the health system's ability to deliver services and deterring patients from seeking care (Okereke et al., 2021; Ahmed et al., 2020), and indirectly through increasing the cost of services if the epidemic impacts negatively on the availability of funds (Abor and Abor, 2020). Of particular concern is the risk of epidemics undoing recent gains in coverage of essential reproductive, maternal, newborn, child and adolescent healthcare (RMNCAH) interventions (Bustreo et al., 2021), which are critical to improving health outcomes (Amouzou et al., 2019).

One important example to learn from is the West African Ebola epidemic of 2014-16, with Sierra Leone providing a useful case study of the impact of epidemics on health systems. The first case of Ebola was recorded in Sierra Leone in May 2014, and there were a total of 14061 laboratory confirmed cases and 3956 Ebola deaths before the country was declared Ebola-free in March 2016. The already weak health system was weakened further by the epidemic (Witter et al., 2018); maternal and child mortality rates in Sierra Leone were among the highest in the world, with an estimated 1120 maternal deaths per 100,000 live births in 2017 (WHO, 2019) and 109 under-5 deaths per 1000 live births in 2019 (UN-IGME, 2020). Maternal mortality has shown a slight increase since the last pre-epidemic estimate of 1100 deaths per 100,000 in 2013

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(UNICEF, 2014), though unde- 5 mortality has improved on the 2013 figure of 161 deaths per 1000 (UN-IGME, 2014). The Ebola epidemic had a major impact on the health workforce which might well be expected to hinder its ability to provide care in the years that followed. Approximately 28% of all healthcare workers in Sierra Leone were reported to have been infected with Ebola, and 72% of these died, an overall mortality risk of 20% (Elston et al., 2015).

There is a wealth of evidence that uptake of RMNCAH services was reduced during the active period of the Ebola epidemic in Sierra Leone. Country-level studies of utilisation, relying on data collected through health facility surveys (Ngo et al., 2021; Jones et al., 2016) or reporting through health management information systems (Sochas et al., 2017), have found that uptake of antenatal and postnatal care, facility-based delivery and family planning services were reduced during the epidemic. Studies examining attendance patterns at particular facilities found decreased utilisation for antenatal, postnatal, and delivery care when the district in which the facility was located had more cases of Ebola compared to when it had fewer or none (Jones et al., 2016; Brolin Ribacke et al., 2016).

There is also concern that the epidemic had longer lasting effects on both health seeking behaviour, and the ability of health facilities to deliver care, which extend beyond the immediate crisis period. There is a suggestion that mistrust and fear of health services remain a barrier to care seeking (Theuring et al., 2018), and that the health system has been weakened permanently. However, evidence on the extent to which the epidemic had lasting effects on utilisation is limited. A study of health facilities in one district of Sierra Leone with a relatively low level epidemic found that utilisation of antenatal, delivery and family planning care had a decreasing trend immediately after the end of the Ebola epidemic (from March 2015 to December 2017), compared to the increasing trend seen before (Quaglio et al., 2019). A study using facility data in the highly affected Forest region of Guinea, which experienced an Ebola epidemic at the same time as Sierra Leone, found that coverage of antenatal care, facility-based delivery, and childhood vaccinations had not recovered to their pre-Ebola levels by February 2016, one year after the last case of Ebola was recorded in the region (Delamou et al., 2017a).

Existing literature documenting the effect of the Ebola crisis on RMNCAH service access in Sierra Leone and the wider region examines utilisation trends at facility level, typically relying on routine health information systems which report on those seeking care. Such data do not offer a full picture of access due to the absence of patient characteristics and information on health expenditures. Data quality could also potentially have been affected by the crisis itself. To date, there is no evidence on the epidemic impact on coverage of RMNCAH interventions at the population level from household surveys, allowing an assessment of utilisation effects across population subgroups together with the cost and affordability of care.

We estimate the impact of epidemic severity on coverage of essential RMNCAH services and the affordability of health care in Sierra Leone in January–December 2018, up to 33 months after the end of the Ebola epidemic, using a difference-in-differences analysis with propensity score weights controlling for confounding factors associated with epidemic intensity, to allow for doubly robust estimates of impact. We use a large nationally representative household survey dataset, instead of relying on facility utilisation data as in previous studies, avoiding the potential bias associated with it.

2. Methods

2.1. Study design

We examined the impact of the 2014–2016 Ebola epidemic with a differences-in-differences analysis, in which we compared changes in care seeking and health expenditure outcomes from households surveyed in 2011 (before the start of the epidemic) and 2018 (up to 33 months after the last case of Ebola) in chiefdoms where few or no Ebola cases were reported and in chiefdoms with larger outbreaks.

2.2. Intensity of epidemic

Sierra Leone's 149 chiefdoms and two districts (referred to hereafter as chiefdoms) of Western Area (the location of Freetown) have been classified into seven patterns according to the size and length of outbreak experienced during the 2014–16 Ebola epidemic (Fang et al., 2016), using a weighted-average linkage-clustering method (Hamilton, 2009). To produce a binary measure of epidemic intensity, we categorised the 151 chiefdoms into two groups: no/mild epidemic (those with no cases, sporadic cases, or a single small-scale outbreak in a short period) and moderate/severe epidemic (with multiple small-scale outbreaks, a continuous low-level epidemic over a long period, or larger or more prolonged outbreaks). 40 chiefdoms were classified into the moderate/severe epidemic (or exposed) group and 111 into the no/mild epidemic (or unexposed) group. Further details of classification are given in the appendix.

2.3. Data

Data from the Sierra Leone Integrated Household Survey (SLIHS) in 2011 (Statistics Sierra Leone, 2011) and 2018 (Statistics Sierra Leone, 2018) were used to measure study outcomes and covariates before and after the Ebola epidemic. The SLIHS are cross-sectional surveys of a representative national sample of households in Sierra Leone, and were conducted in every chiefdom of the country to measure living standards and wellbeing. The sample was selected using a two-stage cluster design, sampled by enumeration areas (EAs) at the first level and households at the second level. In both years, 684 EAs were selected with probability proportional to size selection, stratified by rural or urban location and district, and ten households were randomly chosen to be surveyed in each selected EA, with a target sample size of 6840 households in both surveys. Fieldwork was conducted nationally in January–December 2011 and January–December 2018. The response rate for the 2011 SLIHS was 98.4%, and for 2018 it was 100%. Response rates by chiefdom were unavailable.

2.4. Study outcomes

Outcomes to measure use of services were chosen based on coverage indicators given in Sierra Leone's 2017–2021 RMNCAH strategy (Ministry of Health and Sanitation, 2017), and which could be estimated from both 2011 and 2018 surveys. Cost of care outcomes were based on total healthcare expenditure (comprising of expenditure on outpatient, inpatient and antenatal care). To measure the affordability of healthcare, two outcomes used to monitor universal health coverage were chosen: catastrophic spending on health and impoverishing spending on health (WHO, 2017). Healthcare expenditures were winsorized at 99.9%. Outcomes and their measurement as implemented in this analysis are given in Table 1.

2.5. Study covariates

Individual and household level covariates from the SLIHS surveys were used in the analysis. Household level covariates were location type (rural or urban), sex of the household head (male or female), education level of the household head (none, primary secondary, post-secondary technical, or college/university), number of members of the household (continuous), and household consumption expenditure per adult equivalent, regionally adjusted and inflated to 2018 prices (continuous). Individual level covariates for women aged 15–49 were age (continuous), parity (continuous), religion (Muslim or other) and education (none, primary, secondary or post-secondary). Individual level covariates for children under-5 were age (continuous), maternal age

Table 1
Outcome definitions.

Outcome	Population	Recall period	Definition	2018 national coverage target(Ministry of Health and Sanitation, 2017)
Utilisation outcomes				
Contraceptive prevalence rate	Women aged 15–49 who are married or in union and not currently pregnant	Current user	% currently using any method to prevent or delay pregnancy	25%
At least 4 ANC visits	Women aged 15–49 who had a pregnancy in the last year ending in a live or still birth	1 year	% who reported going for antenatal care at least four times	77%
Delivery at health facility	Children aged under 2	2 years	% who were born at a government or private hospital or clinic	85%
Birth by a skilled provider	Children aged under 2	2 years	% whose birth was attended by a doctor, midwife, nurse, community health officer or maternal and child health aide	62%
PNC for mothers	Women aged 15–49 who had a pregnancy in the last year ending in a live or still birth	1 year	% who reported going for any postnatal care	88%
Birth registration coverage	Children aged under 2	2 years	% who have a government approved birth certificate	74%
Children 12–23 months fully vaccinated	Children aged 12–23 months	Current vaccination status	% who were vaccinated with BCG, DPT (3 doses), measles (at least 1 dose) and polio (at least 3 doses)[d]	66%
Cost and affordability of care				
Outcome	**Population**	**Recall period**	**Definition**	
Total healthcare expenditure	All households	Outpatient care 4 weeks; inpatient and antenatal care 12 months; household expenditure annual	Annualised sum of expenditure on outpatient, inpatient and antenatal care, deflated by region, month and year, converted to US PPP[e] 2018	
Catastrophic healthcare expenditure (>40% of total non-food expenditure)	All households		% of households where total healthcare expenditure>40% of total non-food expenditure	
Catastrophic healthcare expenditure (>25% of total expenditure)	All households		% of households where total healthcare expenditure>25% of total expenditure	
Impoverishing healthcare expenditure	Households above the international poverty line of USD1.90 PPP[e] per capita		% of households where total healthcare expenditure brings per capita expenditure below the international poverty line	

[d] BCG= Bacillus Calmette–Guérin, DPT= Diptheria, pertussis & tetanus
[e] PPP= Purchasing power parity

(continuous), maternal parity (continuous), religion (Muslim or other) and maternal education (none, primary, secondary or post-secondary).

2.6. Statistical methods

Difference-in-differences analysis with propensity score weighting (Stuart et al., 2014) was used to estimate the effects of the Ebola epidemic, with households in the 40 chiefdoms experiencing a moderate/severe epidemic designated as the exposed group, and those living in the remaining 111 chiefdoms with mild or no epidemic serving as the comparison group. Significant differences at baseline and endline were observed in several household characteristics between exposed and comparison group households (Table 2). Propensity score methods were therefore used within the difference-in-differences analysis, to mitigate the concern that the groups may differ in ways that affect their trends over time and therefore violate the 'parallel trends' assumption. This method is tailored to repeated cross-sectional surveys and is described further below. Pre-epidemic trends for two outcomes, the proportion of births at a health facility and the proportion of births attended by a skilled provider, were examined for the five years before the baseline survey (January 2006–December 2010). No evidence of non-parallel trends was found, and further details are given in the appendix. We used a bootstrapping method to carry out post-facto calculations of the minimum detectable effect for each outcome, further details and results of which are given in the appendix. Observations with missing outcomes or covariates were excluded from all analyses, with no attempt to impute missing data. The extent of missingness is described in the appendix.

2.7. Propensity score weighting

The population was divided into four groups by year (2011 or 2018) and exposure (no/mild epidemic or moderate/severe epidemic). A multinomial logistic regression model predicting the probability of being in each group as a function of the study covariates was run separately for each outcome, to account for the different populations included in the estimation of each outcome (household, woman of reproductive age, pregnant woman, child under five years). Each individual or household then has a propensity score, the probability of being in a given year and group, which is used to create weights such that each group is balanced in terms of its covariates. The propensity score weights were multiplied by the survey weights to account for the study sampling strategy.

2.8. Difference-in-differences

A multivariate linear (OLS) difference-in-differences regression model, with propensity score weighting and standard errors taking into account clustering by chiefdom, was estimated for each outcome as follows:

$$Y_{ict} = \alpha + \beta EI_{ct} + \gamma X_{it} + \lambda_t + \mu_c + \varepsilon_{ict}$$

where i indicates the individual or household, c is the chiefdom and t is the year of survey, 2011 or 2018. The variables Y_{ict} are each of the outcomes reported for the individual or household i in year t in chiefdom c. The dummy EI_{ct} indicates the epidemic intensity in chiefdom c at year t; it is equal to 1 in exposed chiefdoms in 2018 and 0 otherwise. X_{it} are

Table 2
Sample characteristics before and after propensity score weighting in 2011 (pre-epidemic) and 2018 (post-epidemic).

	Before propensity score weighting						After propensity score weighting					
	2011			2018			2011			2018		
	No/mild epidemic	Moderate/ severe epidemic	P-value for difference	No/mild epidemic	Moderate/ severe epidemic	P-value for difference	No/mild epidemic	Moderate/ severe epidemic	P-value for difference	No/mild epidemic	Moderate/ severe epidemic	P-value for difference
Household level												
Household size (mean)	7.8	8.2	0.284	7.9	9.3	<0.001	7.9	8.1	0.512	8.7	8.1	0.217
Anuual consumption expenditure (mean, USD 2018)	1278.8	1432.2	0.065	1750.5	2085.0	<0.001	1314.7	1443.1	0.125	1265.8	1478.7	<0.001
% Muslim	84.3	79.3	0.181	83.7	79.3	0.167	83.1	78.9	0.419	80.7	79.3	0.711
% Urban residence	8.8	52.0	<0.001	7.1	54.7	<0.001	45.9	47.5	0.817	46.9	45.2	0.801
Eduction of household head			<0.001			<0.001			0.690			0.395
% None	78.5	61.0		70.0	51.9		57.9	60.3		62.0	59.7	
% Primary	9.4	11.9		13.4	13.4		15.2	12.3		15.0	12.7	
% Seconday	10.1	21.0		12.8	24.4		22.4	21.6		19.6	21.4	
% Post-secondary technical	1.8	4.8		3.8	7.6		4.2	4.5		4.4	4.9	
% College/university	0.3	1.3		0.0	2.8		0.2	1.4		0.0	1.4	
% Female household head	17.3	22.8	0.095	16.5	2.8	0.003	25.3	22.8	0.649	24.0	23.6	0.921
Woman level												
Maternal parity (mean)	4.1	3.7	0.046	4.1	3.4	<0.001	3.7	3.8	0.756	4.0	3.8	0.383
Maternal age (mean, years)	29.3	28.9	0.480	29.2	27.5	<0.001	28.4	28.8	0.718	28.7	29.0	0.578
Maternal education			<0.001			<0.001			0.993			0.502
% None	83.6	68.5		70.8	45.4		67.2	68.0		69.4	68.6	
% Primary	9.5	11.9		16.5	18.4		13.1	12.4		12.2	12.1	
% Secondary	6.3	15.3		12.1	31.0		15.7	15.1		16.4	14.8	
% Post-secondary	0.6	4.3		0.6	5.3		4.1	4.4		2.0	4.4	
Child level												
Child age (mean, years)	0.6	0.6	0.806	0.5	0.5	0.821	0.5	0.6	0.692	0.6	0.6	0.943

Characteristics are described for the sample of under-2s included for analysis of the skilled provider at birth outcome. For characteristics of samples for other outcomes please see appendix.

the study covariates. Fixed effects for year and chiefdom are indicated by λ_t and μ_c respectively, and clustered standard errors by ε_{ict}.

A difference-in-differences model with a binary interaction term for wealth (above and below median per adult equivalent consumption, measured at the household level) and education (no vs some education of the household head for household level outcomes, no vs some maternal education for outcomes in children 0–5, and no vs some education for outcomes in women aged 15–49) was used to test for differential effects of the epidemic intensity in these subgroups. If the interaction term was significant at the $p < 0.1$ level, the overall result was presented alongside the result for each subgroup.

2.9. Ethics

Ethics approval was not sought for this study as it uses only anonymised data entirely in the public domain.

3. Results

13537 households were included across both datasets. In 2011, 2854 households were surveyed in unexposed chiefdoms, and 3873 in exposed chiefdoms. In 2018, 2712 and 4098 households were surveyed in each group respectively. There were significant differences at baseline and endline in several household characteristics before propensity score weighting (Table 2). Households in exposed chiefdoms were more likely to be in urban areas in both 2011 and 2018 compared to those in unexposed areas, and the household heads also had generally higher education levels in those chiefdoms in both years. Households were larger in exposed chiefdoms than those in unexposed chiefdoms in 2018, after the epidemic, but not before in 2011. Households in exposed chiefdoms were more likely to be headed by a woman and were wealthier than those in unexposed areas. There were also differences in individual characteristics, with higher levels of women's and mother's education and lower parity in exposed chiefdoms. Maternal age was lower in exposed chiefdoms in 2018 but not in 2011. The balance of covariates after propensity score weighting was much improved. The only significant difference which remained was that exposed households were wealthier than those in the unexposed group in 2018. Missingness was below 4% for all outcomes and covariates; further details are given in the appendix.

After propensity score weighting, there was a decrease in coverage of postnatal care in the exposed group from 77.8% to 75.6% between 2011 and 2018, while the comparison group coverage increased from 78.2% to 80.5% (Table 3). The coverage of four or more ANC visits increased in both unexposed (75.4%–95.6%) and exposed chiefdoms (69.4%–87.4%) (Table 3). The proportion of births in a health facility also increased in both groups, from 66.0% to 89.2% in unexposed and from 58.7% to 79.5% in exposed groups. The increase between 2011 and 2018 in contraceptive coverage and fully vaccinated under-ones was similar in both exposed and comparison households, while birth registration coverage, total annual equivalent healthcare expenditure, catastrophic expenditure and impoverishment levels decreased in both groups (Table 3).

The difference-in-differences model results suggest that in areas with worse outbreaks, there was a reduction in coverage of births attended by a healthcare professional by 12.2 percentage points (95% CI: 23.2 to −1.3, p = 0.029) (Table 4), compared to what might be expected had there been no or only mild outbreaks. There was no evidence of an interaction between household wealth or maternal education and the epidemic intensity for this outcome. There was no evidence of the effect of the epidemic on any of the other service coverage or health expenditure and affordability outcome (Table 4). There was evidence of interaction between household wealth and epidemic intensity for all four cost and affordability outcomes, and between the education of the household head and epidemic intensity for the impoverishment outcome (appendix Table A7). The results for those outcomes are therefore also

Table 3
Outcomes before and after propensity score weighting in 2011 (pre-epidemic) and 2018 (post-epidemic).

	N	Before propensity score weighting						After propensity score weighting					
		2011			2018			2011			2018		
		No/mild epidemic	Moderate/ severe epidemic	P value (chi2)	No/mild epidemic	Moderate/ severe epidemic	P value (chi2)	No/mild epidemic	Moderate/ severe epidemic	P value (chi2)	No/mild epidemic	Moderate/ severe epidemic	P value (chi2)
Utilisation outcomes													
% contraceptive prevalence	10801	7.3	12.8	<0.001	25.6	34.9	<0.001	12.2	12.8	0.807	27.0	32.5	0.074
% 4+ ANC visits	1525	71.5	69.4	0.737	92.3	88.4	0.152	75.4	69.4	0.450	95.6	87.4	<0.001
% born at health facility	3146	51.6	58.7	0.160	84.6	80.3	0.231	66.0	58.7	0.141	89.2	79.5	0.005
% skilled provider at birth	3129	53.6	66.8	0.007	84.3	81.2	0.375	64.6	66.8	0.656	89.3	80.3	0.010
% mothers receiving postnatal care	1530	71.5	77.8	0.323	81.2	75.6	0.230	78.2	77.8	0.961	80.5	75.6	0.426
% births registered	3173	58.8	57.8	0.967	50.9	51.9	0.830	72.1	57.8	0.016	52.7	49.5	0.526
% 1 year olds fully vaccinated	1702	74.7	63.7	0.030	78.9	76.7	0.506	68.4	63.7	0.424	83.3	77.1	0.178
Cost and affordability of care													
Mean total healthcare expenditure (USD 2018)	13327	577.3	672.2	0.044	252.0	391.1	<0.001	649.4	672.2	0.782	283.3	290.6	0.832
% catastrophic expenditure (>40% of non-food household expenditure on healthcare)	13462	8.5	5.5	<0.001	1.6%	0.8	0.047	7.2	5.5	0.192	1.4	0.7	0.052
% catastrophic expenditure (>25% of total household expenditure on healthcare)	13462	6.6	6.3	0.666	1.7	1.4	0.436	7.8	6.3	0.262	1.3	0.9	0.232
% impoverished by healthcare expenditure (international poverty line)	9669	9.4	6.8	0.017	4.1%	1.5	<0.001	9.8	6.8	0.131	3.0	1.9	0.120

Table 4
Difference-in-difference results, with propensity score weighting and adjusted for covariates.

	N	Difference-in-differences effect (95% CI)	p
Utilisation outcomes			
% contraceptive prevalence	10801	3.4 (−2.5–9.3)	0.260
% 4+ ANC visits	1525	−9.6 (−30.3–11.0)	0.358
% born at health facility	3146	−5.5 (−15.6–4.7)	0.291
% skilled provider at birth	3129	−12.2 (−23.2–−1.3)	0.029
% mothers receiving postnatal care	1530	−4.6 (−25.1–16.0)	0.662
% births registered	3173	6.2 (8.6–21.0)	0.411
% 1 year olds fully vaccinated	1702	−1.3 (−19.2–16.6)	0.885
Cost and affordability of care			
Mean total healthcare expenditure (USD 2018)	13327	10.8 (−110.9–132.5)	0.861
Below median income	*6727*	*19.6 (-73.8–112.9)*	*0.680*
Above median income	*6600*	*27.6 (-211.4–266.7)*	*0.820*
% catastrophic expenditure (>40% of non-food household expenditure on healthcare)	13462	1.8 (−1.2–4.8)	0.240
Below median income	*6731*	*−0.6 (-2.9–1.9)*	*0.642*
Above median income	*6731*	*3.6 (-1.1–8.4)*	*0.128*
% catastrophic expenditure (>25% of total household expenditure on healthcare)	13462	1.9 (−1.2–5.1)	0.229
Below median income	*6731*	*0.8 (-1.6–3.3)*	*0.503*
Above median income	*6731*	*2.8 (-2.7–8.4)*	*0.318*
% impoverished by healthcare expenditure (international poverty line)	9669	2.3 (−3.7–8.2)	0.345
Household head has no education	*5108*	*−1.5 (-8.7–5.8)*	*0.689*
Household head has some education	*4561*	*6.3 (-2.6–15.2)*	*0.163*
Below median income	*2944*	*4.3 (-9.6–18.2)*	*0.544*
Above median income	*6735*	*0.7 (-1.1–2.6)*	*0.415*

shown by subgroup in Table 4. Though the effect sizes varied across the subgroups, there was no evidence of an impact of epidemic intensity in any individual subgroup.

4. Discussion

We carried out a difference-in-differences analysis to examine the effects of the Ebola epidemic on access to RMNCAH and affordability of care in Sierra Leone, up to two years after the end of the epidemic. Our findings show that both service coverage and affordability generally improved across the country between 2011 and 2018, and the change in coverage of only one intervention (skilled birth attendant at delivery) was differential with respect to epidemic severity. However, this is not an indication that coverage decreased in areas which experienced a worse epidemic, rather that the increase in coverage was smaller in those areas (from 66% in 2011 to 80% in 2018 after propensity score weighting) compared to the increase in areas with no or a mild epidemic (from 63% in 2011 to 90% in 2018 after propensity score weighting). The difference-in-differences estimate of −12.2% represents the gap in coverage in 2018 in the severe epidemic areas which can be ascribed to the intensity of the epidemic, that is, had those areas experienced a mild or no epidemic, coverage would be expected to be 12 percentage points higher than is actually observed. This effect of epidemic severity on coverage did not differ across wealth and education subgroups. That the only significant impact of the epidemic was on a process of care outcome which required qualified staff may be explained by the high mortality of healthcare workers during the epidemic.

It is important to note that we did not find an impact of epidemic severity on the other six utilisation outcomes examined, or on the four expenditure and affordability measures. Coverage of interventions was generally higher in exposed chiefdoms in 2011 (though this difference was not observed after propensity score matching), but increased by a similar amount in exposed and unexposed households over the time period of the study. The most immediate conclusion is that the epidemic did not have a long term impact on the ability of the health system to provide accessible and affordable care. This may be in part because chiefdoms which experienced worse epidemics were more likely to be urban, and may have had stronger health systems at baseline, as well as more engrained norms and practices around health seeking. This may have facilitated the rebuilding of the health system and resumption of services after the epidemic. However, it may be the case that unexposed chiefdoms would have recovered equally well, with no true long term impact of the Ebola epidemic. Our findings also suggest that perhaps concerns that mistrust in the health system would be long-lasting are unfounded, and the community were happy to return to health facilities after some time had passed. That birth registration coverage was the only access indicator where coverage decreased in both groups between 2011 and 2018 suggests more focus was on ensuring the resumption of health services than administrative functions. For facility-based delivery, antenatal care and postnatal care, our effect estimates were sizeable but not significant. Post-facto calculations of the minimum detectable effects given our sample size (see appendix) were much larger than these effect estimates: it is therefore also possible that there was a true impact of epidemic intensity on a wider set of outcomes but the analysis was not powered to detect it.

In terms of Sierra Leone's RMNCAH strategy, our analysis suggests the health system was achieving most of its targets regardless of Ebola. Exceptions are postnatal care, where coverage is at 81% in unexposed chiefdoms and 76% in exposed chiefdoms, compared to the 2018 target of 88%, and birth registration coverage, at 53% and 50% respectively, compared to the target of 74%. The target of 85% of children being delivered in health facilities is achieved in the unexposed group (at 89%) but not in the exposed group (at 80%).

These findings are in contrast to research on use of health services in the Forest region of Guinea (where the last Ebola case was recorded in February 2015) in the immediate post-Ebola period (March 2015–February 2016), which found a stagnation of the pre-epidemic trends in increasing coverage of antenatal care, institutional delivery and childhood vaccinations (Delamou et al., 2017b). Research in another district of Guinea also found that antenatal care and institutional deliveries did not recover to their pre-Ebola levels by March–July 2016 (Camara et al., 2017a), nor did childhood vaccinations (Camara et al., 2017b). Other studies have found evidence that health systems can be resilient and 'bounce back' after crises. A study comparing two areas in Guinea, one which experienced a severe Ebola outbreak and one which did not, found that in 2017, two years after the end of the epidemic, parents were more likely to access health services for an under-5 with fever in the Ebola-affected region than those in the non-affected region (Camara et al., 2020). Research in Liberia found that utilisation of many primary healthcare services (including childhood vaccinations, antenatal care, institutional delivery and postnatal care) returned to their pre-Ebola levels by November 2016 (Wagenaar et al., 2018).

This study is the first of its kind to address a number of important unanswered questions on the impact of the Ebola epidemic on access to health services in Sierra Leone. Firstly, unlike previous work which has relied on health facility utilisation data, it uses nationally representative household surveys, which allows us to investigate the impact of the epidemic at the individual and household levels. Secondly, it distinguishes between small chiefdoms which did and did not have large Ebola outbreaks, allowing the examination of the role of epidemic intensity on health service access. Finally, rather than investigating the immediate or short-term impact of the epidemic, this research examines the longer-term effects by measuring outcomes up to two years after the end of the Sierra Leone Ebola epidemic.

As with all non-randomised studies, there are limitations which must be borne in mind when considering our conclusions. Foremost is that chiefdoms which experienced no or mild epidemics might reasonably be expected to differ from those which experienced severe epidemics in several ways, which could violate the 'parallel trends' assumption that, without the Ebola outbreak, the two groups would have had similar trajectories. Our exploration of pre-trends (shown in the appendix) goes some way to assuage this concern, but examines limited outcomes and only includes births in the five years preceding 2011. We also dealt with this by using propensity score weighting and including covariates in the difference-in-differences model to produce doubly robust estimates. Propensity score weighting was overall very effective, with only one variable (household consumption expenditure) imbalanced after weighting. Since this was at endline and not baseline, and consumption expenditure was also controlled for in the difference-in-differences model, we do not believe it has an important impact on the results or their interpretation. Unobserved time-varying confounders may also have had an impact on the results. For example, chiefdoms with worse epidemics are likely to have had higher population densities, and a greater number of health facilities, before the start of the outbreak, and the epidemic might have had a differential impact on factors which would be expected to affect care seeking and affordability. Another concern is the sample selection caused by the epidemic; it could be argued that the epidemic would have affected patterns of pregnancy and childbirth, and so the populations in 2011 and 2018 are not directly comparable. Borders between neighbouring chiefdoms are permeable, so it is realistic to expect people to move between them freely. While this is not a concern for our exposure of interest, since we measure the Ebola cases in each chiefdom directly, so can capture any spread of infection between chiefdoms, this may impact access to care. For example, if an individual lived in a high incidence chiefdom, but could travel to a low incidence chiefdom to access care, their access may be less constrained than someone living in a high incidence chiefdom which was surrounded by high incidence chiefdoms.

Ideally, this analysis would be conducted using coverage estimates taken immediately before the start of the Ebola epidemic. As such data are not available, our results include the time between 2011 and 2014 which was not impacted by Ebola, but during which one might have expected a rapid increase in coverage and affordability due to ongoing health systems reforms (Witter et al., 2018). We were unable to include several important indicators in the RMNCAH strategy, such as the treatment of children with pneumonia and coverage of malaria prevention interventions, and so cannot comment on the effect of Ebola on these.

An important message for policy makers in light of this study, particularly when considering health systems post-Covid-19, is that it cannot be assumed that the regions within a country which experience the worst epidemic will be those which have the least resilient health systems and require most resources in order to recover. Rather, attention should be paid to the characteristics of individual regions and their needs. Further research is needed to understand the factors underpinning health system 'bounce back' following an epidemic or other shock, to facilitate system strengthening strategies that build resilience to future crises.

Credit author statement

Jessica King: Conceptualization, data curation, investigation, methodology, formal analysis, validation, writing- original draft preparation & reviewing and editing. Zia Sadique: Conceptualization, methodology, validation, writing- reviewing and editing. Michael Amara: Conceptualization, funding acquisition, writing- reviewing and editing. Josephine Borghi: Conceptualization, methodology, supervision, funding acquisition, writing- reviewing and editing.

Ethics statement

Secondary analysis of publicly available data.

Declaration of competing interest

We declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2022.114995.

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