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The Next Wave of Deaths from Ebola?

The Impact of Health Care Worker Mortality

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Abstract

The ongoing Ebola outbreak in West Africa has put a huge strain on already weak health systems. Ebola deaths have been disproportionately concentrated among health care workers, exacerbating existing skill shortages in Guinea, Liberia, and Sierra Leone in a way that will negatively affect the health of the populations even after Ebola has been eliminated. This paper combines data on cumulative health care worker deaths from Ebola, the stock of health care workers and mortality rates pre-Ebola, and coefficients that summarize the relationship between health care workers in a given country and rates of maternal, infant, and under-five mortality. The paper estimates how the loss of health care workers to Ebola will likely affect non-Ebola mortality even after the disease is eliminated. It then estimates the size of the resource gap that needs to be filled to avoid these deaths, and to reach the minimum thresholds of health coverage described in the Millennium Development Goals. Maternal mortality could increase by 38 percent in Guinea, 74 percent in Sierra Leone, and 111 percent in Liberia due to the reduction in health personnel caused by the epidemic. This translates to an additional 4,022 women dying per year across the three most affected countries. To avoid these deaths, 240 doctors, nurses, and midwives would need to be immediately hired across the three countries. This is a small fraction of the 43,565 doctors, nurses, and midwives that would need to be hired to achieve the adequate health coverage implied by the Millennium Development Goals. Substantial investment in health systems is urgently required not only to improve future epidemic preparedness, but also to limit the secondary health effects of the current epidemic owing to the depletion of the health workforce.

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Introduction

The recent outbreak of Ebola in West Africa, which began in late 2013 and has claimed more than 11,000 lives to date, [1] has brought awareness to the issue of health system resilience. Much coverage of this issue has addressed resilience to the epidemic itself, highlighting how the limited capacity of health systems in the three most affected countries – Guinea, Liberia, and Sierra Leone – allowed Ebola to proliferate rapidly, with inadequate numbers of qualified health care workers and weak infrastructure (among others) precluding the development of an appropriate and timely response to the outbreak. [2] Beyond the deaths and suffering caused directly by Ebola, however, weak health systems hit by the disease are left without the resources to deal with other normally treatable conditions. Recent research and media reports speak of a "vicious cycle" in which, because of Ebola, there has been a significant increase in the number of people not being treated for malaria, cholera, measles, and HIV. [3, 4, 5] Women have reportedly been reluctant to visit or have been turned away from overextended hospitals for pre- and post-natal care. [6, 7]

Table 1: Ebola Infection and Mortality Rates for Civilians and Health Care Workers

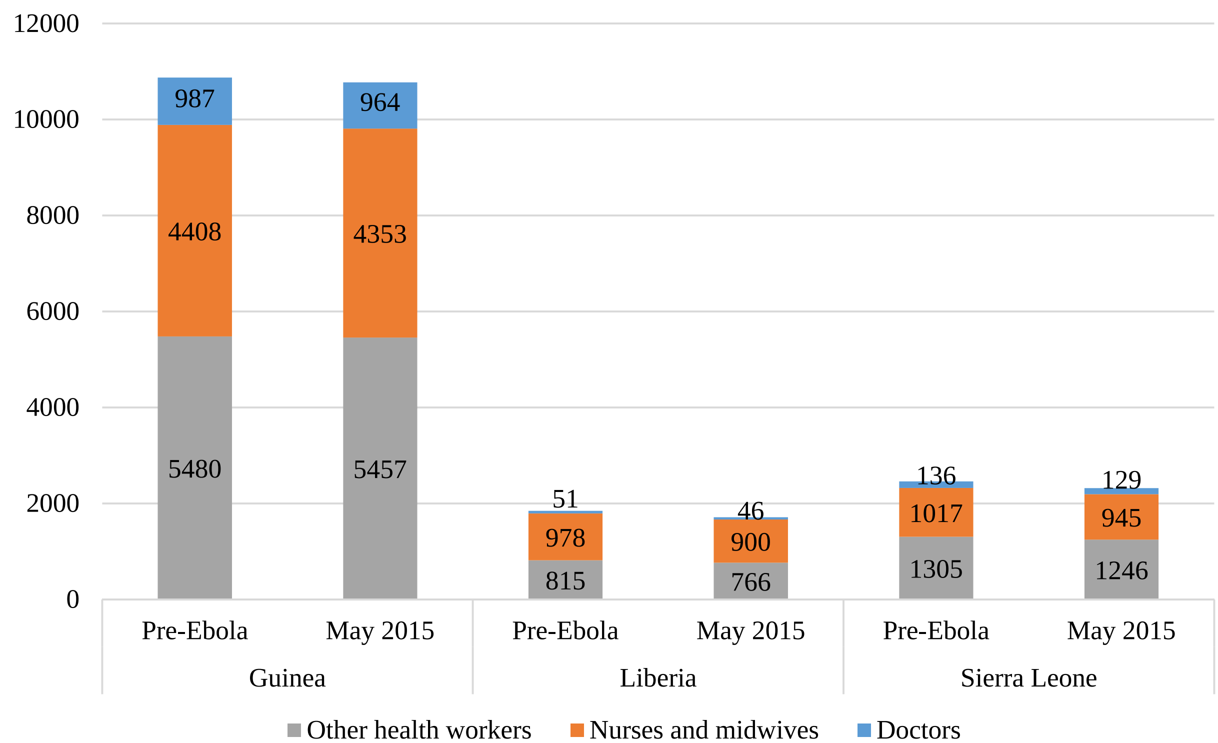
	Civilians		Doctors, nurses, & midwives	
	Cases (% of population)	Deaths (% of population)	Cases (% of workforce)	Deaths (% of workforce)
Guinea	0·03%	0·02%	2·72%	1·45%
Liberia	0·25%	0·11%	10·30%	8·07%
Sierra Leone	0·21%	0·06%	10·67%	6·85%

Source: Author calculations based on infection and mortality data from the WHO [1, 8] and population data from World Development Indicators. [9]

Note: For this analysis civilians means all inhabitants who are not doctors, nurses, or midwives. Data on health care worker deaths are from May 21st for Guinea, Liberia, and Sierra Leone.

Moreover, as shown in Table 1, Ebola deaths have, until now, been disproportionately concentrated among health personnel. As of May 2015, across the three countries a total of 35 doctors, 205 nurses and midwives, and 131 other health care workers had died from Ebola; Figure 1 presents stocks before and after Ebola. The fact that health care workers are at greater risk of contracting Ebola compounds the problem of weak health systems, as health care worker deaths will exacerbate existing skill shortages in countries which had few health personnel to begin with. According to the most recent data from the WHO, before Ebola hit, Liberia, Sierra Leone, and Guinea ranked 2nd, 5th and 28th from the bottom among 193 countries in terms of doctors per 1,000 of the population, with densities of 0·012, 0·022, and 0·084, respectively. [10] Even after Ebola has been eliminated, the reduction in the stock of health care workers from this already low base is likely to have negative effects on the health of affected populations. Furthermore, the disproportionate mortality among health care workers may dissuade students from specializing in health care, making it difficult to increase the density of health care workers.

Figure 1: Stock of Health Care Workers before and after Ebola



Source: Author calculations using data from the WHO.[8, 10]
Note: Data on pre-Ebola stock of health care workers is for the most recent years available for each country: 2004 (nurses and midwives) and 2005 (doctors) for Guinea, 2008 for Liberia, and 2010 for Sierra Leone.

While there have been reports of disproportionate infections and deaths among health care workers, we are unaware of any detailed analysis of the likely consequences of these deaths on non-Ebola mortality. This paper addresses this gap in the literature by modeling how the loss of different types of health care workers to Ebola will affect non-Ebola mortality. We estimate that after Ebola has been eliminated, maternal mortality will increase by 38% in Guinea, 74% in Sierra Leone, and as much as 111% in Liberia because of the reduction in health personnel caused by the epidemic. This means that across the three most affected countries, an additional 4,022 women will die per year due to the loss in health care worker resources owing to Ebola. Estimates of the additional deaths among infants and children under five years old have more variation but are likely to be positive and large. In order to avoid these deaths, 240 doctors, nurses, and midwives would need to be hired immediately across Guinea, Liberia, and Sierra Leone. Moreover, in order meet the estimated number of health care workers needed to reach adequate levels of health coverage according to the Millennium Development Goals, a total of 43,565 doctors, nurses, and midwives would need to be hired. These estimates provide broad support to the importance of having a resilient health system, as well informing policy about the required investment in health care workers.

The Relationship between Health Care Workers and Health Outcomes

A number of studies have attempted to assess the relationship between health care workers and health outcomes. Almost all of these rely on regressions of cross-sectional data, but they vary greatly in which outcome variables (different mortality rates, vaccine coverage, or coverage of births by skilled attendants), explanatory variables (density of health care workers, doctors, or nurses and midwives), and controls they include (poverty, GDP, education), as well as in the functional forms used in their econometric analysis (logit-log, log-linear, linear regressions with arcsin and log transformation of the dependent and independent variables, logit-log and arcsine-log model), not to mention in their results. [11] We focus our attention on those studies investigating the effect of health care worker density (i.e., the number of health care workers per 1,000 of the population) on mortality, as opposed to alternative health outcomes. The relationship between the health care workforce and mortality is more studied than other outcomes and serves as a proxy for the overall quality of the health sector.

Early studies found no significant association between doctor density and infant mortality, [12, 13] or even an adverse association (i.e., positive) between the doctor density, and infant and perinatal mortality. [14] However, more recent studies, with access to more extensive and better quality data, have consistently found a negative and a significant association between the density of health care workers and mortality.

In this paper we focus on five of these recent studies. These studies take a range of approaches, which are summarized in Table A1. One key area of difference in the approaches is how they treat health workers: either as an aggregate, or looking at the effects of doctors, nurses, and midwives separately (possibly allowing for an interaction between doctors and nurses). Robinson and Wharrad use data from 155 countries and find a negative relationship between doctor density and maternal, infant, and under-five mortality. However, they find no statistically significant relationship for nurses once they are included with doctors. [15, 16] Anand and Bärninghausen use data from 117 countries and find a significant negative association between the density of aggregate health care workers (doctors, nurses, and midwives combined) and maternal, infant, and under-five mortality. They also find a significant negative relationship between doctor density and all mortality rates, while the coefficient for nurses is insignificant once the controls are included. [17] Speybroeck et al. use data for 192 countries. They find a significant negative relationship between aggregate health care worker density and maternal mortality, with a similar elasticity to that of Anand and Bärninghausen, but unlike the latter they find the coefficients for infant and under-five mortality to be insignificant. In the case of disaggregate densities – where they are unique in their inclusion of an interaction term between doctor density and the density of nurses and midwives – they again find a significant association between doctor density and all mortality rates, while the relationship for nurses is significant (and negative) only in the case of maternal mortality. [18] Farahani et al. are the first to use panel data in their analysis of 99 countries, which looks at the effect of doctor density on infant mortality. They find that adding one doctor for every 1,000 population is consistent with a significant reduction in infant mortality by about 30%, or 45% in the long-run. [19]

While these recent studies - with their various functional forms - tend to converge on a significant negative association of both aggregate health care worker density and doctor density with mortality rates, they also converge in their inability to sufficiently account for other factors that may be driving mortality rates. Notably, there may be a selection problem such that countries with health systems which are weak in ways other than simply having few health care workers (e.g., low health expenditure, high geographic concentration of services, limited access to external resources, or inappropriate incentive and decision-making structures) [17, 18] experience high mortality rates precisely due to these other weaknesses. Not only would a wider range of inputs to the production of health ideally be included in the models, but health care workers would preferably be separated from the factors likely to mediate the efficiency with which they are able to perform. [18] Data limitations make it difficult to account for these other factors, however, so while these studies acknowledge that the performance of health care workers will be dependent on these factors and note their exclusion as a shortcoming, they either argue that health care workers are the “glue” that allows the rest of the system to function, [20] or that the workers serve as a proxy for general health system resources. [19]

Methods

This paper combines data from the following sources to model how the loss of health care workers to Ebola will affect non-Ebola mortality in Guinea, Liberia, and Sierra Leone: (1) current health care worker deaths from Ebola, disaggregated by country and occupation; (2) the stock of health care workers pre-Ebola, similarly disaggregated; (3) maternal, infant, and under-five mortality rates for each country, pre-Ebola; and (4) health care worker mortality coefficients, which capture the relationship between health care workers in a given country and different mortality rates (i.e., maternal mortality, infant mortality, and under-five mortality[i]).

Addressing the source of each of these in turn, disaggregated data on health care worker deaths from Ebola in Guinea, Liberia, and Sierra Leone come from the World Health Organization (WHO), based on the Viral Haemorrhagic Fever database of each country. [8] We use data on the stock of health care workers from the WHO Global Health Workforce Statistics.[ii] [10] Pre-Ebola mortality rates for each country come from the World Development Indicators (WDI). [9] We use coefficients from Speybroeck et al. [18] as our main estimates for the association between aggregate health care worker density (for doctors, nurses, and midwives, combined) and maternal, infant, and under-five mortality as our primary health care worker mortality coefficients. We rely principally on these because Speybroeck et al. calculate their health care worker mortality coefficients using data with the largest sample of countries, they use the same data source as we use for the stock of health care workers, and they provide coefficients for all three types of mortality (maternal, infant, and under-five). Also, in addition to including controls for income poverty, GDP per capita, and female literacy, they run a disaggregated specification, which reports coefficients for doctors and nurses-midwives separately, which we exploit as one of two robustness checks.[iii]

To calculate the effect on mortality due to health care worker deaths from Ebola, for each of the three countries, we first calculate how many doctors, nurses, and midwives combined have died due to Ebola per 1,000 of the population to date. We then multiply each pre-Ebola mortality rate (maternal, infant, and under-five) by one minus this fraction multiplied by the health care worker mortality coefficient from Speybroeck et al., [18] multiplied by 100, as below.[iv] We then translate this into the percentage change relative to pre-Ebola mortality rates.

$$\begin{aligned} &Jan\ 2015\ mortality\ rate \\ &\quad = pre\ Ebola\ mortality\ rate \\ &\quad * (1 - (health\ care\ worker\ deaths\ per\ 1{,}000\ population \\ &\quad * health\ care\ worker\ mortality\ coefficient) * 100) \end{aligned}$$

We undertake two measures to assess the robustness of our estimates: (1) we calculate lower and upper bound estimates using the 95% confidence intervals for the health care worker mortality coefficients from Speybroeck et al.; [18] and (2) we calculate how much the estimates vary when we use mortality coefficients from the various models discussed in the previous section. For each study providing coefficients for either aggregated health care workers, or disaggregated doctors, and nurses-midwives, we choose the coefficients resulting from the authors' preferred specification, for all available mortality rates. Where both aggregated and disaggregated coefficients are reported, we use both to check for robustness, provided that the latter includes nurses and midwives.[v] Table A1 provides more details on the models underlying each of the coefficients used as robustness checks.

Results

Tables 2 to 4 present the results of our primary estimates, calculated using coefficients from Speybroeck et al. [18] for aggregated health care workers as described above. For each type of mortality (maternal, infant, and under-five), we report the estimated mortality rate in May 2015 attributed to cumulative deaths of doctors, nurses, and midwives, and the percentage change relative to pre-Ebola mortality rates, as well as lower and upper bound estimates of the percentage change based on the confidence intervals from Speybroeck et al. [18]

The largest effects of health care worker deaths for all three countries are observed on maternal mortality. To date, Guinea, Liberia, and Sierra Leone have lost a total of 78, 83, and 79 doctors, nurses, and midwives to Ebola, translating to decreases of 1%, 8% and 7% in the stock of health care workers. We calculate that this may lead to increases in maternal mortality of 38% in Guinea, 74% in Sierra Leone, and as large as 111% in Liberia, relative to pre-Ebola rates. Even if we take the lower bound estimates, health care worker deaths from Ebola would have increased maternal mortality by 26% in Guinea, 51% in Sierra Leone, and as large as 76% in Liberia, relative to pre-Ebola rates. Effects on infant and under-five mortality are positive, ranging from an increase of 7% to 20% and 10% to 28%, respectively, but in both cases the coefficients used are not statistically significant (in the original Speybroeck et. al. paper), and looking at the 95% confidence interval we cannot rule out an effect of 0% in any of the three countries.

Table 2: Effects of Health Care Worker Deaths from Ebola on Maternal Mortality

	Doctors, nurses, & midwives			Maternal mortality ratio (per 100,000 live births)				
	Stock pre-Ebola	Stock post-Ebola	% change	Pre-Ebola ratio (2013)	May 2015 ratio	% change	Lower bound % change (95%)	Upper bound % change (95%)
Guinea	5395	5317	-1%	650	897	**38%**	26%	50%
Liberia	1029	946	-8%	640	1347	**111%**	76%	145%
Sierra Leone	1153	1074	-7%	1100	1916	**74%**	51%	97%

Source: Author calculations based on Ebola mortality data from the WHO,[8] population and maternal mortality data from World Development Indicators,[9] and health worker-mortality coefficients from Speybroeck et al.[18]
Note: Data on pre-Ebola stock of health workers is for the most recent years available for each country: 2004 (nurses and midwives) and 2005 (doctors) for Guinea, 2008 for Liberia, and 2010 for Sierra Leone.

Table 3: Effects of Health Care Worker Deaths from Ebola on Infant Mortality*

	Doctors, nurses, & midwives			Infant mortality rate (per 1,000 live births)				
	Stock pre-Ebola	Stock post-Ebola	% change	Pre-Ebola rate (2013)	May 2015 rate	% change	Lower bound % change (95%)	Upper bound % change (95%)
Guinea	5395	5317	-1%	64.9	69	7%	-2%	15%
Liberia	1029	946	-8%	53.6	64	20%	-4%	43%
Sierra Leone	1153	1074	-7%	107.2	121	13%	-3%	29%

Source: Author calculations based on Ebola mortality data from the WHO,[8] population and infant mortality data from World Development Indicators,[9] and health worker-mortality coefficients from Speybroeck et al.[18]
Note: Data on pre-Ebola stock of health workers is for the most recent years available for each country: 2004 (nurses and midwives) and 2005 (doctors) for Guinea, 2008 for Liberia, and 2010 for Sierra Leone. *Health care worker mortality coefficients in Speybroeck et al. are not statistically significant for infant mortality.

Table 4: Effects of Health Care Worker Deaths from Ebola on Under-five Mortality*

	Doctors, nurses, & midwives			Under-five mortality rate (per 1,000 live births)				
	Stock pre-Ebola	Stock post-Ebola	% change	Pre-Ebola rate (2013)	May 2015 rate	% change	Lower bound % change (95%)	Upper bound % change (95%)
Guinea	5395	5317	-1%	101	110	10%	-2%	21%
Liberia	1029	946	-8%	71	91	28%	-5%	61%
Sierra Leone	1153	1074	-7%	161	191	19%	-4%	41%

Source: Author calculations based on Ebola mortality data from the WHO,[8] population and under-five mortality data from World Development Indicators,[9] and health worker-mortality coefficients from Speybroeck et al.[18]
Note: Data on pre-Ebola stock of health workers is for the most recent years available for each country: 2004 (nurses and midwives) and 2005 (doctors) for Guinea, 2008 for Liberia, and 2010 for Sierra Leone. *Health care worker mortality coefficients in Speybroeck et al. are not statistically significant for under-five mortality.

Table 5 presents estimates for maternal mortality using health care worker mortality coefficients from other studies. All three alternative methods also produce large increases in maternal mortality for all countries. The most comparable effects arise from Method 3, which – similarly to Speybroeck et al. – uses an aggregate coefficient for doctors, nurses and midwives, and produces increases in maternal mortality of 31% in Guinea, 61% in Sierra Leone, and 92% in Liberia. The next most similar estimates arise from Method 2, which uses disaggregated coefficients for doctors, and nurses and midwives, plus an interaction term between them. The smallest estimates come from Method 4, which uses disaggregated coefficients but does not account for an interaction effect. This is a serious limitation because doctors and nurses are likely to be complementary: it is not difficult to imagine that a doctor is more likely to be effective at saving lives when there is a nurse present, and vice versa. Nonetheless, even using this method as an absolute lower bound, health care worker deaths to date would increase maternal mortality by between 12% and 23% across the three countries.

Table 5: Robustness of Maternal Mortality Estimates to Different Coefficients

	Change in maternal mortality due to health care worker deaths from Ebola		
	Guinea	Liberia	Sierra Leone
Method 1: Speybroeck et al. (2006) aggregated doctors and nurses, controlling for GDP per capita, income poverty, female literacy (from Table 2)			
	38%	111%	74%
Method 2: Speybroeck et al. (2006) disaggregated doctors and nurses, plus interaction between doctors & nurses, controlling for GDP per capita, income poverty, female literacy			
	27%	73%	49%
Method 3: Anand and Bärninghausen (2004) aggregated doctors and nurses, controlling for GNI per capita, income poverty, female literacy			
	31%	92%	61%
Method 4: Anand and Bärninghausen (2004) disaggregated doctors and nurses, controlling for GNI per capita, income poverty, female literacy			
	12%	23%	16%

Note: Using coefficients from Robinson and Wharrad [16] yields smaller estimates of 5%, 3%, and 3% increases in maternal mortality for Guinea, Liberia, and Sierra Leone. However, this is explained by the fact that they only report a coefficient for doctors (although nurses are included in their specification, which also controls for GNP, female literacy, and births attended).

Discussion

Taking the estimates from our preferred method (Method 1 in Table 5), the results presented here suggest that even if Ebola were eliminated today, the loss in doctors, nurses, and midwives that has occurred to date as a result of the epidemic could potentially lead to increases in maternal mortality of 38% in Guinea, 74% in Sierra Leone, and 111% in Liberia, relative to pre-Ebola rates. Combining this with data on the most recent rate of live births per 1,000 people and population numbers in each country pre-Ebola [9] implies that an additional 4,022 women would die per year in childbirth as a result of doctors, nurses, and midwives lost to Ebola. Of these, some 1,083 annual deaths would be in Guinea, 1,094 in Liberia, and 1,845 in Sierra Leone. This would bring the countries back to rates of maternal mortality last seen in 2000 in Guinea and Sierra Leone, and 1995 in Liberia. [9] It is important to keep in mind that these are estimates of the direct effect of losing health personnel; these estimates do not take into account potential indirect effects such as lower health system utilization due to fear of contracting Ebola.

Returning to our other outcome variables, while we cannot rule out that the effects of lost health care workers on infant and under-five mortality are zero, confidence intervals suggest an increase in mortality rates. Based on the point estimates, the loss in doctors, nurses, and midwives due to Ebola could lead to increases in infant mortality of 7% in Guinea, 13% in Sierra Leone, and 20% in Liberia, relative to pre-Ebola rates. This would imply an additional 6,700 infant deaths per year across the three countries. For under-five mortality, point estimates suggest increases of 10% in Guinea, 19% in Sierra Leone, and 28% in Liberia, implying an additional 14,100 annual deaths among children under five years old. Aggregating deaths across maternal, infant, and under-five mortality, an additional 24,900 people could die per year as a secondary consequence of Ebola, even after the disease is eliminated.

These mortality estimates may be under- or over-estimated. The cross-country average impact of health care worker supply on maternal, infant, and under-five mortality may be different from the specific impact in Guinea, Liberia, and Sierra Leone. There may be elements of health systems other than health care worker resources – such as their expenditure and geographic distribution of services – which are driving the association with mortality; countries with weak health systems are likely to have both few health care workers and bad health outcomes. This is likely to result in an upward bias of the effect of health care workers on mortality. Unbiased measurement error would bias these estimates toward zero (i.e., attenuation bias). For example, variation in the duration of training, accreditation and classification rules for nurses and midwives across countries means that there is larger heterogeneity in their measurement than in that of doctors, which could potentially mask their true effect on health outcomes. [18] The fact that significant negative coefficients are found in spite of this bias speaks of their strength and provides support to our estimates. Moreover, these estimates are calculated using data on cumulative health care worker deaths from May 2015. With every day that passes before Ebola is eliminated – which seems to have already come for Liberia, which was declared Ebola free on May 9th [21] – in which doctors and nurses continue to die from the disease, the effects on non-Ebola mortality will increase.

To put these numbers into context, countries with fewer than 23 doctors, nurses, and midwives per 10,000 of population generally fail to achieve adequate coverage rates for the key primary health interventions prioritized by the Millennium Development Goals. [22] This is the ratio consistent with having the necessary health care workers to reach 80% coverage of births by skilled attendants. Before Ebola hit, Guinea, Liberia, and Sierra Leone had respective totals of 4·6, 2·4, and 1·9 doctors, nurses, and midwives per 10,000 inhabitants. Accounting for those doctors, nurses, and midwives who have died from the epidemic to date leaves 4·5, 2·2 and 1·8 per 10,000 inhabitants in each country respectively (assuming no additional out-migration as a result of the epidemic). Based on these numbers, in order to fill the health care worker resource gap resulting directly from Ebola, 240 doctors, nurses, and midwives would need to be hired across Guinea, Liberia, and Sierra Leone. But this is in fact a tiny proportion of the necessary health care workers to reach the minimum 80% health coverage targeted by the Millennium Development Goals. To reach those, a total of 43,565 doctors, nurses, and midwives would need to be hired. Although this target is not plausible in the immediate run due to fiscal constraints in each country, it provides a sense of how far these health care systems are from being robustly prepared to face the next health challenges.

Ebola has weakened already fragile systems, and it should be the catalyst to strengthen the systems far beyond their pre-Ebola levels. Our estimates suggest that substantial investment in health systems – and specifically in the health care workforce – is urgently required not only to improve future epidemic preparedness and meet basic needs, but also to limit the secondary health effects of the current epidemic owing to the depletion of the health workforce.

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[i] The coefficients for under-five mortality used in our chosen specification as well as all robustness test are calculated using mortality rates for children aged between one and five years as per Speybroeck et al. [18] and Anand and Bärninghausen. [17]

[ii] For robustness, we also ran our model with data on the stock of health care workers from the World Development Indicators database, [9] which are similar and produced identical effects on mortality.

[iii] This is not our preferred specification because the distribution of doctors versus nurses and midwives may well be endogenous to local factors.
[iv] This is because the coefficients from Speybroeck et al.'s log-linear regressions are elasticities, such that the estimated coefficient b on the log of health care worker density can be interpreted as a 1% increase in health care worker density, ceteris paribus, leading to a b% change in the mortality rate. [18]
[v] Robinson and Wharrad and Farahani et al. both report coefficients for doctors only, thus we do not use these as robustness checks as they are not strictly comparable to our model. [15, 16, 19]

Appendix

Table A1: Summary of Recent Methods to Calculate Health Care Worker – Mortality Coefficients

	Farahani et al. [19]	Speybroeck et al. [18]	Anand and Bärninghausen [17]	Robinson and Wharrad [15]	Robinson and Wharrad [16]
Independent variables					
Aggregate health care workers	No	Yes	Yes	No	No
Disaggregate doctors & nurses	Doctors only	Yes	Yes	Yes	Yes
Dependent variables					
Maternal mortality	No	Yes	Yes	Yes	No
Infant mortality	Yes	Yes	Yes	No	Yes
Under-five mortality	No	Yes	Yes	No	Yes
Model	Log-level regression with (1) cross-country data, (2) panel data, (3) panel data with country fixed effects and (4) panel data with time lags	Log-linear regression	Log-linear regression	Multiple linear regression with log transformations of doctor density, nurse density and GNP, and arcsin transformations of female literacy and births attended	Multiple linear regression with log transformations of doctor density, nurse density and GNP, and arcsin transformation of female literacy
Controls	GDP per capita, average years of schooling, country fixed effects + lags of all dependent and independent variables for long-term analysis	GDP per capita, income poverty, female literacy	GNI per capita, income poverty, female literacy	GNP, female literacy, births attended	GNP, female literacy
Data	Longitudinal panel data from 99 countries from 1960 to 2000 using data from the WDI, Penn World Table, and the Barro–Lee dataset	WHO database on 192 countries	WHO database on 117 countries or 83 countries when income is included	UN database on 116 countries when female literacy is included	UN database on 116 countries when female literacy is included