Hypertension Treatment Rates and Health Care Worker Density

An Analysis of Worldwide Data

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Abstract—Elevated blood pressure is the leading cause of death worldwide; however, treatment and control rates for hypertension are low. Here, we analyze the relationship between physician and nurse density and hypertension treatment rates worldwide. Data on hypertension treatment rates were collected from the STEPwise approach to Surveillance country reports, individual studies resulting from a PubMed search for articles published between 1990 and 2010, and manual search of the reference lists of extracted studies. Data on health care worker density were obtained from the Global Atlas of the Health Workforce. We controlled for a variety of variables related to population characteristics and access to health care, data obtained from the World Bank, World Development Indicators, United Nations, and World Health Organization. We used clustering of SEs at the country level. Full data were available for 154 hypertension treatment rate values representing 68 countries between 1990 and 2010. Hypertension treatment rate ranged from 3.4% to 82.5%, with higher treatment rates associated with higher income classification. Physician and nurse/midwife generally increased with income classification. Total healthcare worker density was significantly associated with hypertension treatment rate in the unadjusted model ($P<0.001$); however, only nurse density remained significant in the fully adjusted model ($P=0.050$). These analyses suggest that nurse density, not physician density, explains most of the relationship with hypertension treatment rate and remains significant even after adjusting for other independent variables. These results have important implications for health policy, health system design, and program implementation. **(*Hypertension*. 2019;73:594-601. DOI: 10.1161/HYPERTENSIONAHA.118.11995.)** • **Online Data Supplement**

Key Words: blood pressure ■ cardiovascular disease ■ health workforce ■ hypertension ■ nurses

The burden of cardiovascular disease (CVD) continues to rise globally, and its increase is not isolated to countries of particular income levels, geographic regions, or social conditions.[1] Elevated blood pressure, a major risk factor for CVD,[2,3] is the leading cause of death worldwide.[4] Treatment for hypertension is well identified and effective.[5] The challenge, however, is that treatment and control rates are low worldwide.[6,7] Institutional and economic barriers to getting treatment to the individuals who need it are complex, and whereas some are shared across countries, others vary with institutional aspects of healthcare delivery and health insurance status across countries.[8,9]

One factor that may affect hypertension treatment rates is the density of the healthcare workforce—specifically physicians and nurses—within a country. Healthcare worker density has been shown to be favorably associated with vaccination rates[10] and overall disability-adjusted life-years (DALYs).[11] In addition, the relationship between healthcare worker density and maternal, infant, and child mortality has been studied, with no clear consensus on the relationship between healthcare worker density and health outcomes. More recent studies indicate that healthcare worker density is associated with improved health outcomes,[12–14] whereas other older studies have demonstrated either neutral[15,16] or negative associations.[17]

Although there has been more recent interest in investigating the relationship between healthcare worker density and noncommunicable disease (NCD; including CVD and hypertension) outcomes, there is no consensus on the direction or strength of the relationship. An analysis of the relationship between healthcare worker density (including physicians, nurses, and others) and CVD outcomes reported that a univariate analysis revealed that healthcare worker density is associated with better CVD outcomes, although a multivariable analysis yielded the opposite relationship.[18] Another study reported no significant relationship between physician density and medical guideline adherence (including for CVD) in Germany.[19]

Current estimates of global healthcare worker shortages have largely not taken into account the human resource requirements for managing NCDs. In particular, the relationship between healthcare worker density and hypertension treatment rates is unknown. Recognizing this gap in the

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literature, and recognizing the growing importance of CVD, in this study, we analyze the relationship between physician and nurse/midwife density and hypertension treatment rates, across countries of all World Bank income classifications.[20]

Methods

All data were extracted from publicly available databases and publicly accessible publications. Analytic methods will be made available to researchers on formal request to the authors.

Choice of Variables

Our dependent variable was hypertension treatment rate, defined as the percentage of hypertensive individuals on treatment. Hypertension was defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg or self-reported current use of blood pressure–lowering medication. Hypertension treatment was defined as self-reported current use of antihypertensive medication.

We used 3 measures of healthcare worker density. First, an aggregate measure was derived by summing physician and nurse/midwife density per 1000 population. We also disaggregated physician and nurse densities. We limited our analysis to these cadres of healthcare workers because most hypertension management, treatment decisions, and prescription issuances are completed by physicians or nurses.[21,22]

To account for differences in population characteristics and access to health care across countries, we adjusted for the following country-level variables: gross domestic product (GDP) per capita, purchasing power parity (current international $), private health expenditure (% of GDP), land area, population, hospital beds, rural access to an improved water source (% of rural population with access), and DALY estimates for 2004. Purchasing power parity–adjusted GDP per capita was used as a measure of the general level of resources available in the country. Access to an improved water source (% of rural population with access) was also included as a measure of access to resources and poverty. Private health expenditure as percentage of GDP was included as a measure of private health expense burden. Land area likely impacts the geographic density of healthcare workers, as well as the distance from patients to healthcare worker; therefore, it was included as it potentially influences treatment rates. Hospital beds per 1000 population were included as an indicator of health system resource availability. DALYs for infectious and parasitic diseases (per 100 000 population, age-standardized, 2004 estimates) were used to control for the potential impact of morbidity from communicable diseases.

Data Sources

Data on hypertension treatment rates were collected from the World Health Organization (WHO) STEPwise approach to Surveillance country reports,[23] individual studies resulting from a PubMed search for articles published between 1990 and 2010 using the key words "prevalence AND awareness AND treatment AND control AND (hypertension OR high blood pressure)" and a manual search of the reference lists from the extracted studies (the full list of references is provided in the Appendix as an online-only Data Supplement). A study was included if it contained information on country-specific hypertension treatment rate. The WHO STEPwise approach to Surveillance data were obtained from surveys that follow a standardized framework for collecting, analyzing, and reporting data on NCD risk factors in WHO member countries.[23]

Data on healthcare worker density (physicians and nurses) were obtained from the WHO Global Atlas of the Health Workforce.[24] Data for the other independent variables were obtained from the following sources: the World Development Indicators for GDP per person in international dollars at purchasing power parity ($), private health expenditure as a percentage of GDP, land area, hospital beds per 1000 population, and access to an improved water source (% of rural population);[25] the United Nations' World Population Prospects: The 2010 Revision for population estimates;[26] and the WHO database for DALYs for infectious and parasitic diseases (per 100 000 population, age-standardized).[27]

The dataset for our analysis was constructed by matching the country and year of our dependent and independent variables, within a ±5-year window around the year of the hypertension treatment rate data. The DALYs data were obtained from the 2004 WHO estimates and thus did not conform to the ±5-year criterion because of data availability limitation. World Bank income classification for each country was aligned with the year of hypertension treatment rate data for that country. In total, our dataset included 154 observations, representing 68 countries over the period 1990 to 2010.

Statistical Procedures

To compare data from the STEPwise approach to Surveillance reports and individual studies collected from our PubMed search, we defined treatment of hypertension as self-reported current use of antihypertensive medication. To create our dependent variable, the rate of hypertension treatment, the number of people reporting hypertension treatment was divided by the total number of study participants with hypertension.

All regressions were estimated using a logistic-logarithmic functional form, similar to the analytic approach previously utilized to assess the relationship between healthcare worker density and vaccination coverage.[10] The logistic form of the dependent variable reflects the boundedness of hypertension treatment rate between 0% and 100%, which in turn prevents predicted values from falling <0% or >100%. The logarithmic form of the independent variables allows for the following interpretation of their estimated coefficients (β): a 1% increase in the independent variable corresponds to a β% change in the sum of the percentage increase in the level of the dependent variable and the percentage reduction in the shortfall from the upper bound of 100%.[10,12] One exception to this is the "access to an improved water source" variable, for which a logit transformation was performed, as the variable is a proportion and is bounded by 0 and 1. All regressions used clustering of SEs at the country level to control for possible correlation of error terms within countries.

We report the results of 3 regression analyses with hypertension treatment rate as the dependent variable, while controlling for GDP per capita, purchasing power parity (current international $), health expenditure, private (% of GDP), land area, population, hospital beds, access to an improved water source, rural (% of rural population with access), and DALYs estimates for 2004. In the first analysis, hypertension treatment rate was regressed against aggregate combined physician and nurse density. In the second analysis, separate models were used to regress hypertension treatment rate against physician and nurse densities, respectively. In the third analysis, hypertension treatment rate was regressed against disaggregate physician and nurse densities in a single model. We formally tested for interaction by World Bank income classification category. We also conducted sensitivity analyses by performing separate regressions for the studies between 1990 and 1999 and 2000 and 2010, as well as separate regressions for studies conducted in each of the World Bank income classification categories. Stata version 11.0 was used to perform the analyses.

Results

Hypertension treatment data were obtained from 28 WHO STEPwise approach to Surveillance reports and 41 individual studies. Healthcare worker density and treatment data were available from 174 country and treatment data combinations, spanning 84 countries and all World Bank income classification categories. However, full data, including all independent variables, were available for 154 of these, representing 68 countries, over the period 1990 to 2010 (Table 1).

Hypertension treatment rate ranged from 3.4% to 82.5% (Table 2). Mean hypertension treatment rate was 34.5% overall, with higher mean treatment rates observed as income classification increased from low to high income. Physician

Table 1. Country-Years and Number of Observations by Country Income Classification

Country	No. of Studies	Years of Treatment Data
High income (n=65)		
Australia	1	1994
Belgium	1	1992
Canada	5	1992, 1995, 2002, 2009 (2)
Czech Republic	1	2008
Denmark	3	1992, 1998, 2004
Finland	4	1992 (3), 2005
France	2	1998, 2006
Germany	6	1992, 1995 (3), 2001 (2)
Greece	6	1997, 1998, 2001 (2), 2002, 2004
Italy	2	1994 (2)
Japan	1	1995
Korea, Republic	2	2001 (2)
Kuwait	1	2008
Netherlands	3	2003, 2004 (2)
New Zealand	1	1994
Portugal	2	2003 (2)
Saudi Arabia	1	2005
Spain	3	1990, 1996, 2004
Sweden	3	1994, 1996
Switzerland	1	1993
United Kingdom	8	1995, 1998 (2), 2003 (4), 2006,
United States	7	1990, 1994, 2000 (2), 2003, 2004, 2005
United Arab Emirates	1	2009
Upper-middle income (n=26)		
Argentina	1	2009
Barbados	1	1996
Botswana	1	2007
Brazil	1	2009
Chile	3	2004 (2)
China	1	2010
Colombia	1	2009
Czech Republic	3	2001 (3)
Gabon	1	2003
Iran, Islamic Republic	1	2009
Korea, Republic	1	2000
Lebanon	1	2008
Malaysia	4	1996 (2), 2004
Mexico	3	1993, 2000, 2002
Romania	1	2005

(*Continued*)

Table 1. Continued

Country	No. of Studies	Years of Treatment Data
St Lucia	1	1996
Turkey	1	2009
Lower-middle income (n=30)		
China	8	1999, 2001 (4), 2002 (2), 2009
Egypt, Arab Republic	1	2005
Fiji	1	2002
Iran, Islamic Republic	1	2005
Iraq	2	2003, 2006
Maldives	1	2004
Mongolia	1	2009
Russian Federation	2	2005 (2)
Thailand	2	2003, 2004
Tunisia	1	2001
Turkey	4	1995, 1999, 2003 (2)
Venezuela, Bolivarian Republic	1	1996
India	3	2007 (2), 2009
Pakistan	1	2009
Micronesia	1	2002
Low income (n=33)		
Bangladesh	1	2009
Benin	1	2007
Cambodia	1	2010
Cameroon	1	2004
China	3	1993, 1994, 1998
Egypt, Arab Republic	1	1991
Eritrea	1	2004
Ghana	5	2001, 2002, 2004 (3)
India	6	1999, 2000, 2002 (2), 2004, 2005
Lao People's Democratic Republic	1	2008
Madagascar	1	2005
Malawi	1	2009
Mauritania	1	2007
Mongolia	1	2006
Mozambique	1	2005
Nepal	2	2003, 2005
Nigeria	1	2003
Sierra Leone	1	2009
Solomon Islands	1	2006
Vietnam	1	2008
Zambia	1	2008

Numbers in parentheses represent the number of studies from that country in that particular year.

Table 2. Summary Statistics of Published Hypertension Treatment Rate and Health Care Worker Density Data (Per 1000 Population) by Country Income Classification

Variable	Mean	SD	Minimum	Maximum
High income (n=65)				
Treatment rate	38.9	18.3	11.1	82.5
Aggregate physician and nurse density	11.46	3.01	3.50	18.41
Physician density	3.03	0.92	1.37	4.91
Nurse density	8.43	3.01	1.93	14.41
Upper-middle income (n=26)				
Treatment rate	35.2	20.2	10.7	79.5
Aggregate physician and nurse density	4.69	3.29	1.72	12.41
Physician density	1.86	1.36	0.29	6.42
Nurse density	2.83	2.59	0.48	8.94
Lower-middle income (n=30)				
Treatment rate	30.9	16.2	3.4	69.5
Aggregate physician and nurse density	3.56	2.80	1.16	12.79
Physician density	1.36	0.98	0.30	4.26
Nurse density	2.20	1.93	0.38	8.53
Low income (n=33)				
Treatment rate	28.5	16.6	5.7	74.2
Aggregate physician and nurse density	1.58	1.32	0.19	6.26
Physician density	0.53	0.67	0.02	2.76
Nurse density	1.04	0.73	0.17	3.50
Overall (n=154)				
Treatment rate	34.5	18.2	3.4	82.5
Aggregate physician and nurse density	6.66	5.03	0.19	18.41
Physician density	1.97	1.39	0.02	6.42
Nurse density	4.69	4.04	0.17	14.41

and nurse density varied widely but generally increased as income classification increased.

As total healthcare worker density (physician and nurse) increased, hypertension treatment rates generally tended to increase as well, although there was notable variation in the scatterplot (Figure in the online-only Data Supplement). Total healthcare worker density was significantly associated with hypertension treatment rate in the unadjusted model and nearly significant at the 0.05 level in the fully adjusted model (Table 3). In the separate regressions, both physician and nurse density were significantly associated with hypertension treatment rate in the unadjusted model; however, only nurse density remained significant in the fully adjusted model (Table 3; Figure). In the disaggregated model, only nurse density was significantly associated with hypertension treatment rate, in both the adjusted and unadjusted models. Taken together, these analyses suggest that nurse density, not physician density, explains most of the relationship between healthcare worker density and hypertension treatment rate. This relationship remains significant even after adjusting for

Table 3. Logistic-Logarithmic Regression Results

Model	Unadjusted (N=154)		Adjusted (N=154)	
	β (CI)	*P* Value	β (CI)	*P* Value
Total density (aggregate physician and nurse density)	0.27 (0.13 to 0.41)	<0.001	0.33 (−0.10 to 0.76)	0.133
Physician density (disaggregate)	0.03 (-0.15 to 0.20)	0.740	−0.07 (−0.41 to 0.27)	0.678
Nurse (disaggregate)	0.22 (0.04 to 0.42)	0.020	0.30 (0.00 to 0.60)	0.050
Physician density (separate regression)	0.18 (0.06 to 0.30)	0.004	−0.03 (−0.36 to 0.30)	0.849
Nurse density (separate regression)	0.25 (0.12 to 0.38)	<0.001	0.29 (−0.01 to 0.58)	0.055

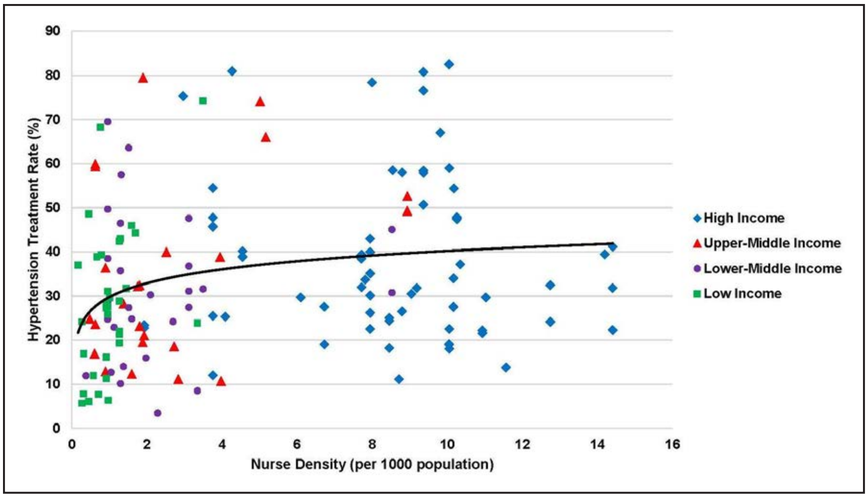

Figure. Relationship between nurse density and hypertension treatment rates worldwide, with countries of different income classification indicated. Solid curve is derived from the fully adjusted model.

all of the other independent variables listed above. Full multivariable regression results for all 4 models are presented in the Table in the online-only Data Supplement.

Sensitivity analyses for year of publication suggested that studies conducted between 2000 and 2010, as compared to those conducted between 1990 and 1999, yielded results consistent with the overall results presented above, although it is difficult to arrive at a definitive conclusion because of small numbers. Similarly, low- and lower-middle-income countries seemed to have nurse density-hypertension treatment rate relationships that were consistent with the overall results, but the small numbers in the stratified analyses restrict any definitive conclusion (Table in the online-only Data Supplement).

Discussion

In our worldwide econometric analysis of the relationship between hypertension treatment rates and healthcare worker density, we report that hypertension treatment rates vary widely, healthcare worker density rates also vary widely, and healthcare worker density was significantly associated with hypertension treatment. Notably, our approach of aggregating and disaggregating physicians and nurses allowed us to highlight that nurse density, not physician density, seems to explain most of the relationship between healthcare worker density and hypertension treatment rate. The relationship between nurse density and hypertension treatment rate remained statistically significant after adjusting for several potential confounder variables.

The relationship between healthcare worker density and NCDs has not been well studied, and examples from the literature are limited.[28] In fact, to the best of our knowledge, this is the first report examining the relationship between healthcare worker density and hypertension treatment rates using worldwide data. Given the health workforce shortage worldwide, this is an important first step in the ultimate goal of aligning disease burden with human resources for health.

One notable finding from our study is that nurse density, not physician density, was more strongly associated with hypertension treatment rate. This is striking because, in many parts of the world, only physicians and clinicians, not nurses, are authorized to prescribe antihypertensive medications.[29] The nurse's role in hypertension care, in contrast, has generally been limited to enhancing self-management strategies by educating and counseling the patient about medication adherence and lifestyle modification.[30,31] It is possible, however, that even in countries or regions that do not allow nurses to treat hypertension directly, the availability of nurses to work with physicians may enable physicians to shift other responsibilities, which may allow them to focus more time and effort on hypertension management, thus contributing to higher hypertension treatment rates. It is also possible that the presence of other cadres of health worker, such as pharmacists, could be confounding the observed results. Unfortunately, data on pharmacist density were not as routinely available as physician or nurse density. Therefore, this potential hypothesis was not able to be tested.

The relationship between healthcare worker density and health outcomes has been characterized by conflicting results in previous literature. An inherent challenge is that, although healthcare worker density may have favorable impacts on healthcare delivery measures, health outcomes per se may be affected by many other factors beyond care delivery alone. For instance, control of hypertension is also impacted by drug supply,[29,32] medication adherence,[33] lifestyle factors,[34] and a variety of socioeconomic factors.[35] Hence, in this study, we limited our analysis to hypertension treatment rates (care delivery measure) rather than hypertension control rates (health outcome measure).

Given the inclusion of NCDs in the Sustainable Development Goals,[36] healthcare worker requirements need to also take into account human resources for health needed to manage hypertension and other NCDs. Healthcare workers are a critical component of the healthcare delivery process that can promote population health, and the supply of health professionals worldwide has been highlighted as a significant problem.[37] In addition, other cadres of health worker, such as community health workers, can also positively impact outcomes for hypertension and other NCDs.[38,39] On balance, our results support the strategy of task redistribution to meet the human resource challenge of management of NCDs including hypertension. Task redistribution, in which specific tasks are reorganized and dispersed among healthcare workers with different duration of training and different qualifications, can allow for more efficient use of available human resources for health.[40,41] Nonphysicians have been effective in hypertension management in low- and middle-income countries.[42–46] Given the growing global need for hypertension and NCD management, dissemination and evaluation of task redistribution strategies are urgently required.

Indeed, the WHO Global Strategy for human resources for health indicates that the supply of healthcare workers needs to match health needs and priorities, including the increasing burden of NCDs.[47] Given that hypertension and other NCDs are chronic conditions that require longitudinal care, repeated contact with the health system, and interaction between patients and health workers, it is critical that governments, health systems, and health facilities account for NCD-related health workforce requirements in their planning and implementation processes.[48] The most recent health workforce requirements calculated by the WHO do in fact include NCDs, such as hypertension, but the empirical basis for these requirements related to NCDs is weak. Our study, therefore, helps to fill that empirical gap, and we anticipate that our results will further inform the policy, planning, and health system development tasks of the global health community.

One limitation of our study is that, by utilizing a single regression analysis across the entire pooled dataset, we assumed that the relationship between healthcare worker density and hypertension treatment rate was the same across countries and over time. The sensitivity analyses we conducted were aimed at evaluating whether there were differences by date of study or income category classification, but the resulting smaller sample sizes did not allow for a definitive conclusion. Thus, although it is possible that this assumption may not hold across all healthcare worker density-treatment dyads, we feel that our contribution is an important first step to incorporate hypertension and other NCDs into healthcare worker requirements worldwide. Similarly, it is possible that high- versus low-quality studies could yield different results. Although this was beyond the scope of this article, future research in this area can consider including quality grading in the selection of study data. Second, we acknowledge that, by focusing only on hypertension treatment rates, we do not take into consideration all of the other tasks that healthcare workers perform (eg, vaccinations, antenatal care, care for other disease entities). The WHO has recently advocated for the use of a more integrated index of services required to meet the Sustainable Development Goals, and future efforts will benefit from that type of approach. Third, health workforce density is only one component that contributes to overall healthcare worker performance; other important components include accessibility, acceptability, and quality of care.[49] In addition, nurse density may reflect better access to health care in general, thus the interpretation of our results requires some caution. Fourth, we were not able to use pharmacist density data because the data were not as routinely available as physician or nurse density. Given the importance of pharmacists in the dispensing of hypertension medications in many parts of the world, future research in this area should include pharmacist density as the data become more routinely available. Fifth, our analytic model aggregated all variables to the country level; therefore, individual-level variables impacting hypertension treatment rates (eg, individual socioeconomic status, access to care) were not evaluated. Relatedly, we pursued an analytic approach analogous to one previously utilized to assess the relationship between healthcare worker density and vaccination coverage.[10] We recognize that this is not the only way to analyze this relationship, and alternative models and approaches can be adopted.

Perspectives

Our results support the strategy of task redistribution to meet the human resource challenge of management of NCDs, including hypertension. Given the growing global need for hypertension and NCD management, our results have important implications for health policy, health system design, and program implementation. Future research assessing dissemination and evaluation of task redistribution strategies is urgently required. Investigating the relationship between health worker performance and other health outcomes will also be critical.

Conclusions

In this worldwide econometric analysis, we found that healthcare worker density was significantly associated with hypertension treatment. Notably, we found that that nurse density, not physician density, seemed to explain most of the relationship with hypertension treatment rate, after adjusting for several potential confounder variables. Our study contributes to the literature on cross-country analyses of healthcare worker density and treatment outcomes. Given the growing burden of CVD, hypertension, and other NCDs, these results have important implications for health policy, health system design, and program implementation. Future research assessing the relationship between healthcare worker performance and other health outcomes will also be critical.

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Disclosures

None.

References

1. GBD 2016 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390:1151–1210. doi: 10.1016/S0140-6736(17)32152-9

2. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R; Prospective Studies Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. *Lancet*. 2002;360:1903–1913. doi: 10.1016/S0140-6736(02)11911-8
3. Rapsomaniki E, Timmis A, George J, Pujades-Rodriguez M, Shah AD, Denaxas S, White IR, Caulfield MJ, Deanfield JE, Smeeth L, Williams B, Hingorani A, Hemingway H. Blood pressure and incidence of twelve cardiovascular diseases: lifetime risks, healthy life-years lost, and age-specific associations in 1·25 million people. *Lancet*. 2014;383:1899–1911. doi: 10.1016/S0140-6736(14)60685-1
4. GBD 2016 Risk Factors Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390:1345–1422. doi: 10.1016/S0140-6736(17)32366-8
5. Whelton PK, Carey RM, Aronow WS, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *J Am Coll Cardiol*. 2018;71:e127–e248. doi: 10.1016/j.jacc.2017.11.006
6. Chow CK, Teo KK, Rangarajan S, et al; PURE (Prospective Urban Rural Epidemiology) Study investigators. Prevalence, awareness, treatment, and control of hypertension in rural and urban communities in high-, middle-, and low-income countries. *JAMA*. 2013;310:959–968. doi: 10.1001/jama.2013.184182
7. Mills KT, Bundy JD, Kelly TN, Reed JE, Kearney PM, Reynolds K, Chen J, He J. Global disparities of hypertension prevalence and control: a systematic analysis of population-based studies from 90 countries. *Circulation*. 2016;134:441–450. doi: 10.1161/CIRCULATIONAHA.115.018912
8. Maimaris W, Paty J, Perel P, Legido-Quigley H, Balabanova D, Nieuwlaat R, McKee M. The influence of health systems on hypertension awareness, treatment, and control: a systematic literature review. *PLoS Med*. 2013;10:e1001490. doi: 10.1371/journal.pmed.1001490
9. Khatib R, Schwalm JD, Yusuf S, Haynes RB, McKee M, Khan M, Nieuwlaat R. Patient and healthcare provider barriers to hypertension awareness, treatment and follow up: a systematic review and meta-analysis of qualitative and quantitative studies. *PLoS One*. 2014;9:e84238. doi: 10.1371/journal.pone.0084238
10. Anand S, Bärnighausen T. Health workers and vaccination coverage in developing countries: an econometric analysis. *Lancet*. 2007;369:1277–1285. doi: 10.1016/S0140-6736(07)60599-6
11. Castillo-Laborde C. Human resources for health and burden of disease: an econometric approach. *Hum Resour Health*. 2011;9:4. doi: 10.1186/1478-4491-9-4
12. Anand S, Bärnighausen T. Human resources and health outcomes: cross-country econometric study. *Lancet*. 2004;364:1603–1609. doi: 10.1016/S0140-6736(04)17313-3
13. Robinson J, Wharrad H. Invisible nursing: exploring health outcomes at a global level. Relationships between infant and under-5 mortality rates and the distribution of health professionals, GNP per capita, and female literacy. *J Adv Nurs*. 2000;32:28–40.
14. Robinson JJ, Wharrad H. The relationship between attendance at birth and maternal mortality rates: an exploration of United Nations' data sets including the ratios of physicians and nurses to population, GNP per capita and female literacy. *J Adv Nurs*. 2001;34:445–455.
15. Kim K, Moody PM. More resources better health? A cross-national perspective. *Soc Sci Med*. 1992;34:837–842.
16. Hertz E, Hebert JR, Landon J. Social and environmental factors and life expectancy, infant mortality, and maternal mortality rates: results of a cross-national comparison. *Soc Sci Med*. 1994;39:105–114.
17. Cochrane AL, St Leger AS, Moore F. Health service 'input' and mortality 'output' in developed countries. *J Epidemiol Community Health*. 1978;32:200–205.
18. Liu Y, Dalal K, Stollenwerk B. The association between health system development and the burden of cardiovascular disease: an analysis of WHO country profiles. *PLoS One*. 2013;8:e61718.
19. Jurges H, Pohl V. Medical guidelines, physician density, and quality of care: evidence from German SHARE data. *Eur J Health Econ*. 2012;13:635–649.
20. World Bank Country and Lending. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups. Accessed December 27, 2018.
21. Carter BL, Bosworth HB, Green BB. The hypertension team: the role of the pharmacist, nurse and teamwork in hypertension therapy. *J Clin Hypertens (Greenwich)*. 2012;14:51–65.
22. Clark CE, Smith LF, Taylor RS, Campbell JL. Nurse led interventions to improve control of blood pressure in people with hypertension: systematic review and meta-analysis. *BMJ (Clinical research ed)*. 2010;341:c3995.
23. STEPS Country Reports. 2016. https://www.who.int/chp/steps/reports/en. Accessed February 23, 2016.
24. WHO Global Health Workforce Statistics. 2016. https://www.who.int/hrh/statistics/hwfstats. Accessed February 23, 2016.
25. Data. Indicators. 2016. https://data.worldbank.org/indicator. Accessed February 23, 2016.
26. World Population Prospects. 2016. https://population.un.org/wpp/. Accessed February 23, 2016.
27. Health Statistics and Information Systems. 2016. https://www.who.int/healthinfo/global_burden_disease/estimates/en/index2.html. Accessed February 23, 2016.
28. Scheffler R, Cometto G, Tulenko K, et al. *Workforce Requirements for Universal Health Coverage and the Sustainable Development Goals*. Geneva, Switzerland: World Health Organization; 2016.
29. Joshi R, Alim M, Kengne AP, et al. Task shifting for non-communicable disease management in low and middle income countries–a systematic review. *PLoS One*. 2014;9:e103754.
30. Bengtson A, Drevenhorn E. The nurse's role and skills in hypertension care: a review. *Clin Nurse Spec*. 2003;17:260–268.
31. Sol BG, van der Bijl JJ, Banga JD, Visseren FL. Vascular risk management through nurse-led self-management programs. *J Vasc Nurs*. 2005;23:20–24.
32. Kishore SP, Vedanthan R, Fuster V. Promoting global cardiovascular health ensuring access to essential cardiovascular medicines in low- and middle-income countries. *J Am Coll Cardiol*. 2011;57:1980–1987. doi: 10.1016/j.jacc.2010.12.029
33. Elliott WJ. What factors contribute to the inadequate control of elevated blood pressure? *J Clin Hypertens (Greenwich)*. 2008;10(1 suppl 1):20–26.
34. Opie LH, Seedat YK. Hypertension in sub-Saharan African populations. *Circulation*. 2005;112:3562–3568. doi: 10.1161/CIRCULATIONAHA.105.539569
35. Niessen LW, Mohan D, Akuoku JK, Mirelman AJ, Ahmed S, Koehlmoos TP, Trujillo A, Khan J, Peters DH. Tackling socioeconomic inequalities and non-communicable diseases in low-income and middle-income countries under the Sustainable Development agenda. *Lancet*. 2018;391:2036–2046. doi: 10.1016/S0140-6736(18)30482-3
36. Sustainable Development Goals. http://www.un.org/sustainabledevelopment/sustainable-development-goals/. Accessed January 25, 2017.
37. Crisp N, Chen L. Global supply of health professionals. *N Engl J Med*. 2014;370:2247–2248. doi: 10.1056/NEJMc1404326
38. Abdel-All M, Putica B, Praveen D, Abimbola S, Joshi R. Effectiveness of community health worker training programmes for cardiovascular disease management in low-income and middle-income countries: a systematic review. *BMJ Open*. 2017;7:e015529. doi: 10.1136/bmjopen-2016-015529
39. Alaofè H, Asaolu I, Ehiri J, Moretz H, Asuzu C, Balogun M, Abosede O, Ehiri J. Community health workers in diabetes prevention and management in developing countries. *Ann Glob Health*. 2017;83:661–675. doi: 10.1016/j.aogh.2017.10.009
40. *Task Shifting: Rational Redistribution of Tasks Among Health Workforce Teams*. Geneva, Switzerland: World Health Organization; 2008.
41. Chen LC, Evans T, for the Joint Learning Initiative Coordination working group members. *Human Resources for Health: Overcoming the Crisis*. Cambridge, MA: Joint Learning Initiative; 2004.
42. Coleman R, Gill G, Wilkinson D. Noncommunicable disease management in resource-poor settings: a primary care model from rural South Africa. *Bull World Health Organ*. 1998;76:633–640.
43. Kumar A, Kamano JH, Too K, et al. *Effect of Nurse-Based Management of Hypertension in Rural Western Kenya*. Chicago, IL: American College of Cardiology Scientific Sessions; 2016.
44. Adeyemo A, Tayo BO, Luke A, Ogedegbe O, Durazo-Arvizu R, Cooper RS. The Nigerian antihypertensive adherence trial: a community-based randomized trial. *J Hypertens*. 2013;31:201–207. doi: 10.1097/HJH.0b013e32835b0842

45. Kengne AP, Awah PK, Fezeu LL, Sobngwi E, Mbanya JC. Primary health care for hypertension by nurses in rural and urban sub-Saharan Africa. *J Clin Hypertens (Greenwich)*. 2009;11:564–572. doi: 10.1111/j.1751-7176.2009.00165.x
46. Jafar TH, Silva Ad, Naheed A, Jehan I, Liang F, Assam PN, Legido-Quigley H, Finkelstein EA, Ebrahim S, Wickremasinghe R, Alam D, Khan AH; COBRA-BPS Study Group. Control of blood pressure and risk attenuation: a public health intervention in rural Bangladesh, Pakistan, and Sri Lanka: feasibility trial results. *J Hypertens*. 2016;34:1872–1881. doi: 10.1097/HJH.0000000000001014
47. *Global Strategy on Human Resources for Health: Workforce 2030*. Geneva, Switzerland: World Health Organization; 2016.
48. Olsen MH, Angell SY, Asma S, et al. A call to action and a life-course strategy to address the global burden of raised blood pressure on current and future generations: the Lancet Commission on hypertension. *Lancet*. 2016;388:2665–2712. doi: 10.1016/S0140-6736(16)31134-5
49. Campbell J, Dussault G, Buchan J, et al. *A Universal Truth: No Health Without a Workforce*. Geneva, Switzerland: Global Health Workforce Alliance and World Health Organization; 2013.

Novelty and Significance

What Is New?

- Health worker density was significantly associated with hypertension treatment rate.
- Our approach of aggregating and disaggregating physicians and nurses allowed us to highlight that nurse density, not physician density, seems to explain more of the relationship with hypertension treatment rate.

What Is Relevant?

- To the best of our knowledge, this is the first report examining the relationship between health worker density and hypertension treatment rates using worldwide data.

Summary

Our results support the strategy of task redistribution to meet the human resource challenge of management of noncommunicable diseases, including hypertension. Future research assessing the relationship between health worker performance and other health outcomes will also be critical.