# Health Care Professional Shortages and Skill-Mix Options Using Community Health Workers: New Estimates for 2015

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## Abstract

Objective: This paper estimates the need, supply, and shortage of doctors, nurses, and midwives in 84 low- and middle-income non-African countries in 2015, the target date of the United Nations Millennium Development Goals (MDG). The wage bill required to eliminate the shortages was calculated based on simulating different skill mixes of workers, including community health workers.

Methods and Data: Based on *World Health Organization, Working Together for Health 2006* report, we assume each country needs 2.28 doctors, nurses, and midwives per 1,000 population. The need is comprised of 0.55 doctors, based on Scheffler et al. (2008), resulting in 1.73 nurses and midwives. Supply estimates were based on Scheffler et al.'s forecasting model, and each country's nurse-plus-midwife-to-doctor ratio. Workforce shortage estimates were calculated based on the difference between the estimated need and supply, and the wage bill to required to eliminate the shortages was calculated based on each cadre's wage and simulating different skill mixes. Data on the number of doctors, nurses, and midwives by country are from the WHO Global Atlas of the Health Workforce. Doctor and nurse wage data are from the Occupational Wages around the World database.

Results: We forecast that 12 of the 84 countries analyzed will experience needs-based shortages of doctors, nurses and midwives in 2015, totaling approximately 581,000 health care professionals. We estimate the additional annual wage bill required to eliminate the shortages to be approximately $1.8 billion (2007 U.S. dollars), or approximately 80 percent of the current wage bill projections for these countries in 2015. We use simulations to illustrate how workforce mix changes, including the introduction of community health workers, can potentially reduce this wage bill shortfall.

Conclusion: The 12 countries identified with workforce shortages need to scale up their cadres of health workers. However, it will be difficult to obtain the required financing, so productivity improvements need to be considered. Identifying the optimal skill mix of workers is important, given the vast training and cost differences among workers. This effort will help these countries achieve the MDGs.

# Introduction

The World Health Organization (WHO) estimated that in 2006 the world had a needs-based shortage of 2.4 million doctors, nurses, and midwives (hereafter “health care professionals”), based on each country needing 2.28 health care professionals per 1,000 population.[1] These shortages are often coupled with skill mix imbalances and uneven geographic distribution.[2] The lack of health workers inhibits countries from meeting the health-related Millennium Development Goals (MDG)[3] and implementing health programs.[4]

A number of studies have examined the skill mix of health workers as a possible solution to overall shortages, but the results have been mixed.[5,6,7,8,9,10] In particular, community health workers (CHW) may present a relatively affordable alternative for basic health care provision and may be able to treat geographically diverse populations that would otherwise not have access to health care providers. The term CHW refers to a wide variety of health care workers.

The 1989 WHO study group, Strengthening the Performance of Community Health Workers in Primary Health Care, defined CHWs as health workers who are not formally part of the health system, but are supported by it, and are members of the community in which they work.[11] The WHO study group stressed that CHWs

generally receive less training than other cadres of health workers.

While the role of CHWs can vary widely across countries, among their common tasks are to educate the community on disease prevention, diagnose common diseases, and provide limited medical treatment.[12] However, the variation in the duties of CHWs leaves a relative dearth in analyses about CHWs' cost-effectiveness in particular roles in health care systems.

In order to describe how a CHW might be a substitute for a primary care doctor, a primary care doctor's key roles are explained. One key role of a primary care doctor is to bring years of training and experience to diagnose the patient's medical condition in order to determine the most appropriate treatment, or to determine which specialist needs to examine the patient. The diagnosis is a complex process that involves evaluating readily apparent symptoms and determining which procedures (e.g., blood tests, medical imaging, endoscopy, electrocardiography, and biopsy) are needed to obtain additional necessary information. The primary care doctor will continue monitoring the patient and adjust the treatment as needed. When a patient has simultaneous medical conditions (e.g., hypertension, diabetes, and malaria), the primary care doctor is responsible to coordinate the patient's care.

Medical conditions that have readily apparent symptoms can be diagnosed by an individual who has significantly less training than a primary care doctor. These diseases include many that are prevalent in low- and some middle-income countries, such as malaria, tuberculosis, and diarrhea. In some cases, the CHW may be able to immediately treat the patient with medication, a task that is sometimes done by a primary care doctor or nurse. For example, evidence from the Democratic Republic of Congo shows that CHWs trained specifically to administer and diagnose malaria increased treatment rates and decreased morbidity.[13]

CHWs play a large role in the prevention, diagnosis and treatment of HIV/AIDS. Recent studies have shown that in many African countries, anti-retroviral treatment strategies are being constructed to enable CHWs to treat the patient.[14] The relatively low level of technical knowledge needed, their low cost, and their presence in most communities make CHWs ideal for this type of outreach and treatment. CHWs are especially effective in ensuring that patients follow an appropriate treatment plan.[15] For example, in addition to HIV/AIDS anti-retroviral treatment, CHWs can play a pivotal role in administering drugs for malaria, tuberculosis, and diarrhea.[16]

CHWs increase access to treatments because they often serve populations that do not have access to health care

professionals. When a patient's medical condition becomes too complex for a CHW, the CHW may refer the patient to the nearest medical facility. When patients do have access health care professionals, the CHWs free up a portion of professionals' time to engage in more complex medical tasks that require their advanced training.

The use of CHWs is not without controversy. The major concern is whether patient safety is put in jeopardy, because the patients are being advised and treated by a health worker who has less training than a health care professional. This concern may be compounded by fears about lower-cost workers taking over duties of higher-paid physicians and nurses. Because of these concerns, some physician groups and policy makers have opposed increasing CHWs. An additional issue stems from the tension to create a comprehensive CHW training regime for scaling-up while ensuring that CHWs are able to provide localized care, specific to the communities in which they serve.[17] Although these concerns exist, with some training, the CHW will be able to make better decisions than most patients with limited education and health background who do not have access to a health care professional.

Given the severe health worker shortages in low-income countries, it is important that each country uses the optimal mix of health workers, including CHWs. The optimal mix of health

workers is obtained when the marginal product (e.g., measured by number of additional medical office visits or additional vaccinations given because of an additional worker) divided by the worker's wage is equal across all health workers; training costs could be incorporated as well. Although health workers do many tasks, this concept is easiest to illustrate using a single task. For example, if the number of additional vaccinations given per dollar wage was higher from hiring an additional CHW versus an additional nurse, then more CHWs should be hired. As more CHWs are hired, the additional number of vaccinations given will likely decrease (because of diminishing returns) and the wage may increase because of the increased demand for CHWs. The opposite will likely occur to nurses, eventually causing the number of additional vaccinations given per dollar wage from hiring an additional worker will be the same across health workers.

Policy-makers and funders not only need forecasts, but also need frameworks to produce forecasts in order to make decisions about the number, training level, and distribution of health workers. Our recent paper estimated forecasts for doctors, nurses, and midwives in Africa in 2015.[18] This paper applies the same methodology to provide empirically based forecasts for doctors, nurses, and midwives in low- and middle-income non-African countries in 2015, and extends the analysis to include

CHWs. Specifically, the study addresses the following three questions: (1) What is the projected health workforce needs-based shortage (or surplus) of doctors, nurses, and midwives in low- and middle-income non-African countries in 2015? (2) What is the estimated annual wage bill required to pay for these health care professionals? (3) How do different skill mixes of doctors, nurses, midwives, and CHWs change the annual wage bill? We conclude by discussing the policy implications of our findings from these three questions.

## Data and Research Methods

The data and research methods are described in Scheffler et al., 2009, and are summarized next.[19]

***Data***

Country-level data on the number of doctors, nurses, and midwives are from the WHO Global Atlas of the Health Workforce database (as of Mar. 1, 2007). Doctor and nurse wage data by country are from the Occupational Wages around the World (OWW) database, published by the National Bureau of Economic Research (NBER). The OWW standardizes wages using several methods; we used the mean doctor and mean nurse wages that were standardized with country-specific and uniform calibration with uniform weighting (variable: x3wuus).[20] This standardization method increased the sample of non-missing wages; wages were not

sensitive to the standardization option chosen. Because of the lack of midwife wage data, we assume a midwife's wage was equal to a nurse's. Projected population numbers are from the United Nations Population Division.[21]

***Estimating Wages***

The latest year that OWW wages were available varied across countries; therefore, we inflated wages to 2007. This was done using the following three steps: (1) convert the U.S.-dollar (USD) denominated wage to local currency units (LCU) using the LCU-to-USD exchange rate in the OWW data year, (2) inflate the LCU to 2007 using the country's GDP deflator, and (3) convert the LCU back to USDs using the LCU-to-USD 2007 exchange rate. Both exchange rate and GDP deflator data are from The World Bank's World Development Indicator database. If the OWW did not include the wage for a country, the wage was predicted with a regression model using the country's gross national income per capita. The models regressed the natural log of each country's mean doctor or nurse wage on the natural log of its per capita income; the regression models were estimated for doctors and nurses separately. Given the current global financial crisis, economic growth between now and 2015 is difficult to predict; therefore, we chose to not increase wages in real terms between 2007 and 2015.

***Estimating Workforce Need, Supply and Shortage***

For 84 low- and middle-income non-African countries, we estimated each country's needs-based shortage (or surplus) of doctors, nurses, and midwives in 2015 as follows: (1) estimated the workforce need by worker type, (2) estimated the workforce supply by worker type, and (3) estimated the workforce needs-based shortage by worker type, the difference between the first two estimates. We used WHO's categorization to determine each country's geographical region.[22]

Based on WHO, we assumed each country needs 2.28 doctors, nurses, and midwives per 1,000 population,[23] comprised of 0.55 doctors, based on Scheffler et al. (2008), resulting in 1.73 nurses and midwives. To be consistent with WHO (2006), we used the term "doctor" instead of "physician" throughout this study.[24]

We then estimated each country's supply of health care professionals in 2015. To estimate doctors, we used Scheffler et al.'s (2008) supply estimates because, to our knowledge, it is the only study that forecasts doctor supply by country in 2015. To estimate nurses and midwives, we calculated the nurse-plus-midwife-to-doctor ratio for each country using the WHO Global Atlas of the Health Workforce data, and then multiplied this ratio by the number of doctors from Scheffler et al. (2008) to obtain the nurse-and-midwife supply estimate. Thirty-two countries were missing midwife data. For these countries, we

estimated the number of midwives by assuming there were 0.11 midwives per doctor, which was the median midwife-to-doctor ratio for the other countries.

The workforce shortage (or surplus) for each country by worker type in 2015 was calculated by subtracting each country's supply from its need by worker type. To measure the shortages in a single dimension, we calculated each country's shortage (or surplus) in doctor-equivalent units by assuming that a nurse or midwife was equal to 0.8 doctors. We chose the 0.8-doctor level based on estimates in the U.S., because there are few reliable estimates of this relative productivity factor in low- and middle-income countries.[25,26,27] In our sensitivity analyses, we allow this factor to vary between 0.7 and 0.9, because we recognize that the factor may be higher in low- and middle-income countries, because a greater share of tasks involves primary health care.

***Calculating the Wage Bill to Eliminate Health Workforce Shortages***

The wage bill for the health workforce need is the wage of 2.28 health care professionals (0.55 doctors and 1.73 nurses and midwives) per 1,000 population, and the wage bill for the health workforce supply is the wage for the estimated workforce supply. The wage bill for the health workforce shortage is the difference between the need and supply wage bills.

We then re-calculated the need wage bill under various workforce mix scenarios, all of which increased the needed number of nurses and midwives relative to needed doctors. Some of the scenarios also replaced a percentage of the needed nurses and midwives with CHWs. All scenarios held each country's needed number of doctor-equivalent units constant. We assumed that the supply wage bill would not change, because that is the wage bill that the country is estimated to be willing and able to pay. The difference between these two wage bills resulted in a new wage bill required to eliminate the health workforce shortage.

For our estimates, we want to caution the reader that, given the quality of the available data and the assumptions that are required, these estimates are to be considered approximations with a wide confidence interval (see Limitations Section for additional information). But waiting for ideal data is not an option given the dire health problems in low- and middle-income countries.

## Results

We estimate that 17 of the 84 low- and middle-income non-African countries that we analyzed will experience a needs-based shortage of doctors, nurses, and midwives in 2015. Of these 17 countries, 12 countries had a shortage of doctors as well as nurses and midwives. We focus on these 12 countries because the

remaining five countries, with the exception of Costa Rica, had doctor-equivalent shortages that were less than 0.25 health care professionals per 1,000 population. Exhibit 1 presents the summary of the need, supply, and shortage of these health care professionals for the 12 countries. The estimated shortage is substantial. We estimate the total need for doctors, nurses, and midwives to be approximately 1.231 million health care professionals, whereas supply is estimated to be only 650,000, or 53 percent of need. Our estimated shortage of 581,000 health care professionals includes 155,000 doctors and 426,000 nurses and midwives.

Exhibit 2 presents each country's estimated health care professional shortage in 2015. Based on the doctor-equivalents measure, shortages were found in 17 of 84 countries analyzed, of which, 12 had shortages of doctors as well as nurses and midwives. Of the 12 focus countries with shortages, the doctor-equivalent shortage ranges from 1.74 per 1,000 population in Nepal to 0.28 per 1,000 population in Fiji. The largest doctor shortage occurs in Papua New Guinea and Vanuatu, both which have a 0.50 doctor per 1,000 population shortage, and the largest nurse and midwife shortage occurs in Nepal, which has a 1.58 nurse and midwife per 1,000 population shortage. The largest countries by population with shortages include Indonesia and Bangladesh.

Exhibit 3 provides each of the 12 country's doctor and nurse annual wages, either from the OWW data or from our regression model estimates that were based on a country's per capita income. OWW doctor wage data were available for 104 low- and middle-income non-African countries; OWW nurse data were available for 103 of these countries. Because midwife data were not comprehensive, we assumed a midwife's wages was equal to a nurse's. The results of the regression models are shown in Eq. 1 and Eq. 2. The per-capita-income parameter estimate and the F-statistic in both models were statistically significant at the 0.05 level.

$$\text{Ln(mean doctor wage)} = 3.72 + 0.66\ \text{Ln(per capita income)} \quad (1)$$
$$R^2 = 0.52$$

$$\text{Ln(mean nurse wage)} = 3.19 + 0.65\ \text{Ln(per capita income)} \quad (2)$$
$$R^2 = 0.56$$

Based on these wages and the estimated workforce shortages, Exhibit 4 provides the annual estimated wage bill required to pay for needed and supplied health care professionals by country. The difference between these two wage bills is the shortage wage bill (i.e., the wage bill shortfall required to meet the need), which is also presented for doctors versus nurses and midwives. The annual wage bill to pay for the need in the 12 focus countries with projected shortages is approximately $4.0 billion (in 2007 U.S. dollars), and the annual wage bill for the supply is approximately $2.2 billion. The $1.8 billion

difference is the annual wage bill required to eliminate the health care professional shortage for these countries, including $0.8 billion for doctors and $1.0 billion for nurses and midwives. The $1.8 billion shortfall is significant, because it is approximately 80 percent of the $2.2 billion wage bill for the supply, the estimate of what these countries are willing and able to pay. Doctors represent 43 percent of the wages needed to eliminate the shortage, but only represent 27 percent of the health care professional shortage.

Next, we examined how altering the workforce mix would impact the estimated $1.8 billion annual wage bill required to eliminate the workforce shortage. In the above analyses, the need is comprised of 0.55 doctors per 1,000 population and 1.73 nurses and midwives per 1,000 population, resulting in a nurse-plus-midwife-to-doctor ratio of 3.1. Exhibit 5 shows the percent reduction in the annual wage bill shortage from increasing the nurse-plus-midwife-to-doctor need ratio by different percentages and assuming a nurse or midwife was equal to either 0.7, 0.8, or 0.9 doctors. The needed number of doctor-equivalent units for each country was held constant. For a given nurse-plus-midwife-to-doctor need ratio increase, the magnitude of the reduction increased as a nurse’s or midwife’s assumed productivity became relatively more equal to a doctor’s. For example, increasing the nurse-plus-midwife-to-doctor ratio by 50 percent results in a

reduction of 2.0 percent when a nurse or midwife equaled 0.7 doctors, and the reduction increases to 6.1 percent when a nurse or midwife equaled 0.9 doctors. When a nurse or midwife equaled 0.625 or fewer doctors, no reduction resulted from increasing the nurse-plus-midwife-to-doctor need ratio.

Exhibit 6 shows each country's percent reduction in its annual wage bill shortage from increasing the nurse-plus-midwife-to-doctor need ratio by 50 percent. Although the needed workforce skill mix changed, each country's needed number of doctor-equivalent units was held constant. We assumed that a nurse was equivalent to 0.8 doctors. The overall reduction for the 12 countries was 4.3 percent, but there was significant variance among countries, ranging from -1.7 percent in Sudan to 22.4 percent in Fiji. The reduction was negative in Sudan because the nurse wage was greater than 0.8 of a doctor's wage. In Indonesia, the largest country by population, the reduction was 10.5 percent. The reduction depends on the country's relative wages of doctors versus nurses and midwives, and its original shortage wage bill amount.

Exhibit 7 shows the percent reduction in the annual wage bill shortage by substituting CHWs for nurses or midwives for three workforce mix scenarios, all of which increased the needed number of nurses and midwives relative to needed doctors, holding each country's needed number of doctor-equivalent units

constant. In the first, or baseline, scenario, no nurses and midwives are replaced with CHWs. In the exhibit, this is represented by the lower curve, which is the same curve within Exhibit 5 for which a nurse's or midwife's productivity equals 0.8 doctors. This relative productivity was used for each scenario in Exhibit 7. In the second and third scenarios, 10 percent and 20 percent, respectively, of each country's needed nurses and midwives are replaced with CHWs. These scenarios are represented by the middle and upper curves in the exhibit, respectively. The reduction in the annual wage bill shortage is significantly higher as compared to the scenario that does not include CHWs. For these latter two scenarios, a CHW's productivity was assumed to equal 0.3 nurses or midwives. For example, in the scenario in which 10 percent of the needed nurses and midwives are replaced with CHWs, then a country will need 1.56 nurses and midwives per 1,000 population (1.73 x 90%) and 0.58 CHWs ([1.73 x 10%] / 0.3). (Recall that our estimates are based on each country needing 1.73 nurses and midwives per 1,000 population.) A CHW's wage was assumed to be 0.2 of a nurse's or midwife's. Because of the lack of CHW studies estimating productivity and wages, the relative CHW to nurse-and-midwife productivity and wage estimates are based on the authors' very preliminary assessment, and the authors realize

these estimates will vary across countries (see Limitations Section for additional information).

## Discussion

We estimated the needs-based shortage of doctors, nurses, and midwives in 84 low- and middle-income non-African countries in 2015, and found 12 countries had a shortage of doctors as well as nurses and midwives. This shortage totaled approximately 581,000 health care professionals, the difference between a 1.231-million worker need and a projected 650,000 worker supply. The shortage is composed of 155,000 doctors and 426,000 nurses and midwives. These numbers do not include shortages of other health care professionals and support staff. We estimate the annual wage bill necessary to eliminate the shortage to be approximately $1.8 billion (in 2007 U.S. dollars). This amount could potentially be reduced by substituting nurses and midwives for doctors as well as substituting CHWs for nurses and midwives.

Our 581,000 needs-based shortage estimate is similar to WHO’s 680,000 shortage estimate in 2006 for these 12 countries; however, the supply and shortage estimates by country sometimes differed because we used different methods and our estimates are based on forecasts in 2015 while WHO’s estimates were as of 2006.[28]

### *Limitations and Suggested Next Steps to Enable Policy Decisions*

As with other health worker studies in low- and middle-income countries, the study's greatest limitation is poor data quality, including both the accuracy of the data that were available as well as the paucity of data that were available. Similar to WHO (2006), we chose to include a large number of countries in our analyses, but this choice limited us to data variables that were available across these countries. Another approach would have been to select a few countries for in-depth case studies. Although our approach causes us to consider our health care professional shortage and wage bill estimates to be approximations with a wide confidence interval, our goal was to present a framework and methods to forecast health workforce shortages and to evaluate skill mix scenarios, because we realize each country can update our estimates using more accurate data and additional data variables to make policy decisions.

For example, the 2.28 needed health workers per 1,000 population estimate from WHO (2006) could be refined by accounting for factors such as other health care system inputs (e.g., facilities, equipment, supplies, and pharmaceuticals) as well as the population's burden of disease, age distribution, and share living in rural areas.

The forecasted supply of doctors in 2015 is based on each country's change in the number of doctors between 1980 and 2001. WHO estimates the number of health care professionals from four major sources: government administrative systems, national population censuses, employment surveys, and health facility assessments. Administrative data are often incomplete and do not fully capture professionals employed in both the public and private sectors; professionals in the private sector are often undercounted. Moreover, if the factors that caused the historical changes in the supply of doctors do not continue to have the same impact in the future (e.g., the factors that caused rapid growth in the number of doctors in the Philippines during the mid-1990s), then countries can incorporate those factors and adjust the estimates accordingly. For example, the forecasted supply of health workers could be refined by accounting for factors such as the impact of the current global recession, the country's share of global aid for health, the age distribution of the health workforce, the availability of pre-service medical education, health worker migration, and particular events (e.g., the January 2010 earthquake in Haiti).

The relative productivity of a CHW as compared to a nurse or midwife should be estimated in each country, because of the different tasks that CHWs perform across countries. Our focus is to illustrate that it is possible to reduce the annual wage bill

shortfall when substituting CHWs for nurses (and midwives), as long as a CHW's relative productivity to a nurse is greater than its relative wage to a nurse.

CHWs play a variety of roles both across and within countries. Given the lack of CHW wage data, we chose to set a CHW's wage to be 0.2 of a nurse's or midwife's in order to be able to do cross-country estimates, while realizing that the relative wage varies across countries. For example, in South Africa there are thousands of volunteer CHWs providing important HIV/AIDS care who are not paid for their work and receive no training.[29] In contrast, a community nurse in Ghana makes approximately three-fourths of the annual income of a nurse.[30] Variations in CHW wages across countries may also reflect variations in training costs and durations. Mullan and Frehywot (2007) show that annual training costs for a CHW in five Sub-Saharan African countries range from $1,000 (U.S. dollars) to $2,000 (U.S. dollars), and the duration of the programs is three years in four of the five countries and only one year in the fifth country.[31] In order to use our methodology to model potential skill mix changes and increased use of CHWs within a single country, specific CHW wages within the country should be used. Doctor and nurse wage estimates could be updated, because the OWW wage data is dated in many countries. The optimal skill

mix choice should be based on the latest data for each cadre's wage, productivity, and training costs.

### *Conclusion*

In each country, the government and private sector need to decide how best to spend their limited health care dollars. The 12 countries identified with workforce shortages will likely need to scale up their cadres of health workers, if they are to meet the MDGs. This effort can be improved by planning to mitigate these shortages by increasing funds from the public sector, private sector, and external donors. However, it will be difficult to obtain the required financing so productivity improvements need to be considered. Identifying the optimal skill mix of workers is important, given the vast training and cost differences among health workforce cadres. This effort will help these countries come closer to achieving the MDGs.

**Exhibit 1: Summary of Health Care Professional Need, Supply, and Shortage Estimates for 12 Low- and Middle-Income Non-African Countries with Projected Shortages, 2015 (in thousands)**

| | Doctors | Nurses & Midwives | Total | Doctor Equivalents |
|---|---|---|---|---|
| Need | 296 | 935 | 1,231 | 1,044 |
| Supply | 141 | 509 | 650 | 548 |
| Shortage | 155 | 426 | 581 | 496 |

Sources: Authors' analysis, Scheffler et al. (2008), WHO Global Atlas of the Health Workforce (Mar. 1, 2007), United Nations Population Division

Notes: The number of doctor equivalents is equal to the number of doctors plus 0.8 times the number of nurses and midwives. Numbers may not add to total because of rounding.

For this exhibit and all calculations, as was done in R.M. Scheffler et al., "Forecasting the Global Shortage of Physicians: An Economic- and Needs-Based Approach," Bulletin of the World Health Organization 86, no. 7 (2008): 516–523, we use more precise workforce need numbers per 1,000 population: 0.5487 doctors and 1.7313 nurses and midwives per 1,000 population.

## Exhibit 2: Health Care Professional Shortage Estimates for 84 Low- and Middle-Income Non-African Countries, 2015

(professionals per 1,000 population)

| | Country | Doc-tors | Nur-ses & Mid-wives | Total | Doctor Equiv-alents | 2015 Popu-lation (1000s) | In-come Grp | Re-gion |
|---|---|---|---|---|---|---|---|---|
| 1 | Nepal | 0.48 | 1.58 | 2.06 | 1.74 | 32,747 | low | SEARO |
| 2 | Djibouti | 0.47 | 1.54 | 2.01 | 1.70 | 930 | mid | EMRO |
| 3 | Yemen | 0.39 | 1.40 | 1.79 | 1.51 | 28,480 | low | EMRO |
| 4 | Papua New Guinea | 0.50 | 1.18 | 1.68 | 1.44 | 7,013 | low | WPRO |
| 5 | Haiti | 0.19 | 1.51 | 1.69 | 1.39 | 9,751 | low | PAHO |
| 6 | Solomon Islands | 0.46 | 1.12 | 1.57 | 1.35 | 596 | low | WPRO |
| 7 | Bangladesh | 0.20 | 1.31 | 1.50 | 1.24 | 168,200 | low | SEARO |
| 8 | Vanuatu | 0.50 | 0.74 | 1.24 | 1.09 | 252 | mid | WPRO |
| 9 | Sudan | 0.35 | 0.92 | 1.28 | 1.09 | 44,035 | low | EMRO |
| 10 | Samoa | 0.24 | 0.83 | 1.07 | 0.90 | 190 | mid | WPRO |
| 11 | Costa Rica | -0.37 | 1.09 | 0.71 | 0.50 | 4,983 | mid | PAHO |
| 12 | Indonesia | 0.30 | 0.20 | 0.49 | 0.46 | 246,800 | mid | SEARO |
| 13 | Fiji | 0.26 | 0.03 | 0.29 | 0.28 | 903 | mid | WPRO |
| 14 | Pakistan | -0.61 | 1.02 | 0.41 | 0.21 | 193,400 | low | EMRO |
| 15 | Saint Lucia | -0.77 | 1.10 | 0.33 | 0.11 | 174 | mid | PAHO |
| 16 | Vietnam | -0.32 | 0.52 | 0.20 | 0.10 | 95,029 | low | WPRO |
| 17 | India | -0.15 | 0.25 | 0.09 | 0.05 | 1,260,000 | low | SEARO |
| 18 | Bolivia | -0.31 | 0.18 | -0.14 | -0.17 | 10,854 | mid | PAHO |
| 19 | Tonga | 0.28 | -0.87 | -0.59 | -0.42 | 104 | mid | WPRO |
| 20 | Peru | -0.92 | 0.63 | -0.29 | -0.42 | 32,172 | mid | PAHO |
| 21 | Colombia | -1.27 | 0.67 | -0.60 | -0.74 | 52,086 | mid | PAHO |
| 22 | Belize | -0.74 | -0.06 | -0.79 | -0.78 | 321 | mid | PAHO |
| 23 | Ecuador | -1.10 | -0.12 | -1.22 | -1.20 | 15,144 | mid | PAHO |
| 24 | Mexico | -1.64 | 0.42 | -1.21 | -1.30 | 119,100 | mid | PAHO |
| 25 | Sri Lanka | -0.36 | -1.18 | -1.54 | -1.31 | 22,293 | mid | SEARO |
| 26 | Chile | -1.63 | -0.08 | -1.71 | -1.69 | 17,926 | mid | PAHO |
| 27 | Trinidad and Tobago | -0.36 | -1.69 | -2.05 | -1.71 | 1,338 | mid | PAHO |
| 28 | China | -1.47 | -0.34 | -1.80 | -1.74 | 1,393,000 | mid | WPRO |
| 29 | Nicaragua | -0.50 | -1.67 | -2.17 | -1.84 | 6,637 | mid | PAHO |
| 30 | Bosnia and Herzegovina | -0.49 | -1.70 | -2.19 | -1.85 | 3,893 | mid | EURO |
| 31 | Argentina | -2.45 | 0.55 | -1.90 | -2.01 | 42,676 | mid | PAHO |
| 32 | Grenada | -0.06 | -2.91 | -2.97 | -2.39 | 119 | mid | PAHO |
| 33 | Honduras | -0.97 | -1.79 | -2.76 | -2.40 | 8,780 | mid | PAHO |
| 34 | Albania | -0.77 | -2.10 | -2.87 | -2.45 | 3,325 | mid | EURO |
| 35 | Paraguay | -1.36 | -1.36 | -2.72 | -2.45 | 7,613 | mid | PAHO |
| 36 | Thailand | -0.06 | -2.99 | -3.05 | -2.45 | 69,064 | mid | SEARO |
| 37 | Morocco | -1.45 | -1.31 | -2.76 | -2.50 | 36,152 | mid | EMRO |
| 38 | Malaysia | -1.05 | -2.11 | -3.16 | -2.74 | 29,558 | mid | WPRO |
| 39 | Turkey | -1.68 | -1.54 | -3.22 | -2.91 | 82,640 | mid | EURO |
| 40 | Venezuela (Bolivarian Republic of) | -2.81 | -0.13 | -2.95 | -2.92 | 31,330 | mid | PAHO |
| 41 | Tajikistan | -1.17 | -2.64 | -3.81 | -3.28 | 7,605 | low | EURO |
| 42 | Mongolia | -2.07 | -1.70 | -3.77 | -3.43 | 2,988 | low | WPRO |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 43 | Romania | -1.52 | -2.76 | -4.28 | -3.73 | 20,871 | mid | EURO |
| 44 | El Salvador | -2.68 | -1.50 | -4.18 | -3.88 | 8,017 | mid | PAHO |
| 45 | Latvia | -1.85 | -2.64 | -4.49 | -3.96 | 2,191 | mid | EURO |
| 46 | Barbados | -1.11 | -3.61 | -4.71 | -3.99 | 276 | mid | PAHO |
| 47 | Ukraine | -1.30 | -3.36 | -4.66 | -3.99 | 41,849 | mid | EURO |
| 48 | Armenia | -2.31 | -2.11 | -4.42 | -3.99 | 2,970 | mid | EURO |
| 49 | Tunisia | -1.66 | -3.00 | -4.66 | -4.06 | 11,140 | mid | EMRO |
| 50 | Cambodia | -0.61 | -4.56 | -5.17 | -4.26 | 17,066 | low | WPRO |
| 51 | Iran (Islamic Republic of) | -2.25 | -2.71 | -4.96 | -4.42 | 79,917 | mid | EMRO |
| 52 | Poland | -1.77 | -3.40 | -5.16 | -4.48 | 38,110 | mid | EURO |
| 53 | Dominica | -0.27 | -5.27 | -5.54 | -4.49 | 87 | mid | PAHO |
| 54 | Guyana | -0.73 | -4.71 | -5.44 | -4.50 | 742 | mid | PAHO |
| 55 | The former Yugoslav Republic of Macedonia | -1.51 | -3.82 | -5.33 | -4.56 | 2,055 | mid | EURO |
| 56 | Syrian Arab Republic | -2.25 | -3.02 | -5.27 | -4.67 | 23,802 | mid | EMRO |
| 57 | Kazakhstan | -2.14 | -3.23 | -5.37 | -4.72 | 14,877 | mid | EURO |
| 58 | Turkmenistan | -1.98 | -3.93 | -5.91 | -5.13 | 5,498 | mid | EURO |
| 59 | Panama | -2.14 | -3.90 | -6.05 | -5.26 | 3,774 | mid | PAHO |
| 60 | Jordan | -2.75 | -3.54 | -6.29 | -5.58 | 6,956 | mid | EMRO |
| 61 | Georgia | -3.79 | -2.26 | -6.05 | -5.60 | 4,183 | mid | EURO |
| 62 | Slovakia | -2.27 | -4.51 | -6.78 | -5.88 | 5,385 | mid | EURO |
| 63 | Oman | -2.05 | -5.17 | -7.22 | -6.19 | 3,173 | mid | EMRO |
| 64 | Estonia | -2.61 | -4.51 | -7.11 | -6.21 | 1,292 | mid | EURO |
| 65 | Uruguay | -5.51 | -0.88 | -6.39 | -6.22 | 3,676 | mid | PAHO |
| 66 | Bulgaria | -3.70 | -3.27 | -6.98 | -6.32 | 7,156 | mid | EURO |
| 67 | Republic of Moldova | -2.30 | -5.08 | -7.38 | -6.36 | 4,114 | mid | EURO |
| 68 | Croatia | -2.53 | -5.05 | -7.57 | -6.56 | 4,454 | mid | EURO |
| 69 | Azerbaijan | -2.50 | -5.39 | -7.89 | -6.82 | 9,083 | mid | EURO |
| 70 | Lebanon | -6.15 | -2.39 | -8.54 | -8.06 | 3,965 | mid | EMRO |
| 71 | Uzbekistan | -1.92 | -7.81 | -9.73 | -8.17 | 30,651 | low | EURO |
| 72 | Jamaica | -3.06 | -7.03 | -10.10 | -8.69 | 2,748 | mid | PAHO |
| 73 | Lithuania | -3.65 | -6.67 | -10.32 | -8.99 | 3,288 | mid | EURO |
| 74 | Saint Vincent and the Grenadines | -2.66 | -8.44 | -11.10 | -9.42 | 124 | mid | PAHO |
| 75 | Hungary | -3.08 | -8.14 | -11.22 | -9.59 | 9,802 | mid | EURO |
| 76 | Russian Federation | -3.90 | -7.18 | -11.07 | -9.64 | 136,700 | mid | EURO |
| 77 | Egypt | -2.77 | -10.94 | -13.71 | -11.52 | 88,175 | mid | EMRO |
| 78 | Brazil | -2.93 | -11.24 | -14.17 | -11.92 | 209,400 | mid | PAHO |
| 79 | Dominican Republic | -6.20 | -8.11 | -14.30 | -12.68 | 10,124 | mid | PAHO |
| 80 | Guatemala | -2.44 | -13.30 | -15.73 | -13.07 | 15,869 | mid | PAHO |
| 81 | Czech Republic | -4.06 | -11.62 | -15.68 | -13.36 | 10,066 | mid | EURO |
| 82 | Belarus | -5.78 | -15.17 | -20.95 | -17.91 | 9,218 | mid | EURO |
| 83 | Saint Kitts and Nevis | -3.98 | -19.50 | -23.48 | -19.58 | 47 | mid | PAHO |
| 84 | Philippines | -6.89 | -25.41 | -32.30 | -27.22 | 96,840 | mid | WPRO |

Sources: Authors' analysis, Scheffler et al. (2008), WHO Global Atlas of the Health Workforce (Mar. 1, 2007), United Nations Population Division

Notes: A positive number of workers per 1,000 population represents a shortage, and a negative number represents a surplus. The number of doctor equivalents is equal to the number of doctors plus 0.8 times the number of nurses and midwives. Numbers may not add to total because of rounding.

A sample calculation using Nepal, the first country in the exhibit, follows. We assumed the need to be 0.55 doctors and 1.73 nurses and midwives per 1,000 population. We estimated Nepal's supply of doctors in 2015 would be 0.07 per 1,000 population, resulting in a shortage of 0.48 doctors per 1,000 population. We estimated its supply of nurses and midwives would be 0.15 per 1,000 population, resulting in a shortage of 1.58 nurses and midwives per 1,000 population. This results in a total shortage of 2.06 health care professionals per 1,000 population, or a doctor-equivalent shortage of 1.74 health workers per 1,000 population. The 1.74 doctor-equivalent shortage per 1,000 population is equal to the 0.48 doctor shortage plus 0.8 times the 1.58 nurse-and-midwife shortage, because one nurse or midwife was assumed to equal 0.8 doctors.

WHO Country Income-Level Abbreviations
low: Low-income country
mid: Middle-income country
high: High-income country

WHO Region Abbreviations
SEARO: Southeast Asian Region
WPRO: West Pacific Region
EMRO: Eastern Mediterranean Region
EURO: European Region
PAHO: Pan American Health Organization Region

**Exhibit 3: Doctor and Nurse Annual Wages (in 2007 U.S. Dollars) for 12 Countries with Projected Health Care Professional Shortages, 2015**

| | Country | Doctor | Nurse |
|---|---|---|---|
| 1 | Nepal | 1,946* | 1,105* |
| 2 | Djibouti | 37,622 | 13,929 |
| 3 | Yemen | 3,543* | 2,000* |
| 4 | Papua New Guinea | 20,773 | 5,807 |
| 5 | Haiti | 2,525* | 1,430* |
| 6 | Solomon Islands | 3,213* | 1,815* |
| 7 | Bangladesh | 1,930 | 1,420 |
| 8 | Vanuatu | 5,802* | 3,258* |
| 9 | Sudan | 9,659 | 8,794 |
| 10 | Samoa | 18,466 | 11,819 |
| 11 | Indonesia | 5,400* | 3,035* |
| 12 | Fiji | 17,481 | 8,065 |
| | mean | 10,696 | 5,206 |

Sources: Authors’ analysis and OWW database

*Indicates wage was estimated by a regression model that included each country’s per capita income.

**Exhibit 4: Annual Wage Bill Estimates for Health Care Professional Need, Supply, and Shortage for 12 Countries with Projected Health Care Professional Shortages, 2015 (in millions $US 2007)**

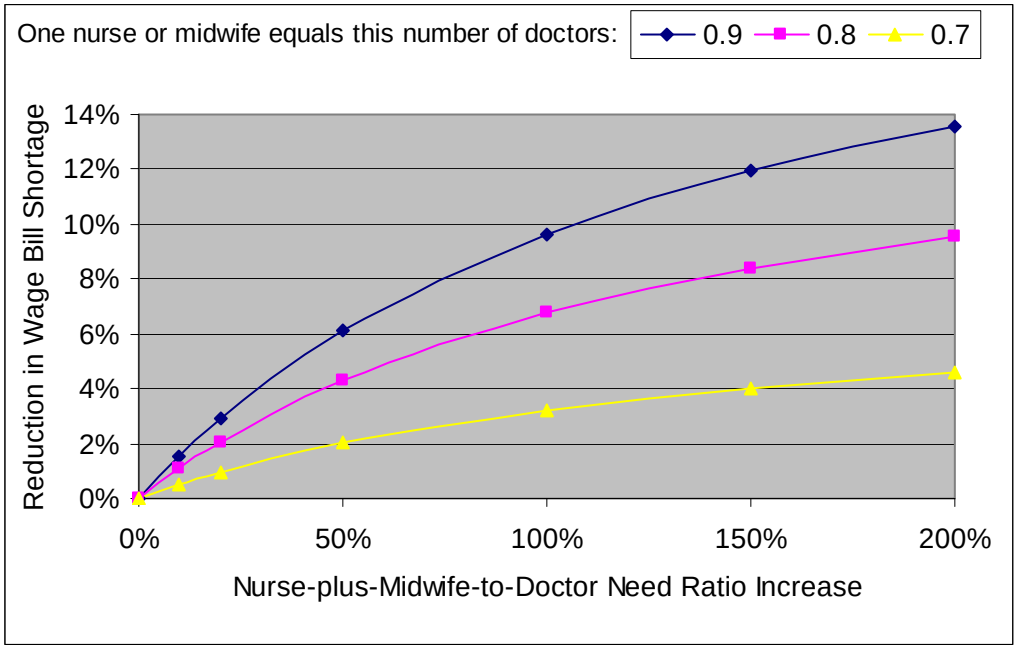
| | Country | Need | Supply | Shortage (all worker types) | | Shortage (doctors) | Shortage (nurses & midwives) |
|---|---|---|---|---|---|---|---|
| 1 | Nepal | 98 | 10 | 88 | | 31 | 57 |
| 2 | Djibouti | 42 | 5 | 36 | | 16 | 20 |
| 3 | Yemen | 154 | 35 | 119 | | 39 | 80 |
| 4 | Papua New Guinea | 150 | 30 | 121 | | 72 | 48 |
| 5 | Haiti | 38 | 12 | 26 | | 5 | 21 |
| 6 | Solomon Islands | 3 | 1 | 2 | | 1 | 1 |
| 7 | Bangladesh | 592 | 215 | 376 | | 64 | 312 |
| 8 | Vanuatu | 2 | 1 | 1 | | 1 | 1 |
| 9 | Sudan | 904 | 396 | 507 | | 151 | 357 |
| 10 | Samoa | 6 | 3 | 3 | | 1 | 2 |
| 11 | Indonesia | 2,028 | 1,484 | 544 | | 396 | 148 |
| 12 | Fiji | 21 | 17 | 4 | | 4 | 0 |
| | Total | 4,037 | 2,210 | 1,827 | | 781 | 1,046 |

Sources: Authors' analysis, Scheffler et al. (2008), WHO Global Atlas of the Health Workforce (Mar. 1, 2007), United Nations Population Division, and OWW database

Notes: Positive dollar amounts represent millions of dollars required to pay the wage bill. The total estimated annual wage bill for the needed and supplied doctors, nurses, and midwives is $4,037 million and $2,210 million, respectively, resulting in a shortage of $1,827 million. This shortage is composed of $781 million for doctors and $1,046 million for nurses and midwives.

Numbers may not add to total because of rounding.

**Exhibit 5: Summary of Estimated Reduction in Annual Wage Bill Shortage from Increasing the Nurse-plus-Midwife-to-Doctor Need Ratio for Different Nurse-and-Midwife-to-Doctor Productivity Equivalencies, 2015**




Sources: Authors' analysis, Scheffler et al. (2008), WHO Global Atlas of the Health Workforce (Mar. 1, 2007), United Nations Population Division, and OWW database

Note: This exhibit shows the percent reduction in the $1.8 billion annual wage bill shortage in the 12 low- and middle-income non-African countries (see vertical axis) from increasing the nurse-plus-midwife-to-doctor need ratio by different percentages (see horizontal axis), holding each country's needed number of doctor-equivalent units constant. This is done for three scenarios by assuming a nurse or midwife was equal to either 0.7, 0.8, or 0.9 doctors (see three curved lines within exhibit).

**Exhibit 6: Estimated Reduction in Annual Wage Bill Shortage from Increasing the Nurse-plus-Midwife-to-Doctor Need Ratio by 50%, 2015**

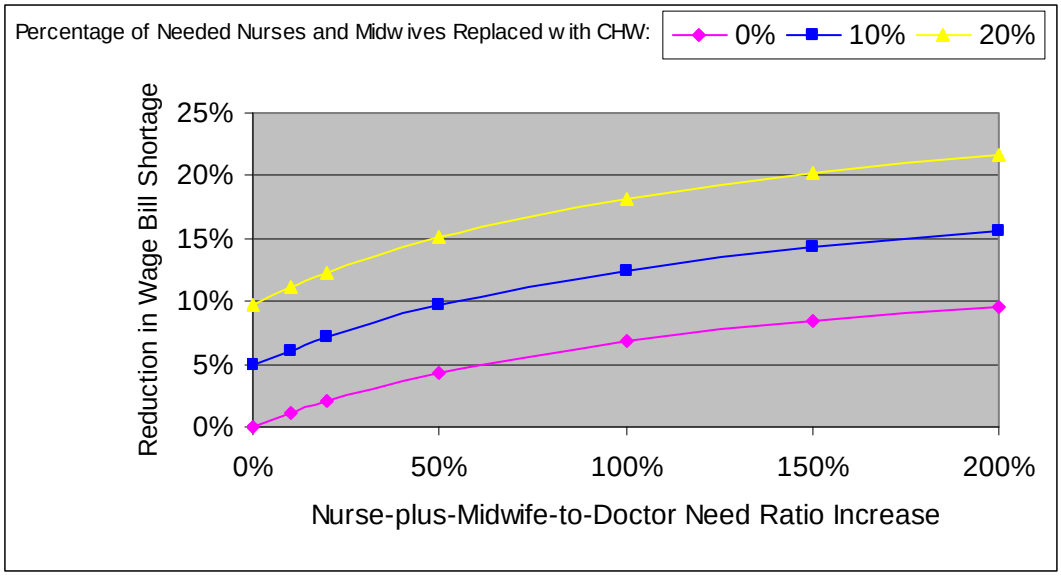
| | Country | Original Annual Wage Bill (in millions $US 2007) | Reduction in Wage Bill Shortage |
|---|---|---|---|
| 1 | Nepal | 88 | 3.1% |
| 2 | Djibouti | 36 | 7.5% |
| 3 | Yemen | 119 | 3.6% |
| 4 | Papua New Guinea | 121 | 11.4% |
| 5 | Haiti | 26 | 4.1% |
| 6 | Solomon Islands | 2 | 3.9% |
| 7 | Bangladesh | 376 | 1.0% |
| 8 | Vanuatu | 1 | 4.7% |
| 9 | Sudan | 507 | -1.7%* |
| 10 | Samoa | 3 | 3.8% |
| 11 | Indonesia | 544 | 10.5% |
| 12 | Fiji | 4 | 22.4% |
| | Total | 1,827 | 4.3% |

Sources: Authors' analysis, Scheffler et al. (2008), WHO Global Atlas of the Health Workforce (Mar. 1, 2007), United Nations Population Division, and OWW database

*Sudan had a negative reduction because the nurse wage was greater than 0.8 of a doctor's wage.

Note: This exhibit shows each country's percent reduction in its annual wage bill shortage from increasing the nurse-plus-midwife-to-doctor need ratio by 50 percent, holding the needed number of doctor-equivalent units constant. A nurse or midwife is assumed to equal 0.8 doctors. For example, if Nepal were to increase its nurse-plus-midwife-to-doctor need ratio by 50 percent, the wage bill required to eliminate the workforce shortage would decrease from $87.7 million to $85.0 million, or 3.1 percent. For all 12 countries, the wage bill required to eliminate the workforce shortage would decrease from $1,827 million to $1,749 million, or 4.3 percent.

**Exhibit 7: Summary of Estimated Reduction in Annual Wage Bill Shortage from Increasing the Nurse-plus-Midwife-to-Doctor Need Ratio for Replacing Different Percentages of the Needed Nurse and Midwife Workforce with Community Health Workers, 2015**




Sources: Authors' analysis, Scheffler et al. (2008), WHO Global Atlas of the Health Workforce (Mar. 1, 2007), United Nations Population Division, and OWW database

Note: This exhibit shows the percent reduction in the $1.8 billion annual wage bill shortage in the 12 low- and middle-income non-African countries (see vertical axis) by substituting CHWs for needed nurses and midwives for three workforce mix scenarios, all of which increased the number of needed nurses and midwives relative to needed doctors (see horizontal axis), holding each country's needed number of doctor-equivalent units constant. For each scenario, a nurse's or midwife's productivity is assumed to equal 0.8 doctors. In the first, or baseline, scenario, no nurses and midwives are replaced with CHWs (see lower curve). In the second and third scenarios, 10 percent and 20 percent, respectively, of the needed nurses and midwives are replaced with CHWs. These scenarios are represented by the middle and upper curves in the exhibit, respectively. For these latter two scenarios, a CHW's productivity is assumed to equal 0.3 nurses or midwives, and a CHW's wage is assumed to be 0.2 of a nurse's or midwife's.

## Endnotes

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