Human resources and health outcomes: cross-country econometric study

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Summary

Background **Only a few studies have investigated the link between human resources for health and health outcomes, and they arrive at different conclusions. We tested the strength and significance of density of human resources for health with improved methods and a new WHO dataset.**

Methods **We did cross-country multiple regression analyses with maternal mortality rate, infant mortality rate, and under-five mortality rate as dependent variables. Aggregate density of human resources for health was an independent variable in one set of regressions; doctor and nurse densities separately were used in another set. We controlled for the effects of income, female adult literacy, and absolute income poverty.**

Findings **Density of human resources for health is significant in accounting for maternal mortality rate, infant mortality rate, and under-five mortality rate (with elasticities ranging from –0·474 to –0·212, all p values ⩽0·0036). The elasticities of the three mortality rates with respect to doctor density ranged from –0·386 to –0·174 (all p values ⩽0·0029). Nurse density was not associated except in the maternal mortality rate regression without income poverty (p=0·0443).**

Interpretation **In addition to other determinants, the density of human resources for health is important in accounting for the variation in rates of maternal mortality, infant mortality, and under-five mortality across countries. The effect of this density in reducing maternal mortality is greater than in reducing child mortality, possibly because qualified medical personnel can better address the illnesses that put mothers at risk. Investment in human resources for health must be considered as part of a strategy to achieve the Millennium Development Goals of improving maternal health and reducing child mortality.**

Introduction

Human resources for health are clearly a prerequisite for health care, with most medical interventions needing the services of doctors, nurses, or other types of health worker.[1,2] In turn, health care is one of the determinants of population health, with other determinants including socioeconomic, environmental, and behavioural factors. These two relations generate a link between human resources and population health, even if the link might be weakened by the presence of non-health-care factors. Here, we test the extent to which human resources affect population health outcomes.

The population health outcomes that we focus on are the standard measures of maternal, infant, and under-five mortality. All three have been incorporated as indicators of the United Nations Millennium Development Goals (MDGs), and various exercises are underway by national governments, international agencies, and others to investigate how the mortality rate reduction targets can be achieved by the year 2015.[3] The results of this study will help to assess the role of human resources for health in achieving the health MDGs, including tradeoffs with other factors.

The few cross-sectional studies that have studied the effect of health workers on health outcomes have reached differing conclusions. To our knowledge, there are five cross-country studies that use either doctor density or doctor and nurse densities as independent variables to account for mortality outcomes. Robinson and Wharrad[4,5] found that a high density of doctors has a beneficial effect on maternal, infant, and under-five mortality. By contrast, Cochrane and colleagues[6] showed doctor density had an adverse effect on infant and perinatal mortality (they call it a doctor anomaly), but no effect on maternal mortality. Conversely, Kim and Moody[7] recorded no significant association between doctor density and infant mortality, and Hertz and co-workers[8] did not note an association between doctor density and either infant or maternal mortality. Three of these five studies also investigated the link between nurse density and health outcomes, and all recorded a nurse invisibility—in other words, no association between nurse density and maternal mortality, infant or under-five mortality, and infant mortality.[4,5,7]

All five studies have relevant shortcomings, which stem from the methods, variables, and procedures they use. They all used national income per person as an independent variable, but they all measured national income in US$ at market exchange rates rather than in international dollars at purchasing power parity (PPP) rates. This method will exaggerate the real income gap between richer and poorer countries and lead to a biased estimate of the income coefficient. None of the studies included absolute poverty as an explanatory variable, which has been shown to have an effect on health outcomes independent of average income per person.[9] Furthermore, all five studies used stepwise regression to choose their independent variables from larger sets of variables, which might, according to the authors, be relevant. In selecting final independent variables by use of statistical criteria rather than a priori argumentation, all studies probably overfit the data, and the equation(s) chosen by stepwise regression from the sample(s) used might not generalise well to the population. Thus, for example, Hertz and colleagues[8] drop national income per person from their final equations but include instead total fat residual and total fat calories consumed, even though income is a proxy for many (other) factors that affect infant and maternal mortality.

In addition to these cross-country studies, a few within-country studies have investigated the link between densities of human resources for health (per population or per patient) and mortality or intermediate health outcomes. Some report no association whereas others find that high densities can be associated with better or worse health outcomes.[10–15] No generalisable conclusion emerges from these within-country studies, which use different methods, levels of analysis (facility *vs* geographical unit), and explanatory variables.

The aim of our study is to investigate the cross-country relation between maternal and child mortality and human resources for health using a parsimonious framework that allows us to control for the main socioeconomic determinants of health. Our aim is simply to test the strength and significance of density of human resources for health, not to provide an exhaustive set of independent variables to maximise explanatory power—even if reliable and comparable cross-country data were available to enable us to do so.

Our study improves on the previous five cross-country studies because we use a new WHO dataset on human resources for health, which is both more reliable and more comprehensive than any hitherto available. Moreover, unlike previous studies, we measure national income per person in PPP$, we include absolute poverty (the proportion of a country's population living below PPP$1-a-day) as an explanatory variable, and we adopt an improved model specification and regression procedure.

Methods

Choice of variables

Our dependent variables are measures of population health included as MDG indicators: maternal mortality rate, infant mortality rate, and under-five mortality rate.[3] A priori, one would expect a strong link between the maternal mortality rate and human resources for health. The main medical causes of maternal deaths are severe bleeding, unsafe abortion, eclampsia, obstructed labour, and indirect causes such as anaemia or infection—all of which need skilled health workers for accurate and timely diagnosis and treatment.[16–19] One would also expect a link between the infant mortality rate or the under-five mortality rate and human resources for health. Many instances of infant and child mortality can be averted by medical interventions such as vaccinations, oral rehydration treatment, or administration of antibiotics and other drugs. Furthermore, health workers can play an important part in bringing about behaviour changes that reduce infant and childhood mortality, such as breastfeeding, vitamin A supplementation, and bednet use.[20–22]

Although human resources for health should matter for all three measures of population health, they can be expected to matter to different degrees for the different mortality rates. Maternal mortality is likely to be more strongly affected by human resources than the other mortality rates because medical interventions to avert maternal deaths, including safe abortion and delivery, are more dependent on implementation by qualified personnel than are interventions to avert infant and child deaths, such as oral rehydration treatment and vaccinations. The proximate causes of maternal mortality are more likely to be amenable to medical services than are the causes (proximate and distal) of infant and child mortality.

We used three measures of human resources for health. First, as an aggregate measure, we included the sum of three different categories of health workers—doctors, nurses, and midwives. The reason for this choice is that these categories account for the largest number of health personnel in most countries. Other categories of worker could not be included because data for their numbers are not available on a comprehensive basis across countries. These workers include paraprofessionals such as community health workers and social workers, ancillary health workers such as laboratory and other technicians, and alternative and traditional health practitioners.

Unlike Robinson and Wharrad,[4] we excluded as an independent variable births attended by trained personnel, which they included in addition to doctors, nurses, and midwives. Trained personnel who attend births are mainly doctors, nurses, and midwives, which have already been entered as separate independent variables. More importantly, in countries where maternal mortality rate statistics are absent, the variable of births attended by trained personnel is used to estimate the missing data for this rate. Any association that is then recorded between these variables in multiple regression could well turn out to be spurious.

To investigate the effect of different types of health worker, we split the aggregate measure of human resources for health into two categories: (1) doctors; and (2) nurses and midwives combined. The reason for not separating the nurses and midwives is that in countries where nurses and midwives exist as separate categories of health worker they receive similar training and undertake overlapping tasks, whereas in countries where midwives do not exist as a separate category nurses do the work of midwifery.[23–26]

To account for the major socioeconomic determinants of population health, we included average income per person as a general resources variable, which captures or proxies for several distal factors that affect mortality rates—including nutrition, safe water, sanitation, housing, etc.[27,28] Following Anand and Ravallion,[9] we also included absolute poverty as an independent variable, because with the same average income per person a higher rate of poverty would be expected to lead to higher mortality rates. The effect of income on an individual's health is likely to be sharply concave, with high returns for income increases below the poverty line. Finally, we included female adult literacy as an independent variable, because it is well known to be associated with improved health outcomes for various behavioural, lifestyle, and other reasons.[29–31]

Data sources

Our data for human resources for health are taken from the 2004 WHO dataset, *Estimates of Health Personnel*.[32] This dataset is intended to update the WHOSIS information on health personnel compiled by WHO in 1998.[33] The 2004 WHO dataset is more reliable than any other hitherto available on human resources for health because it is based on triangulated data from alternative sources. The WHO human resources for health department describes the procedure for obtaining data and information as follows. Country information on health personnel is "provided to the six WHO Regional Offices by member government ministries of health, often with the cooperation of other national statistical bodies. While ministries of health mostly have administrative records, national statistical bodies often have access to censuses and labour force surveys. Upon submission to the WHO Regional Offices and Headquarters, the data and information are scrutinised, reviewed, and triangulated using additional sources such as national and international employment surveys, records from professional associations, and other publications. The triangulated estimated data are returned to national authorities in member countries or the Regional Office for validation if significant differences are noted."[34] In attempting to make the data for human resources for health comparable across countries, WHO aims to use wherever possible the International Labour Organization international standard classification of occupations at the most detailed level (four digits).[34]

In addition to being more reliable and consistent, the WHO 2004 estimates are more comprehensive in terms of country coverage (with data for doctors for up to 198 countries). The dataset also covers a larger number of human resources for health categories for countries (five compared with two or three for some countries in WHOSIS 1998) and, unlike WHOSIS 1998, the sources of the data are referenced. Note that other datasets such as *World Development Indicators* and World Bank *HNPStats* list only doctor densities and do not provide information on other categories of health workers.[35,36]

Although the 2004 WHO dataset on human resources for health is more reliable, consistent, and comprehensive than any other hitherto available, three limitations have nevertheless been identified. "First, countries do not always collect the same types of information: some countries provide data only for physicians, nurses, and midwives, while others also provide statistics for dentists, pharmacists, and other health occupations. Second, data on health occupations are available only for the public sector for some countries. Third, some countries include only professional nurses and midwives, while associate professionals, such as aides and assistants, are not included in their statistics."[37]

The first limitation does not concern us here: our analysis relies only on doctors, nurses, and midwives (and does not involve dentists, pharmacists, etc). The second difficulty can be mitigated to some extent by the fact that in several countries, private-sector health care is delivered by providers who are employed in the public sector.[38] The third limitation will lead to measurement error in our variable of nurses and midwives and thus could lead to bias in the regression coefficients for this category of health worker. A proper comparison of health worker counts across countries does require standardisation of definitions and classifications, which is a task the WHO is well placed to undertake.

The measures of human resources might not be strictly comparable across countries; however, regression analyses using the 2004 WHO dataset can, nevertheless, be informative. The classic errors-in-variables assumption seems to be applicable here: random errors arise through mismeasurement or lack of standardisation of definitions (eg, for nurses and midwives), but there is no reason to suppose the errors are correlated with true density of human resources for health or have non-zero expectation for any given density. For example, in countries with low density of human resources for health, under-reporting of resources could happen (perhaps because of poor information systems), or equally plausibly, over-reporting could take place, by double-counting of human resources for health personnel working in both the public and private sectors, emigration or attrition not reflected in the statistics, or ghost workers.[39] In view of such measurement errors, which are uncorrelated with true human resources for health density and have zero expectation, our estimated coefficients on densities of human resources for health will be biased towards zero.[40] If, despite such a bias, we obtain coefficient estimates that are significantly positive or negative, the strength of the observed association between density of human resources for health and health outcomes would seem to be secure.

The following sources provide data for the other independent variables: *World Development Indicators* for gross national income per person in PPP$ and for income poverty (percentage of population living below PPP$1-a-day);[35] and *Human Development Report 2003* for female

	Regressions without income poverty (n=117)	Regressions with income poverty (n=83)
Maternal mortality rate (per 100 000 livebirths)	404·9 (488·6)	424·7 (508·5)
Infant mortality rate (per 1000 livebirths)	57·7 (51·8)	59·9 (51·3)
Under-five mortality rate (per 1000 children under five)	16·5 (15·6)	17·1 (15·6)
Gross national income per person (PPP$)	5688·5 (5336·3)	4629·3 (3702·2)
Income poverty (% population living below PPP$1-a-day)	··	19·8 (21·2)
Female adult literacy rate (% of female population age 15 years and older)	73·8 (24·6)	74·2 (25·7)
Doctor density (per 10 000 population)	12·3 (12·9)	12·2 (12·4)
Nurse density (per 10 000 population)	22·1 (24·5)	23·1 (27·2)
Human resources for health density (per 10 000 population)	34·4 (34·9)	35·3 (37·5)

Table 1: **Means (SDs) of variables**

adult literacy.[3] Data for the dependent variables are from WHO.[41,42]

Procedures

We estimated all regression equations with a log-linear functional form. In our first set of equations, we regressed three separate health outcome indicators—maternal mortality rate, infant mortality rate, and under-five mortality rate—against an aggregate human resources for health density, while controlling for gross national income per person in PPP$ and female adult literacy. We then re-estimated the same equations with income poverty included as an additional independent variable. Income poverty is the percentage of the population in a country living on less than PPP$1-a-day. The second set of equations mimicked the first set, but with human resources for health disaggregated into doctor density and combined nurse and midwife density as separate independent variables.

In view of the log-linear functional form of the regression equations, the estimated coefficients are elasticities. In other words, the estimated coefficient *b* on the logarithm of an independent variable can be interpreted as a 1% increase in the independent variable, *ceteris paribus*, leading to a *b*% change in the dependent variable. This functional form therefore allows a unit-free comparison of the relative effect of percentage changes in different independent variables.

Our selection of countries for analysis was guided by the availability of data for the variables used in the regressions. There were 118 countries with data for all dependent and, with the exception of income poverty, independent variables. After undertaking diagnostic tests, we excluded one country (Niger), which was an outlier, leaving us with a sample of 117 countries. For the regressions with income poverty, we had to drop 34 of these countries for which no PPP$1-a-day poverty estimates were available, leaving us with a subsample of 83 countries.

By the World Bank income classification,[43] the 117-country sample included 85 low-income and lower-middle income countries and ten (out of 54 worldwide) high-income countries. A large proportion of high-income countries was lost because information on adult (female) literacy is not available for them.[3] In the 83-country subsample, 67 were low-income or lower-middle income and only two were high-income countries (Portugal and Slovenia). Thus, both our 117-country sample and our 83-country subsample consist largely of less developed countries. The 83-country subsample has a lower gross national income per person because a disproportionate number of the highest income countries in the sample of 117—eg, 13 of the 18 richest countries—were dropped because they had no statistics on PPP$1-a-day poverty. Detailed information is available from the authors on the diagnostic tests done and the list of countries in the two samples.

	Regressions without income poverty			Regressions with income poverty		
Dependent variables	Maternal mortality	Infant mortality	Under-five mortality	Maternal mortality	Infant mortality	Under-five mortality
Independent variables						
Constant	14·978	11·183	10·274	12·071	9·809	8·653
	(16·810)	(19·295)	(16·862)	(9·915)	(11·093)	(9·237)
	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001
Gross national income per person	−0·881	−0·710	−0·741	−0·558	−0·570	−0·583
	(−8·504)	(−10·539)	(−10·466)	(−4·022)	(−5·657)	(−5·461)
	<0·0001	<0·0001	<0·0001	0·0001	<0·0001	<0·0001
Income poverty	··	··	··	0·167	0·106	0·132
				(1·899)	(1·666)	(1·950)
				0·0613	0·0997	0·0548
Female adult literacy	−0·304	−0·258	−0·277	−0·313	−0·273	−0·286
	(−1·327)	(−1·731)	(−1·767)	(−1·342)	(−1·613)	(−1·595)
	0·1871	0·0861	0·0799	0·1836	0·1109	0·1147
Human resources for health density	−0·474	−0·235	−0·260	−0·474	−0·212	−0·231
	(−5·182)	(−3·958)	(−4·154)	(−4·858)	(−2·998)	(−3·080)
	<0·0001	0·0001	<0·0001	<0·0001	0·0036	0·0029
n	117	117	117	83	83	83
R^2	0·791	0·815	0·818	0·791	0·787	0·789
F	142·535	165·988	169·008	73·644	71·882	73·133
p	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001

All dependent and independent variables were transformed into natural logarithms for the regressions. The numbers in the cells are *b* (regression coefficient), t_b (t value of *b*), and p value.

Table 2: **Multiple regression equations with human resources for health as an independent variable**

Dependent variables	Regressions without income poverty			Regressions with income poverty		
	Maternal mortality	Infant mortality	Under-five mortality	Maternal mortality	Infant mortality	Under-five mortality
Independent variables						
Constant	13·596	10·362	9·234	10·302	9·009	7·598
	(13·999)	(16·264)	(13·996)	(8·390)	(9·573)	(7·741)
	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001
Gross national income per person	−0·776	−0·647	−0·660	−0·403	−0·500	−0·488
	(−7·326)	(−9·307)	(−9·174)	(−2·959)	(−4·784)	(−4·484)
	<0·0001	<0·0001	<0·0001	0·0041	<0·0001	<0·0001
Income poverty	..	..	..	0·158	0·103	0·129
				(1·925)	(1·633)	(1·972)
				0·0580	0·1065	0·0522
Female adult literacy	−0·292	−0·245	−0·256	−0·309	−0·272	−0·281
	(−1·351)	(−1·726)	(−1·742)	(−1·471)	(−1·689)	(−1·670)
	0·1793	0·0872	0·0843	0·1454	0·0952	0·0990
Doctor density	−0·325	−0·183	−0·225	−0·386	−0·174	−0·216
	(−4·450)	(−3·822)	(−4·534)	(−5·230)	(−3·079)	(−3·657)
	<0·0001	0·0002	<0·0001	<0·0001	0·0029	0·0005
Nurse density	−0·162	−0·062	−0·047	−0·102	−0·044	−0·024
	(−2·034)	(−1·186)	(−0·874)	(−1·250)	(−0·702)	(−0·364)
	0·0443	0·2380	0·3838	0·2150	0·4848	0·7170
n	117	117	117	83	83	83
R^2	0·808	0·827	0·835	0·823	0·799	0·808
F	117·628	133·807	141·218	71·695	61·331	64·855
p	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001	<0·0001

All dependent and independent variables were transformed into natural logarithms for the regressions. The numbers in the cells are *b* (regression coefficient), t_b (t value of *b*), and p value.

Table 3: **Multiple regression equations with doctors and nurses as separate independent variables**

Results

Table 1 shows the mean and SD of every dependent and independent variable in natural units (non-log form). The mean values of the variables in the subsample of 83 countries were similar to those in the 117-country sample, with the exception of gross national income per person (table 1).

Tables 2 and 3 present the results of the regression equations. All coefficients had the expected signs in terms of the direction of the relation between the independent and dependent variables. The explained variation, or coefficient of determination R^2, in all equations was 79% or more, and the *F* tests decisively rejected the hypothesis of joint non-significance of the independent variables. The independent variables varied in both size (elasticity) and level of significance or p value.

Human resources for health in aggregate terms significantly accounted for the three health outcome measures: maternal, infant, and under-five mortality rates. Doctors, nurses, and midwives together significantly lower these three mortality rates after controlling for other variables used to account for these health outcomes.

Discussion

Our findings are consistent across all model specifications used. Thus, investment in human resources can be expected to contribute significantly to the achievement of the MDGs—in addition to and independently of policies that bring about income growth, poverty reduction, and expansion of female education.

As we expected, the human resources for health elasticity of the maternal mortality rate is higher than that of the infant and the under-five mortality rate. The effect of human resources for health is greater in reducing maternal mortality than either infant or child mortality because qualified medical personnel are able to address a larger proportion of conditions that put mothers at immediate risk of death compared with infants or children. The higher human resources for health elasticity of under-five mortality than of infant mortality might be the result of similar considerations: infants may face fewer medical conditions that put them at risk of death than children between 1 and 4 years of age, because infants may be relatively better protected by breastfeeding and other behaviours of mothers.

In view of these broad findings for our aggregate measure of human resources for health, we proceeded to investigate the effect of specific types of health workers, and disaggregated the human resources for health variable into what we judged to be fairly homogeneous categories. Thus, instead of aggregate human resources for health, doctors and the combined category of nurses and midwives were entered separately in a parallel set of regressions.

As was the case for human resources in aggregate, doctor density was important in accounting for all three health outcomes. Thus, we reject any notion of doctor anomaly or invisibility, as indicated in some earlier studies.[6–8] Our estimated elasticity of doctor density ranged from –0·174 to –0·386 (table 3). Further, the coefficient of nurse density was significant (p=0·0443) when maternal mortality rate was the dependent variable in the regression without income poverty. In the other regressions in table 3, the coefficient on nurse density did not differ much from zero. However, in view of the measurement error in our nurses' variable (as discussed in Data sources), we would expect the coefficients on nurse density to be biased towards zero. Hence, the insignificant coefficients recorded for nurse density in table 3 cannot be taken to conclude that nurses do not matter.

Our range of estimates for the elasticity of health outcomes with respect to gross national income per person in tables 2 and 3 (–0·403 to –0·881) is within the range reported across other studies.[27] We included income poverty in the regressions to take account not only of average income but also of its distribution between the poor and non-poor. Holding average income per person constant, we noted that a reduction in income poverty significantly reduced maternal, infant, and under-five mortality rates (p values 0·0522–0·1065). While income per person remains significant, its elasticity is diminished by the introduction of income poverty. By contrast, the size of the coefficients on aggregate density of human resources for health, doctor density, and female adult literacy remain substantially unaffected by the inclusion of income poverty.

Female adult literacy has the predicted negative coefficient in the regression equations for maternal, infant, and under-five mortality rates, with or without income poverty. Although the coefficient of female adult literacy was significant for the infant and under-five mortality regressions (p values 0·0799–0·1147), its significance is lower for maternal mortality rate. The higher significance of female adult literacy in accounting for infant and under-five mortality rates seems plausible since the causes of maternal mortality are less likely to be affected by individual behaviour and lifestyle choices than are the causes of infant and child mortality.

Our results seem to be consistent and robust across the 12 regression equations estimated. As more comprehensive and disaggregate data become available on the health workforce, more detailed analyses will be possible to undertake. For example, the categories of community health workers, social workers, and alternative and complementary medicine practitioners should be included in the regressions since they might have an effect on health outcomes. Such health workers exist in all countries,[44–46] although their relative proportions might differ between the developing and developed countries. Thus, in relative terms, community health workers may be more numerous in developing countries whereas social workers are more common in developed countries. A priori, we have no reason to expect a strong correlation across countries between the total numbers in the omitted categories and our more narrowly defined human resources for health variable(s). Their exclusion will, thus, not necessarily bias the coefficient(s) of our variable(s). The extent of any bias depends on the size of the effect of the omitted variable and its correlation with the included variable.[47]

In this article, we have not adjusted for differences in skill level or occupational mix across countries or for the geographical—eg, urban or rural—distribution of human resources within countries. Again, omission of geographical distribution as an explanatory variable might not have much effect on the coefficient of our density of human resources for health because urban bias in distribution of these resources is likely to arise across the range of countries with different densities of human resources for health. Nonetheless, including it as a separate independent variable, when data become available, should help us to quantify the health losses from maldistribution of human resources for health.

We did not adequately account for the degree of substitutability or complementarity between the different types of health workers. It would be an interesting exercise to incorporate different substitutability assumptions—for example, between doctors and nurses—through appropriate choice of functional form for the regression equations.

Further within-country analyses of human resources for health should clearly be undertaken. It is possible that the strength of the relation between human resources density and health outcomes is different in different countries or regions. For instance, worker-deficit regions such as sub-Saharan Africa[1] may show a particularly large effect of human resources for health. Within-country, cross-district or time-series, studies are also likely to avoid definitional and comparability difficulties arising from non-standard definitions of health-worker categories across countries. Finally, district-level or local-level studies might help to account for the actual health-service activities of health workers and to explain their relative effect on different outcomes—eg, of doctors and nurses on maternal and child mortality.

Our cross-country results strongly confirm the importance of human resources for health in affecting health outcomes. Although the performance of human resources in attaining health-system goals will be dependent on their distribution across occupations and geographical regions, and other factors such as incentive and decision-making structures, our findings confirm that human resources for health densities affect health outcomes independently of other determinants.

An implication of our results is that investing in human resources for health should be explicitly considered as part of a strategy to achieve the MDGs—in addition to raising national income per person, reducing absolute poverty, and expanding female education. Ignoring human resources for health will, at best, overlook an important determining factor in achieving the health MDGs; at worst, it could disregard a constraint that renders these goals unattainable.

Contributors
S Anand and T Bärnighausen jointly formulated the study design, obtained and analysed the data, interpreted the findings, and wrote the article. Both authors had access to all data in the study and had final responsibility for the decision to submit for publication.

Conflict of interest statement
We declare that we have no conflict of interest.

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