It is believed that low wages are an important reason why doctors and nurses in developing countries migrate, and this has led to a call for higher wages for health professionals in developing countries. In this paper, we provide some of the first estimates of the impact of raising health workers’ salaries on migration. Using aggregate panel data on the stock of foreign doctors in 16 Organization for Economic Cooperation and Development countries, we explore the effect of a wage increase programme in Ghana on physician migration. We find evidence that 6 years after the implementation of this programme, the foreign stock of Ghanaian doctors abroad had fallen by approximately 10% relative to the estimated counterfactual. This result should be interpreted with caution, however, given the sensitivity of the results to changes in model specification.

**Keywords** Brain drain, physicians, migration, Africa

**KEY MESSAGES**
- Higher salaries can help to reduce physician migration.
- This may not be a cost-effective way of increasing physician supply.

**Introduction**
Physician migration from sub-Saharan Africa (SSA) has increased substantially over the past three decades (Hagopian et al. 2004; Okeke 2012). This trend of increasing migration has sparked a debate about the potential consequences of physician migration for the countries of origin. Hagopian et al. (2005), e.g. argue that unimpeded migration of a country’s physicians may impair delivery of health services; Awases et al. (2004) posit that it may reduce the quality of care provided in these countries (perhaps because more care will be provided by less skilled professionals). Another argument that has been advanced is that countries of origin suffer fiscal losses when domestically trained physicians emigrate, mostly because the training of physicians in many African countries is subsidized by public funds. Dovlo and Nyonator (1999) estimate that between 1986 and 1995, Ghana lost approximately US$6 million in tuition costs from the 61% of medical graduates produced from one of its medical schools over that period who later emigrated. Kirigia et al. (2006) estimate that for each doctor who emigrates, the country loses approximately US$517,931 in returns from that investment. Mills et al. (2011) estimate financial losses from physician migration ranging from $2.2 million for Malawi to $1.4 billion for South Africa.

Even though the debate about the consequences of physician migration is still ongoing, there is general agreement among policy makers that the scale and the extent of migration is problematic. Doctor-to-population ratios in many developing countries are already critically low and there is concern that migration of health professionals can only exacerbate these problems. In its 2006 report, the World Health Organization (WHO) identified some of the challenges to meeting the Millennium Development Goals and highlighted the critical role of health professionals (WHO 2006). In a bid to at least slow the migration of doctors and other health professionals from developing countries, various strategies have been called for (see discussion in Bärnighausen and Bloom 2009). One strategy that is often mentioned is increasing the salaries of health professionals in developing countries.

Despite its potential importance, we know very little about whether increasing the salaries of health professionals actually leads to a reduction in the rate of migration. In this article, we make an initial contribution to filling what is a rather large gap in the literature by evaluating the impact of a government
salary increase programme for doctors in Ghana on the subsequent migration of doctors.

**Previous literature**

Numerous papers discuss the factors that contribute to the migration of physicians and other health professionals. Bärnighausen and Bloom (2009) provide a good overview. Much of this literature is in agreement that the wage gaps between developing and developed countries play an important role in the migration of health professionals from developing countries (McCoy et al. 2008). Empirical estimates of these wage gaps indicate that they are quite large (Clemens and Pettersson 2008). Dovlo and Martineau (2004) go as far as to call remuneration (wages) the most important factor for retaining health workers.

Surveys of health professionals in developing countries provide some evidence in keeping with this point of view. In a 2002 survey of 2382 health workers spread across six African countries, between 68% (Cameroon) and 90% (Senegal) said they would not migrate if they were better paid (Awases et al. 2004). In another survey, 91% of the physicians surveyed rated a desire for higher income as a highly significant motivating factor for migrating abroad, and more than 80% agreed that increasing physicians salaries would be an effective way of reducing physician migration (Astor et al. 2005). While there is still disagreement about the importance of wages relative to other factors, see, e.g. Gibson and McKenzie (2009), who find that individual characteristics such as risk aversion and patience have a lot more to do with the migration decision of skilled workers than higher expected earnings in destination countries, there appears to be fairly broad consensus that low wages are an important ‘push’ factor. This line of reasoning would therefore suggest that one (important) way to slow the migration of health professionals from developing countries would be to raise their salaries.

Partly because of data constraints, there are not many studies that directly examine the relationship between doctors’ salaries and migration. Vujićic et al. (2004) is a notable exception. There are other papers, however, that examine the impact of wage differentials more broadly. Hatton and Williamson (2003), e.g. estimated the effect of wages on net migration using a panel dataset of 21 African countries covering the years 1977–95. In their IV models, they found that a 10% increase in the foreign to domestic wage ratio for unskilled labour increased out-migration by nearly one per thousand of the population. Clark et al. (2002) found qualitatively similar results using a different panel dataset on migration to the USA from 81 countries between 1971 and 1998. They found that a 10% decrease in a country’s income per capita (relative to the USA) increased migration to the USA by about 6%. Ortega and Peri (2009) examined migration flows from 74 countries of origin into 14 Organization for Economic Cooperation and Development (OECD) countries between 1980 and 2005 and found that income per capita differences had a positive and significant effect on bilateral migration flows. Increasing the income differential by $1000, after making adjustments for differences in purchasing power, increased migration flows by approximately 10%. These results are consistent with theoretical models that predict that wage differentials will have an impact on migration (Borjas 1987). This again suggests that increasing doctors salaries should decrease the rate of migration. There are several reasons, however, why increasing physicians’ salaries may not have the desired effect on migration.

**Credit constraints**

The existence of credit constraints in developing countries is fairly well established (De Mel et al. 2008; Banerjee and Duflo 2008), and this might act as a binding constraint limiting physician migration. There are large fixed costs associated with international migration, especially for physicians, who in addition to moving costs, also need to pay for the licensing examinations that are often required to practise in a foreign country. The licensing examinations, required for practice in the USA, e.g. cost nearly $3000—equivalent to nearly 1 year’s wages for physicians in some developing countries. If wages are sufficiently low, and credit constraints make borrowing difficult, then it is certainly possible that there are doctors at the margin who would like to migrate but cannot because they cannot afford to. This raises, at least in theory, the possibility that increasing salaries may lead to a (perverse) increase in migration rather than a decrease, because by increasing salaries we relax the (binding) financial constraint on migration. A recent study finds evidence consistent with this (Bazzi 2012).

**Immigration restrictions**

It is possible that destination country immigration restrictions constrain migration. Most countries, we know, place limits on the number of immigrants allowed in over a given period. Imagine, e.g. that every year m doctors would like to migrate from country i to j but there are only pm visas available where 0 < p < 1. If the number of visas that can be issued to doctors from country i is fixed and the number of doctors wishing to migrate from i to j strictly exceeds the number of visas available, then it is easy to show that under plausible conditions, increasing doctors’ salaries may have no effect on the migration rate.

So even though at first glance it seems obvious that paying doctors more should reduce migration, more careful consideration reveals that in fact it is not so clear.

**Ghana’s ADHA scheme**

According to data from the World Development Indicators, Ghana has a domestic physician stock of about 15 per 100 000 people in 2004. Approximately two-thirds of the physicians work in the public sector whilst the remainder provide services in a variety of parastatals and in the private sector (Dovlo and Nyonator 1999). Ghana is one of the sub-Saharan countries most affected by health professional migration. In an exploratory study to quantify the extent of migration, Dovlo and Nyonator (1999) found that 61% of the doctors produced by the University of Ghana Medical School, one of the leading medical schools in Ghana, between 1985 and 1994, had left the country by 1996. If one expresses the number of Ghanaian doctors abroad as a fraction of the domestic doctor stock, then about 30% of the domestic physician stock in Ghana is working overseas (WHO 2006).
In response to major challenges in recruitment and retention, the Ghanaian Federal Government in 1998 instituted a scheme known as the additional duty hours allowance (ADHA) scheme. It was introduced as a negotiated settlement to strikes by doctors over the issues of long hours and low pay. The stated objectives of the ADHA scheme were to ‘compensate doctors for any additional hours worked beyond the standard 40 hours a week/160 hours a month’ as well as to ‘motivate health workers for higher performance towards provision of improved quality care’ (Ruwoldt et al. 2007). A memorandum of understanding was signed between the Ghanaian government and the Ghanaian Medical Association in December 1998 with implementation to begin the following year.

For political reasons, the ADHA was not explicitly referred to as a salary increase—because the government wanted to avoid a situation where other health workers would also demand similar increases—in reality however, that is exactly what it was. Doctors were allowed to claim reimbursement for up to 200 additional hours of work per month provided the work was duly authorized and documented, but in many cases doctors did not even have to submit claim forms to get reimbursed (Ruwoldt et al. 2007). Even though precise estimates are hard to come by, several reports suggest the ADHA scheme significantly increased doctors’ incomes (Mensah et al. 2005). Most estimates put the increase in doctors incomes post-ADHA at between 75% and 150%. Note that average monthly basic salaries in Ghana in 1999 ranged from $200 to $300 depending on seniority (Dovlo and Martinseau 2004).

How much of an effect did the ADHA scheme have on doctors’ incomes? A 2005 survey of doctors in two regions in Ghana revealed average annual incomes of approximately $14,000, nearly half (46%) of which were ADHA payments. Although the ADHA was originally intended as a bonus for working extra hours, 97% of health workers surveyed described the ADHA as a fixed payment (Witter et al. 2007). To date there has been no rigorous evaluation of the impact of the ADHA on physician migration. There is some anecdotal evidence from Ghana that the number of newly trained doctors migrating declined from 70% to 50% following introduction of ADHA. In addition, ‘the trend in the doctor to population ratio showed some improvement during the period 2001 and 2003’ (Ruwoldt et al. 2007). The ADHA programme was discontinued in 2005 and the payments were folded into the base salary of health professionals.

**Methods**

To answer the question how did the ADHA programme affect the rate of physician migration, one needs to know the counterfactual—in other words, what would the migration rate have been if the programme had not been implemented. The problem is that we only observe Ghana in which the programme was implemented. This is the standard identification problem in programme evaluation. The usual solution is to approximate this counterfactual using untreated units, i.e. units that did not receive the programme. One major drawback to the usual methods is that the choice of comparison group(s) often relies on the researchers’ own subjective evaluation of which untreated unit(s) are the most similar, and therefore the most relevant for comparison, to the treated unit. Some studies avoid making a choice by simply using the set of all untreated units as the comparison group. If, e.g. a policy intervention is applied at the state level, then all the other untreated states are used as the comparison.

There is an additional challenge in this case as well because there is only one treated unit. In the presence of multiple treated units, standard difference-in-difference estimators can be used, but in this case as there is only one treated unit, identification is more complicated. The treatment here, a salary increase, is applied at the country level, and potentially all doctors in Ghana are exposed to the treatment. It seems reasonable therefore that the appropriate level of analysis is at the country level especially given the fact that the outcome of interest is international (cross-country) migration. We address this problem using econometric methods developed by Abadie et al. (2010) specifically for these set of problems, i.e. robust estimation of treatment effects in the presence of a single treated unit.

The key insight of Abadie et al. (2010) is that a weighted average of untreated units, where higher weights are assigned to unexposed units that are more similar on explicit quantifiable dimensions to the treated unit, results in a much better comparison group than one in which all the untreated units are essentially assigned the same weight. Interested readers can refer to Appendix 2 for a more formal exposition. Intuitively, we construct a counterfactual (synthetic) Ghana without the salary increase from a weighted average of all the other unexposed countries in the sample, and then compare the migration rates in this synthetic Ghana with the actual migration rates observed in Ghana following the implementation of the ADHA scheme. Obviously, a critical component of this is how the weights are determined. As suggested by Abadie et al. (2010), we choose weights to recreate, as closely as possible, the outcomes in Ghana before the salary increase. More accurately, we attempt to match as closely as possible values of a set of migration predictors for Ghana prior to implementation of the ADHA scheme.

Migration predictors used in our model include: log per capita gross domestic product (GDP) to capture the benefits from migration—on average the wealthier the source country, the smaller the benefit from migrating; the domestic stock of physicians to capture supply—ceteris paribus, countries with a larger domestic stock of doctors should have a larger foreign stock; and the number of coup attempts, and whether or not there is conflict in a given year. The last two are proxies for political instability in the source country. We also include the size of the domestic population (in logs) to capture the size of the health-care market, and three lags of migrant stock to capture network effects. More migrant physicians from developing country i in OECD country j reduce the cost of migration for future migrants from i; e.g. because of better information about job opportunities in j.

Data on per capita GDP comes from the Penn World Tables Version 6.2 (Heston et al. 2006), the data on conflict is from the well-known UCDP/PRIO Armed Conflict Dataset (Version 4, 2008), developed by the International Peace Research Institute of Oslo, Norway, and the University of Uppsala, Sweden (Gleditsch et al. 2002). The conflict variable is equal to one in
years in which $25 < X < 1000$, where $X =$ number of battle-related deaths in a given year. In alternative models, conflict is defined as $X > 1000$. These definitions are taken from the PRIO database and are commonly used in the conflict literature. Data on the number of coup attempts in year $t$ comes from McGowan (2003). Data on domestic physician stock and population come from Docquier and Bhargava (2007).

The values of the migration predictors for the real Ghana, the ‘synthetic’ (counterfactual) Ghana and a simple average of all the countries in the donor pool are contained in columns 1, 2 and 3, respectively, in Table 2. We started out with 44 other African countries as potential candidates for the donor pool but excluded Lesotho and Swaziland because they had zero migration over the period covered in the data. Comoros and Sao Tome were also excluded because of missing migration data, and Tanzania and Kenya were excluded because of possible confounding programmes. Lastly, we excluded South Africa because it is in many ways atypical amongst SSA countries. The final sample consists of 37 countries. The primary outcome variable is $\sum_{j=1}^{S} S_{ij}$, the total migrant stock of physicians from country $i$.

### Data

Our data on physician migration comes from a dataset compiled by Alok Bhargava and Frederic Docquier (Docquier and Bhargava 2007). This dataset measures the annual stock of African physicians in 16 OECD countries. Together these 16 countries account for more than 90% of all skilled immigrants in the OECD. The dataset covers the period from 1991 to 2004. Data on migrant stock was sourced from national medical associations (for seven countries), and from national censuses and registers (for nine countries). Data sources for each country are shown in Table A1.

A major strength of this dataset is its wide coverage (16 countries and 14 years). In addition, it measures physician stock which is a more stable (less noisy) measure than physician flows. Related to this is that using physician stock as a measure of migration reduces the problem of years with zero migration. Somewhat fortuitously, the first year of the ADHA programme falls almost exactly in the middle of the period covered by the dataset meaning that we have roughly the same number of pre- as well as post-intervention years.

The data has a few limitations. First, the definition of the emigrant physician is not consistent. For some countries migrant physicians were identified based on their country of training; in other cases based on their country of birth, and in a few cases, based on their country of citizenship (see Table A1). Second, annual data were not available for all countries. Where it was unavailable, interpolation was done using a log-linear adjustment. Docquier and Bhargava (2007) argue that these are not significant limitations because for the majority of the data (73% of the sample in 2004), migrant classification was in fact consistent (based on country of qualification); and because data on migration to the most important destination countries: the USA, UK, Canada, New Zealand and Germany, which together accounted for about 75% of all the medical migrants, were annual and not interpolated.

In the analysis that follows, we present results using the entire sample of destination countries, but as a robustness check, we present results for a restricted sample of four OECD countries, USA, UK, Canada and France, for which the emigrant definition is consistent (based on country of qualification) and for which there are annual data (see Table A1). We show that the qualitative conclusions are not affected by the choice of sample.

### Results

Table 1 shows the average stock of migrant physicians from African country $i$ in all 16 destination countries (standard deviations are reported in parentheses). To give a sense of scale, we also show the domestic physician stock for each country. It is evident from Table 1 that there is tremendous variation in migration between countries such as Equatorial Guinea, Gambia, and Namibia which have a migrant stock in the single digits, while countries like Ethiopia, Ghana and Sudan have several hundred physicians abroad. There is also significant within-country variation in migration over time. Sierra Leone and Senegal are two good examples. They both have the same number of migrants on average, but the standard deviations differ by a factor of 1.5.

In Figures 1 and 2, we graph annual migratory physician flows to the USA and the UK, the two most important destination countries for Ghanaian physicians (data on physician flows comes from Okeke 2012), and compare it to the average outflow from other untreated SSA countries. If the salary increase had the anticipated effect of reducing physician migration, then one would expect to see a decrease in the outflow of physicians following the introduction of the ADHA programme in 1998. In general, the data show a decline in physician migration flows from Ghana starting around the time of introduction of the ADHA programme. A similar decline is not observed for the other countries. We find a broadly similar pattern when we look at per capita physician migration, i.e. physician migration standardized by origin country population size (Figure 3).

The picture for the USA is slightly muddied by the fact that the US Educational Commission for Foreign Medical Graduates (ECFMG), the body that oversees certification of all foreign medical graduates, introduced a new exam in 1998 for foreign-trained doctors that could only be taken in the USA. This had the effect of increasing the cost of migration for foreign medical graduates. Given this increase, one would expect a decrease in migration and this shows up in the data—for Ghana as well as for the other countries in the sample. Notice however that the drop-off for Ghana is much steeper. Overall, however, we find evidence that the ADHA scheme is associated with reduced migration of physicians from Ghana. Next we turn to the main analysis.

Looking at the results in Table 2, we see that the synthetic Ghana formed from a weighted average of untreated countries is very similar to the real Ghana on a set of variables that predict migration. The one exception is the conflict variable which turns out to be a very weak predictor of migration rates and is thus assigned a small weight in the weighting matrix. Ghana is one of the more stable countries in the sample and
experiences no conflict between 1991 and 2004 (based on our definition). Not surprisingly, we find that an unweighted average of all the untreated countries in the pool does not provide a good comparison for the treated unit, Ghana. Notice that while an unweighted average of the other countries matches the pre-intervention values of Ghana on some of the predictor variables, it provides a very poor approximation on all of the lagged stock variables which are important predictors of migration rates.

In Table 3 we show the weighting matrix. The best approximation of Ghana is a weighted average of five SSA countries: Ethiopia, Nigeria, Sudan, Uganda and Zimbabwe. All the other countries are assigned a zero weight.

In Figure 4, we plot the outcome for Ghana and the synthetic control for each year in the data. We see that prior to 1998, experiences no conflict between 1991 and 2004 (based on our definition). Not surprisingly, we find that an unweighted average of all the untreated countries in the pool does not provide a good comparison for the treated unit, Ghana. Notice that while an unweighted average of the other countries matches the pre-intervention values of Ghana on some of the predictor variables, it provides a very poor approximation on all of the lagged stock variables which are important predictors of migration rates.

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migration in the synthetic control Ghana tracks very closely with actual migration but shortly after 1998, the lines start to diverge. Our results suggest that by 2004, six years after the ADHA programme was instituted, there were 91 fewer Ghanaian doctors abroad than there would have been if the ADHA programme had not been implemented. This is not a trivial number. A decrease of 91 physicians amounts to roughly 14% of the mean foreign migrant stock (of Ghanaian doctors) in all 16 OECD countries, and approximately 7% of the mean domestic stock. Alternatively, relative to what the foreign migrant stock would have been in 2004 had the ADHA scheme not been implemented, this translates to an approximately 10% decrease in emigration.

Robustness checks

To examine how robust these results are, we carry out a number of sensitivity checks. First, we repeat the analyses for a smaller subset of OECD countries: the USA, UK, Canada and France. For these four countries, the data are annual and the definition of the emigrant is consistent throughout the sample (see Table A1). With this sub-sample of the data, the weighting matrix assigns positive weights to all the comparison countries even though Ethiopia, Nigeria and Uganda still have the largest weights (results available on request). Overall, the results are similar to results obtained using the larger sample. We find a decrease of 105 physicians in the foreign migrant stock in these countries by 2004 relative to the counterfactual. This translates to an approximately 13% decrease in emigration.

Next we check whether the results are sensitive to including or excluding some of the predictors. As earlier discussed, the
most important predictor variables are the lagged values for migration, and so not surprisingly we find that the results are not sensitive to dropping the other predictors one at a time. They are also not sensitive to how conflict is defined. Next we check whether the results are sensitive to which lag years are included in the model. We find that changing the lag years used does not change the qualitative conclusions but it does change how closely we are able to replicate outcomes in pre-intervention Ghana. We get the best fit [lowest mean square prediction error (MSPE)] when we use 1992, 1993 and 1995 as our lag years. In Table 4 we present root MSPEs (RMSPE) for models with alternative lag years. For brevity, the results shown here are for six randomly selected lag years. For comparison, the RMSPE in our model of choice is 4.46.

In our main specification, we expressed domestic and foreign physician stock in levels. As an additional robustness check, we scale the stock variables by domestic population and express them in per capita terms, i.e. the outcome is now migrant stock per 100 000 domestic population. The per capita version of the model has much worse fit relative to the model in levels and so we are not able to reproduce the same results. Our results should therefore be interpreted with that caveat in mind.

Discussion

Taken together, our results suggest that the ADHA programme reduced physician migration. Figures 1–3 are quite compelling; they all show a sharp decline in the flow of doctors from Ghana from around 1998 but not for the other countries. This is supported by evidence from our main model comparing migration pre- and post-implementation of the ADHA to the counterfactual (Figure 4). This conclusion is however tempered by the finding that the results are sensitive to changes in the model specification.

There are important predictors of migration that are not included in our model. Unobserved changes in these variables that are correlated with the implementation of the ADHA scheme may bias our estimates. An important (unmeasured) predictor e.g. is changes in destination-country immigration policy. If there was an easing of migration restrictions over this time period, then our results should be biased downwards. A tightening of immigration restrictions, on the other hand, would bias our estimates upwards. To evaluate what changes there might have been in immigration policy over this period, we turn to a database of immigration laws described in (Ortega and Peri 2009). It is an updated version of two previous datasets and is a complete account of immigration reforms for 14 OECD countries over the period 1980–2005. It includes 11 of the 16 OECD countries in our sample.

Ortega and Peri (2009) construct an index of tightness for each immigration reform mentioned in the database. Of interest to us, is the index that measures tightening or loosening of entry for non-asylum immigrants. The starting value for each country is 0. Loosening, a change in the index of −1, describes reforms that (1) lower requirements, fees or documents for entry and to obtain residence or work permits, and/or (2) reforms that introduce the possibility (or increase the number of) temporary permits. A tightening reform, a change in the index of +1, (1) introduces or decreases quotas for entry, and/or (2) increases requirements, fees or documents for entry and to obtain residence or work permits.

Based on the index, only Denmark and the USA tightened their entry laws over this period. Countries like Canada, Germany and Sweden significantly loosened their immigration laws while for the remaining countries, immigration laws stayed mostly unchanged. In Figure 5, we plot the change in immigration tightness over time for the 11 countries for which we have data. We notice two things: first, there does not appear to be a sharp change in immigration policy in or around 1998 that would confound the effect of the ADHA programme. Secondly, the evidence indicates a net loosening (not a tightening) of immigration policy on average, suggesting that the direction of bias is downward. In that case our estimates can be interpreted as a lower bound on the true effect.

Another concern is Ghana-specific changes that are correlated with the ADHA but are not captured by the included predictors. One way to address this would have been to use another health professional group in Ghana as an additional control group, and conduct a triple-difference. The control group however must satisfy the following restriction: they must be affected by the unobserved change, but not by the ADHA programme. In practice, it is difficult to come up with a group that would satisfy this restriction. We know that the ADHA programme was expanded to include other health professionals. This invalidates nurses (and any other group of health professionals) as a control group. Using non-health professional groups as a

<table>
<thead>
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<th>Lag years included</th>
<th>RMSPE</th>
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<tbody>
<tr>
<td>1992, 1994, 1995</td>
<td>5.77</td>
</tr>
<tr>
<td>1991, 1992, 1997</td>
<td>5.09</td>
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<tr>
<td>1992, 1994, 1995</td>
<td>4.95</td>
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Table 4 RMSPEs for randomly selected lag years

Figure 4 Did the ADHA scheme reduce physician migration?

Note: The Y-axis is stock of migrant Ghanaian physicians in 16 OECD countries

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Another concern is Ghana-specific changes that are correlated with the ADHA but are not captured by the included predictors. One way to address this would have been to use another health professional group in Ghana as an additional control group, and conduct a triple-difference. The control group however must satisfy the following restriction: they must be affected by the unobserved change, but not by the ADHA programme. In practice, it is difficult to come up with a group that would satisfy this restriction. We know that the ADHA programme was expanded to include other health professionals. This invalidates nurses (and any other group of health professionals) as a control group. Using non-health professional groups as a
control group is also problematic because of potential spillovers. It is hard to argue that other professional groups would not be affected by the ADHA programme. Migration of this other group of professionals might increase because of the ADHA programme, if e.g. they become frustrated because only doctors salaries were increased, or more realistically if giving doctors a raise crowded out raises for other groups or at least the expectation of one. The ADHA programme could also reduce migration (at least in the short run) if there was a realistic expectation of also getting a salary increase, i.e. if this group of professionals adopted a wait-and-see attitude. The experience of the ADHA, which was initially supposed to only be for doctors but was later expanded to include others, suggests that this was not an unreasonable expectation.

How can we assess the significance of our results? In other words, how do we assess whether the effects we observe are spurious? One way to assess this is to iteratively assign the intervention to each of the untreated countries to generate a distribution of estimated gaps and then assess whether the gap we observe for Ghana, the actual intervention country, is unusually large relative to this distribution (Abadie et al. 2010). If the observed gap for Ghana is unusually large relative to this distribution of placebo gaps, then we can conclude that the ADHA programme had a significant effect. This method of inference is based on permutation inference, where the distribution of a test statistic is computed under random permutations of the sample units assignments to the treated and untreated groups (Fisher 1935; Rosenbaum 2002). For empirical applications see Auld and Grootendorst (2004) and Buchmueller et al. (2011).

In Figure 6 we graph the distribution of outcomes for all the countries in the sample and compare it to Ghana’s. The decrease for Ghana (dotted line) appears to be unusual relative to the other countries. There is only one other country which has a decrease larger than Ghana’s and that may simply be due to poor fit—notice that the pre-intervention gap is also large. Using this measure, the probability of having a decrease this large is 2/37, i.e. ~0.05. This is analogous to a P-value and would be significant at the 5% level for a one-sided test. For a two-sided test, the analogous P-value would be 0.08 (3/37), which would be significant at the 10% level.

Figure 6 should be interpreted with caution though because here we are comparing the change in Ghana’s physician migrant stock to the change in the migrant stock for other countries. Ghana has a larger migrant stock and so is likely to experience a larger drop. Note that this problem would still exist even if we used a different measure because Ghana has more physician migration regardless of which measure is used. It ranks fourth based on the number of migrant physicians, fourth based on migrant stock per 100 000 population, and third based on the migration rate. An additional caveat is that we get poor fit for some of the comparison countries, especially countries with low levels of migration. Poor fit is analogous to ‘noise’ in the data making inference difficult. One way to address both these problems is to compute a ratio of the post-intervention MSPE to the pre-intervention MSPE for each country. With a ratio, one is effectively doing a within-country comparison of the post-intervention and pre-intervention gaps. This is the same thing as asking how large is the gap between the actual outcome and the counterfactual after 1998 relative to the same gap before 1998? Table 5 reports MSPE ratios for all the countries in the sample. When we look at the MSPE ratio, Ghana is not quite as remarkable. Using this measure, she ranks 10th out of 37 (a probability of 0.27).

We therefore caution that we cannot completely rule out the possibility that these findings are due to chance. Even if the
wage increase programme reduced physician migration, this does not automatically make it a good policy solution. An important question is whether the programme would pass a cost–benefit test. We can do a quick back-of-the-envelope calculation. The starting budget for the programme was approximately $1.6 million; if we assumed that this represented the actual cost of the salary increases in the first year, and we allowed for yearly increases indexed to inflation which we put at a modest 10%, then by 2004, the government would have spent approximately $15 179 473. This translates to approximately $167 000 per physician retained.\footnote{This estimate raises questions about the cost-effectiveness of a salary increase programme. We can compare this to the cost of producing a new doctor. Estimates of this cost in the literature range from $30 000 to $70 000 per doctor (Kirigia et al. 2006; Mills et al. 2011).}

### Conclusion

In this article, we have attempted to answer a very important policy question: do higher salaries for health professionals reduce migration? The relatively low salaries of health professionals in developing countries are often cited as an important contributor to what is sometimes referred to as the medical brain drain, and many have called for salaries for health professionals in developing countries to be increased (McCoy et al. 2008). Several countries have gone ahead to institute programmes that provide extra payments to health workers. Despite its importance, there has before now been very little direct empirical evidence concerning what the potential impact of increasing salaries might be. To our knowledge, this study is the first to provide estimates of the possible impact of increasing doctors’ salaries.

To address this question, we have attempted to evaluate the impact of a salary increase programme in Ghana on physician migration. Our results suggest that by 2004 (six years after the programme was implemented), the foreign stock of Ghanaian doctors abroad had fallen by approximately 10%. To the extent that one accepts this conclusion, it is possible to calculate a rough elasticity. If the ADHA scheme increased salaries by between 75% and 150% and we accept that the ADHA programme led to a 10% decrease in emigration, this translates to a wage elasticity of migration of between −0.06 and −0.13.

Our work has a number of limitations many of which we have tried to address in the paper. However some remain. First, even though we conducted an extensive review of the literature to identify (and exclude) countries that implemented some kind of large-scale programme between 1991 and 2004, it is possible that we still have included countries that implemented some kind of programme to reduce physician migration. In other words, it is possible that some of the comparison countries are actually treated countries. This is not a problem if those countries are assigned a zero weight in the weighting matrix. If, however, one of the countries assigned a positive weight is in reality a treated country, then our results will be biased towards understating the true effect. Another concern is that the ADHA scheme may have had other components, e.g. a subsidized loan to enable purchase of a car, so that all of the impact of the programme could not be attributed to a salary increase. What evidence we do have suggests that the ADHA was mainly a salary support programme.

We note in conclusion that while our evidence is by no means conclusive, this paper is an important first step towards addressing a first-order global health question and we look forward to future work that will attempt to replicate these results in other settings and using different data. Finding other policy experiments, similar to the approach we have taken in this article, is probably the most viable approach for future research.

<table>
<thead>
<tr>
<th>Country</th>
<th>MSPE ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uganda</td>
<td>1.22</td>
</tr>
<tr>
<td>Cote D’Ivoire</td>
<td>1.29</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>1.49</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>1.49</td>
</tr>
<tr>
<td>Mauritiutus</td>
<td>1.79</td>
</tr>
<tr>
<td>Zambia</td>
<td>2.31</td>
</tr>
<tr>
<td>Eritrea</td>
<td>2.48</td>
</tr>
<tr>
<td>Gabon</td>
<td>2.48</td>
</tr>
<tr>
<td>Guinea-Bissau</td>
<td>2.56</td>
</tr>
<tr>
<td>Botswana</td>
<td>2.79</td>
</tr>
<tr>
<td>Zambia</td>
<td>3.03</td>
</tr>
<tr>
<td>Guinea</td>
<td>3.09</td>
</tr>
<tr>
<td>Namibia</td>
<td>3.81</td>
</tr>
<tr>
<td>Mauritania</td>
<td>4.15</td>
</tr>
<tr>
<td>Burundi</td>
<td>4.30</td>
</tr>
<tr>
<td>Chad</td>
<td>4.70</td>
</tr>
<tr>
<td>Malawi</td>
<td>5.20</td>
</tr>
<tr>
<td>Cape Verde</td>
<td>6.60</td>
</tr>
<tr>
<td>Central African Rep.</td>
<td>7.36</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>7.99</td>
</tr>
<tr>
<td>Liberia</td>
<td>8.41</td>
</tr>
<tr>
<td>Benin</td>
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</tr>
<tr>
<td>Zimbabwe</td>
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<tr>
<td>Congo</td>
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</tr>
<tr>
<td>Togo</td>
<td>9.81</td>
</tr>
<tr>
<td>Sudan</td>
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</tr>
<tr>
<td>Mali</td>
<td>10.67</td>
</tr>
<tr>
<td>Ghana</td>
<td>11.93</td>
</tr>
<tr>
<td>Senegal</td>
<td>12.36</td>
</tr>
<tr>
<td>Gambia</td>
<td>13.16</td>
</tr>
<tr>
<td>Cameroon</td>
<td>13.79</td>
</tr>
<tr>
<td>Somalia</td>
<td>14.72</td>
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<tr>
<td>Mozambique</td>
<td>16.96</td>
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<tr>
<td>Dem. Rep. of Congo</td>
<td>17.25</td>
</tr>
<tr>
<td>Equatorial Guinea</td>
<td>18.57</td>
</tr>
<tr>
<td>Niger</td>
<td>35.93</td>
</tr>
<tr>
<td>Madagascar</td>
<td>36.43</td>
</tr>
</tbody>
</table>

\textit{Note:} Bold indicates Ghana’s position stand out in the table.
Acknowledgements

I am grateful for the many useful comments and suggestions received from Jeffrey Smith, Dean Yang, Daniel Eisenberg, Catherine McLaughlin and Margaret Kruk. All mistakes are my own.

Conflict of interest

None declared.

Endnotes

1 It has been estimated that the cost of training a medical student is somewhere in the neighbourhood of $10 000 per student per year, in a region where the average per capita income was approximately $1000 in 2005 (World Bank 2008).

2 The six countries were Cameroon, Ghana, Senegal, South Africa, Uganda and Zimbabwe. Approximately 336 doctors were interviewed.

3 In total, 644 physicians across five countries were surveyed in Colombia, India, Nigeria, Pakistan and the Philippines.

4 It is possible to frame physician migration as a locational choice problem. If one does, then there is an extensive literature on physician location choice within developed countries that becomes relevant. Ernst and Yett (1985) was an early influential piece of work in this area.

5 An intriguing alternative explanation for why raising salaries may lead to increased migration is proposed by Hagopian et al. (2005). They raise the possibility that increasing salaries may increase pass rates on foreign exams and consequently increase migration, because doctors can substitute away from work hours towards study hours.

6 Also as Vujicic et al. (2004) argue, if the wage premium is very high, then the wage elasticity of migration in that range might be very small.

7 To put this number in perspective, consider that the USA has about 260 physicians per 100 000 people.

8 It was not primarily intended as a strategy to reduce physician migration.

9 The Ghanaian Medical Association publicly stated that its members were not required to complete duty rosters or submit claim forms.

10 As a further sign of the impact it had, there is some evidence that the increase in incomes allowed some health workers to purchase homes for the first time (Ruwoldt et al. 2007).

11 Basic salaries make up roughly between 30% and 60% of salaries. Various allowances make up the remainder.

12 Per capita incomes also act as a proxy for demand.

13 Like other papers in this literature, we were also constrained by data availability.

14 Data on coup attempts are only available until 2001.

15 In 2001, Tanzania implemented a programme that increased the pay of doctors in senior administrative positions within the public sector (Dominick and Kurowski 2004). The net effects of the programme are unclear. Given the limited scope of the programme, it is possible that it would have no effects on migration at all, especially given the lower propensity of older doctors to migrate (Clemens 2010). It could also have opposing effects on different groups of doctors. For example, it could have decreased migration among affected doctors, while simultaneously increasing migration for other doctors (because of increased dissatisfaction). To be safe, we excluded it. We also excluded Kenya because there is some indication that allowances were increased for some doctors towards the end of the period covered by our data (Mathauer and Imhoff 2006).

16 Amongst other things, it is itself an important destination country (Clemens 2007).

17 We drop Nigeria from the donor pool because no convex combination of the other countries is able to reproduce outcomes for Nigeria. This is not surprising because it has the highest foreign migrant stock outside of South Africa, which we already exclude. The RMSPE for the pre-intervention period is approximately 1110.

18 In practice, inference based on permutation tests can be conservative as an anonymous reviewer has noted (Buchmueller et al. 2011).

19 The migration rate is calculated as \[ \frac{\sum_{i=1}^{m} S_{i}/S_{j}}{m} \]

20 Admittedly, these are crude estimates and fail to take into account a number of different things including the spillover effects on other health professionals, but if anything we are underestimating the true cost of the programme.

21 One can take issue with this latter estimate because it does not really correspond to an economist’s idea of the marginal cost of producing another doctor, but it is useful as a handy guide.

References


Appendix 1

Table A1 OECD countries and data sources

<table>
<thead>
<tr>
<th>Country</th>
<th>Data source</th>
<th>Definition</th>
<th>Available data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Statistik Austria</td>
<td>Country of birth</td>
<td>1991, 2001</td>
</tr>
<tr>
<td>Canada</td>
<td>Canadian Medical Association</td>
<td>Country of qualification</td>
<td>1994–2004</td>
</tr>
<tr>
<td>Denmark</td>
<td>Statistics Denmark</td>
<td>Country of birth</td>
<td>2004, 2005</td>
</tr>
<tr>
<td>France</td>
<td>French Medical Association</td>
<td>Country of qualification</td>
<td>1991–2004</td>
</tr>
<tr>
<td>Germany</td>
<td>German Medical Association</td>
<td>Country of citizenship</td>
<td>1991–2004</td>
</tr>
<tr>
<td>Italy</td>
<td>Instituto nazionale di statistica</td>
<td>Country of citizenship</td>
<td>1991</td>
</tr>
<tr>
<td>New Zealand</td>
<td>New Zealand Medical Association</td>
<td>Country of qualification</td>
<td>1991, 2004</td>
</tr>
<tr>
<td>Norway</td>
<td>Norway Medical Association</td>
<td>Country of qualification</td>
<td>2004</td>
</tr>
<tr>
<td>UK</td>
<td>General Medical Council</td>
<td>Country of qualification</td>
<td>1991–2004</td>
</tr>
<tr>
<td>USA</td>
<td>American Medical Association</td>
<td>Country of qualification</td>
<td>1991–2004</td>
</tr>
</tbody>
</table>

Source: Reproduced from Table 1 in Docquier and Bhargava (2007).

Appendix 2

Let $J$ represent all the countries in the sample where $j \in [1, \ldots, J]$. Let $E$ denote exposure to some policy intervention, $P$, and let $U$ denote lack of exposure. Let $T_0$ represent the pre-intervention period and $T_1$ represent the post-intervention period where $t \in [1, \ldots, T]$ and $1 \leq T_0 < T$. Let $Y$ represent the outcome of interest. Without loss of generality, if we assume that country $1$ is the only country exposed to the policy intervention, $P$, then the impact of $P$ is given by

$$a_{11} = Y^*_1 - Y^U_1 \quad \forall t > T_0$$

The problem is that we only observe the first term but not the second, often referred to as the counterfactual, because the country cannot be both exposed and unexposed at the same time. The key contribution of Abadie et al. (2010) is to show that under certain conditions $\sum_{j=1}^{J-1} w_j Y_j$ is a good approximation of $Y^U_1$, where $w_j \in W^* = (w^*_1, \ldots, w^*_J)^\top$, $w^*_j \geq 0$ and $\sum_{j=1}^{J-1} w^*_j = 1$.

The impact of the intervention, $P$, can therefore be estimated by:

$$\tilde{a}_{11} = Y^*_1 - \sum_{j=1}^{J-1} w_j Y_j \quad \forall t > T_0$$

The intuition here is that one can construct a counterfactual (synthetic) Ghana without the salary increase from a weighted average of all the other unexposed countries in the sample, and then compare the migration rates in this synthetic Ghana with the actual migration rates observed in Ghana following the implementation of the ADHA scheme. The optimal vector of weights $W^*$ is chosen from the universe of all possible $W$s in order to minimize the following function $(X_1 - X_0W)V(X_1 - X_0W^*)$ where $w_j \geq 0$ and $\sum_{j=1}^{J-1} w_j = 1$. $X$ is a matrix of $K$ country characteristics which predict migration; typically defined for $t \in [1, \ldots, T_0]$. The subscripts 0 and 1 denote unexposed and exposed countries respectively.

The variables included in $X$ are guided by the literature. Clearly, all determinants are not created equal and so a matrix ($V$) assigns weights to each determinant in relation to how strongly it predicts migration rates. $V^*$ is chosen to minimize the MSPE of the estimator, i.e. $E[(Y_1 - Y_0W^*)(Y_1 - Y_0W^*)]$. In the absence of strong priors regarding the relative importance of each predictor, $V^*$ can be chosen to minimize $E[(Y_1 - Y_0W^*)(Y_1 - Y_0W^*)]$ for $t < T_0$, i.e. for the pre-intervention period.