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Foreign doctors and hospital quality: Evidence from the English NHS

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ABSTRACT

This paper examines the relationship between hospital quality and the share of foreign doctors in the English NHS. Baseline findings suggest that heart attack mortality is higher in hospitals with greater shares of foreign doctors practising relevant specialties. Robustness tests and heterogeneity analyses indicate that this association is specific to Acute Myocardial Infraction (AMI) treatment and is driven by hospitals that are smaller, of lower-quality, and ill-equipped to provide optimal care. When explicitly considering for treatment type, AMI mortality does not vary with the share of foreign AMI specialists in hospitals capable to access certain treatment technologies within 150 min. Overall, the results suggest that higher AMI mortality is not caused by foreign-trained AMI doctors but instead reflects structural challenges and resource-driven hiring patterns in constrained hospitals, which tend to rely more heavily on foreign doctors to mitigate worse outcomes. Further research is needed to better understand the allocation of foreign doctors to underperforming hospitals and its implications for healthcare delivery.

1. Introduction

Recent events like austerity policies, Brexit, and the COVID-19 pandemic have put the English NHS and its reliance on overseas medical staff into the spotlight. Following that larger inflows of healthcare workers have been shown to bolster both staff headcounts and service quality (Stevens et al., 2015), there are growing concerns that immigration restrictions will further strain an already overextended NHS. Furtado and Ortega (2023), and Grabowski et al. (2023) showed that immigration increased the availability of workers and improved care in US nursing homes. In England, fewer European nurses joining the NHS after the Brexit referendum led to slightly higher emergency readmission rates for elective patients (Castro-Pires et al., 2023). However, most research has focused on nursing staff. This paper shifts the focus to doctors and puts the relationship between hospital quality and the share of foreign-trained physicians directly to the test, using English NHS data at the hospital level.

Quality is measured using deaths from heart attacks (Acute Myocardial Infarctions; AMI). AMI mortality is a reliable and commonly used outcome reflecting the effectiveness of hospital interventions and care pathways for heart attack patients. These patients are the sickest and most dependent ones on the quality of care, so heart failure treatment matters greatly and is clearly linked to patient outcomes (Gaynor et al., 2013; Lee et al., 2020). AMIs have the advantage of being easily identifiable in clinical settings. Hence, they do not suffer from potentially serious measurement problems, and they are not susceptible to manipulation or "gaming" as some elective outcomes are (Cooper et al., 2011). Due to the emergency nature of those incidents, AMIs rule out concerns of patient sorting across hospitals. Given the context of this paper, AMIs also mitigate concerns related to linguistic barriers between patients and medical staff. Moreover, this outcome is tangible and directly tied to the hospital's clinical practices and protocols. Accordingly, only doctors in specialties typically involved in treatment of patients admitted with heart failure are considered for constructing the

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explanatory variable of interest (Chen et al., 2006).[1]

The NHS has heavily relied on overseas staff since its foundation. As in other countries, the presence of immigrants in the healthcare sector far exceeds their representation in the general workforce (Furtado and Ortega, 2023). By 1960, 30–40 % of NHS junior doctors hailed from India, Pakistan, Bangladesh, and Sri Lanka (Williams, 2015). More recently there has been an influx of European doctors; however, historical trends continue, with two-thirds of all overseas-trained doctors in the NHS originating from countries with historical ties to the UK. Despite the relatively modest financial incentives compared to other countries (OECD, 2015), several factors continue to attract these professionals. The UK's immigrant population doubled from 7 % of the working-age population in the early 2000s to 14 % by 2015. Additionally, population aging and unforeseen extreme events, such as the COVID-19 pandemic, continued to drive demand, while rationing in medical education has led to shortages of domestically trained doctors. Push factors in origin countries, such as educational upgrading, and less favourable economic and working conditions also play a role. Moreover, the global appeal of the English language and the widespread pre-migration exposure to it reduce linguistic barriers and facilitate human capital transferability to the host country (Adserá and Pytliková, 2015). Furthermore, NHS employers are committed to promoting equal opportunities and diversity in line with Equality Acts. Therefore, personal information is monitored to ensure non-discriminatory recruitment and selection processes. As stated in NHS Equality Monitoring Statements, a primary objective is to help hospitals align their workforce with the diversity of the population they serve.[2]

Blending different cultures in the workplace is thought to enhance performance, though the evidence from the corporate sector is mixed. Profit-maximising firms tend to match workers with similar skills (Kremer, 1993). However, when considering racial and ethnicity aspects, productivity gains depend on effective within-group communication (Lazear, 1999).[3] Some studies have uncovered negative correlations between ethnic dissimilarity and performance (Hamilton et al., 2012; Kurtulus, 2011; Parrota et al., 2014; Hjort, 2014). Hamilton et al. (2012) argued that demographic differences harm productivity and increase turnover by imposing cultural and linguistic barriers to knowledge transfer, weakening social ties and trust between co-workers and reducing peer pressure for improved performance, and generating disutility from belonging to a diverse workforce. This aligns with Becker's (1957) model of co-worker discrimination, which predicts that demographic diversity creates communication frictions and workplace segregation, leading to productivity losses and labour turnover if workers prefer more homogeneous environments.[4] Conversely, ethnic diversity can enhance firm performance because by improving problem-solving and decision-making, fostering new ideas and knowledge transfer, and providing product market insights (Berliant and Fujita, 2008; Hong and Page, 2001; Osborne, 2000; Parrotta et al., 2016).[5] Additionally, some studies show no relationship between firm productivity and the share of foreign workers (e.g. Barrington and Troske, 2001; Trax et al., 2015).

As England's population diversifies, employing more international doctors could improve the capacity to meet patients' needs. But despite the NHS's objective to build a workforce that reflects the diversity of the local population, there is no evidence on the links between hospital quality and foreign doctors. Without discrimination, recruiting from the international medical labour market could enhance performance by expanding the applicants' pool. Castro-Pires et al. (2023) show that a restricted labour supply among NHS nurses lowered hiring standards leading to joiners and outcomes of lower quality. However, if hospitals are required to adhere to affirmative action policies and hire minority doctors, this could harm performance if overseas-trained doctors are selected over more qualified candidates. Additionally, maintaining a diverse medical workforce could be costly due to recruitment expenses, diversity training and cross-cultural dealing, and potential discouragement from discriminatory preferences of patients and medical staff, that might negatively affect hospital quality.

Given the essential role that foreign physicians play in the performance of the NHS, it is important to investigate their implications on patient outcomes. First, there is a quality gradient in training that might lead to productivity differences between domestic and overseas-trained physicians. Second, cultural interactions between doctors and patients, as well as among doctors of different nationalities within the same hospital or specialty can influence outcomes. Language barriers may also lead to worse patient outcomes. Even if such barriers are less relevant in treating conditions like heart attacks, less effective communication among staff members could still compromise quality (Lazear, 1999). The medical literature offers some evidence on performance differences between native and foreign-trained doctors. Tiffin et al. (2014) found that international medical graduates tend to have poorer outcomes in the Annual Review of Competence Progression (ARCP) compared to home-trained doctors, even when accounting for demographics and work experience. However, no significant differences were noted between home and overseas-trained doctors who excelled in a prerequisite professional and linguistic assessment.[6] In Esmail and Roberts (2013), non-white international graduates were more likely to fail the skills assessment of the Membership of the Royal College of General Practitioners (MRCGP) exam compared to white UK graduates. Humphrey et al. (2011) investigated outcomes of inquiries received by the General Medical Council (GMC). Conditional on demographics, job experience, and medical specialty, doctors qualified outside the UK were more likely to face further investigation, adjudication, and potential erasure or suspension, raising concerns about their fitness to practice. Zaheer et al. (2017) compared native and international medical graduates in Florida and New York, finding that despite demographic and training differences, patient outcomes such as mortality, complications, and length of stay were similar. Tsugawa et al. (2017) reported that compared to patients treated by US graduates, those treated by international graduates had lower mortality.

The extent to which any relationship between hospital quality and the share of overseas physicians is causal is particularly challenging as "*… more often than not international graduates work in areas that are low priority, insufficiently resourced, and high need*" (Esmail and Simpson,

[1] These specialties are acute internal medicine, cardiothoracic surgery, cardiology, emergency medicine, general medicine, general surgery, and intensive care medicine.

[2] In the corporate sector, it is commonly argued that a diverse customer base is better served by a diverse workforce; although there is no consistent empirical support (Hamilton et al., 2012; Leonard et al., 2004). However, a similar reasoning applies for public services, e.g. police officers from an ethnic minority should be patrolling neighbourhoods where their minority is more prevalent (Osborne, 2000). In education, evidence shows that students from underrepresented minorities perform significantly better across various short- and long-term outcomes, e.g., class dropout rates, grade performance, high school graduation, and college enrolment, when taught by instructors of the same ethnicity or race (Fairlie et al., 2014; Gershenson et al., 2022).

[3] The importance of communication costs, due to language or other cultural differences (e.g. gender, age), for organisational behaviour and performance is well documented in economics (Arrow, 1974; Lang, 1986).

[4] Performance might also be negatively affected by issues related to trust among partners from different ethnic and national groups (Glaeser et al., 2000; Alesina and La Ferrara, 2002).

[5] Studies using area-level data have documented a positive impact of cultural diversity on performance (e.g. Ottaviano and Peri, 2006; Suedekum et al., 2014).

[6] The purpose of the Professional and Linguistic Assessment Board (PLAB) is to ensure that the clinical skills of foreign-trained doctors are comparable to those expected by UK-trained ones upon completing the initial phase of their training.

2017). If hospitals respond to worsening outcomes by hiring more staff, those of poorer quality might disproportionately recruit foreign-trained doctors to prevent understaffing, which could further exacerbate poor outcomes (Lin, 2014). Thus, any observed effect might stem from this sorting process, rather than reflecting a direct causal relationship. The Brexit referendum could be considered as a source of exogenous variation to check for differential mortality impacts in hospitals with more EU-trained doctors. However, Castro-Pires et al. (2023) show that, unlike nurses, the Brexit vote did not affect the composition of NHS doctors, whose total headcount continued its pre-referendum increasing trend. According to the authors, migrant doctors already working in the UK were less responsive to the referendum outcome due to gained settlement rights and the delay in defining the immigration regulatory framework until 2020.[7] Other exogenous factors that might influence the variation in the share of foreign doctors across hospitals include the timing of doctor retirements, various types of leaves, and the nationality distribution of applicants whenever a hospital opens a vacancy. However, investigating these factors would require much more detailed data and the ability to link patient outcomes to individual physicians, which is challenging – particularly in accident and emergency settings like the one considered here – where doctors work as part of a team (Esmail and Simpson, 2017).

The relationship between heart attack mortality and the share of foreign doctors is examined using hospital-level data from various sources, covering all acute NHS providers from 2009 to 2014. While the paper does not explore the factors driving variation in the share of foreign-trained doctors, which limits the ability to fully address concerns about endogeneity, it mitigates potential biases from non-random sorting in several ways. First, models control for hospital fixed effects, holding constant quality differences between hospitals. Second, they account for hospital and local population characteristics, partially ruling out time-varying selection of foreign doctors into hospitals correlated with changes in case-mix, demographics, local economic conditions, and financial performance. Third, considering that foreign doctors might be more likely to work in more poorly performing hospitals, the relationship is examined across the hospital quality distribution. Finally, a novel aspect of this paper is the examination of how the treatment provided in each hospital matters for AMI mortality and its relationship with the share of foreign-trained doctors in related specialties. Treatment type significantly determines outcomes, despite inherent physician fixed effects such as place of training or country of origin.[8] AMI mortality is a tangible outcome directly tied to hospitals' clinical practices and protocols, with up to one-fifth of the variation in hospital-level AMI mortality attributed to differences in treatment (Chung et al., 2015). Information on the treatment provided by each hospital is available from the Myocardial Ischaemia National Audit Project (MINAP) for the 2012–2014 sub-period. This data is merged to the hospital-level panel used in the main analysis to offer some additional insights.

The baseline results suggest that AMI mortality is higher in hospitals with larger shares of foreign AMI doctors. Specifically, a 1 % increase in the share of foreign doctors in AMI-related specialties is associated with 0.28% increase in AMI mortality, on average. This finding is robust to a series of robustness and placebo tests. In heterogeneity analyses, the estimated coefficient of the share of foreign-trained AMI doctors is positive and significant in sub-samples of smaller hospitals, in terms of the number of AMI admissions, and of hospitals of lower quality based on the quartiles of the fixed residual of the AMI mortality rate distribution. When considering explicitly for treatment type, the results are driven by the sub-sample of hospitals without a designated Heart Attack Centre capable of providing the recommended treatment for severe heart attacks in a timely manner.[9] Overall, findings indicate that the negative association between foreign doctors and AMI mortality is driven by hospitals at the lower end of the quality distribution, and hospitals where access to recommended treatment is more limited. Moreover, the share of foreign-trained AMI specialists is higher in those poorly performing hospitals, implying that a selection process may be at play. However, even if their hiring is resource-driven, foreign doctors may mitigate potentially worse patient outcomes in these hospitals, and the specificity of these findings highlights areas where medical staff might not be utilised most effectively. This is particularly important because advancements in care delivery and access to preferred treatments ensure consistency in patient outcomes across hospitals of varying quality.

The paper contributes to the literature on the implications of immigrant healthcare workers on care quality (Castro-Pires et al., 2023; Furtado and Ortega, 2023; Grabowski et al., 2023; Stevens et al., 2015).[10] However, rather than focusing on nurses in hospitals or nursing homes, it focuses on doctors in hospitals for which the evidence remains scarce. Moreover, it uses a condition-specific outcome – heart attack mortality – that eliminates issues related to selectivity between patients and hospitals. The explanatory variable – the share of foreign doctors – is precisely tailored to the outcome by calculating it using headcounts of doctors practising those medical specialties involved in the treatment of heart attacks. The paper also intersects with the broader literature on the relationship between staffing and patient outcomes. For instance, Friedrich and Hackmann (2021) found that parental-leave policies caused substantial shortages in the labour supply of registered nurses, resulting to increased heart-attack hospital readmission rates and higher mortality rates in nursing homes. Lin (2014) and Akosa Antwi and Bowblis (2018) showed that increased labour supply of nurses improved care delivery in US nursing homes. Propper and Van Reenen (2010) linked higher heart-attack mortality in NHS hospitals to difficulties in nurse retention due to better outside options in their region. Stoye and Warner (2023) demonstrated that lower availability of junior doctors in the NHS due to a nationwide strike had negative consequences for patients from specific minority groups. Finally, by considering the type of treatment each hospital provides, this work also relates to the literature on

[7] Drawing from the immigration literature, a shift-share instrumental variable was constructed based on the past settlement patterns of foreign-trained medical staff across locations, like in studies focusing on the total number of immigrants or low-skilled immigrants (Card, 2001). However, first-stage results indicated that past settlement patterns of foreign-trained medical staff were not particularly correlated with their current distribution across hospitals.

[8] For example, physicians who are young, male, and trained at more prestigious medical schools are more willing to undertake invasive treatment procedures and have better outcomes on higher risk patients (Currie et al., 2016). Physician beliefs and practices can also explain variation in patient outcomes and healthcare spending (Cutler et al., 2019), and they are largely shaped by environmental factors themselves, e.g., access to secondary care, physician style etc. (Molitor, 2018).

[9] Heart Attack Centres (HACs) operate 24/7 and are suitably equipped to perform procedures to open fully blocked arteries. When this procedure is needed, patients must be transferred to these hospitals immediately.

[10] On the demand side, Wadsworth (2013) showed that natives and immigrants use primary and secondary health services in England at similar rates. Giuntella et al. (2015) estimated a negative effect of immigration on waiting times for outpatient referrals, with no impact on waiting times for accident and emergency or elective care in the NHS. They attributed their findings to the internal mobility responses of the native population. More generally, there has been an extensive literature regarding the effects of immigration on various outcomes in the UK. Dustmann et al. (2005, 2013), and Manacorda et al. (2012) found that immigration decreased wages at the bottom of the wage distribution and slightly increased wages in the upper tail. Those effects were attributed to imperfect substitution between immigrants and natives in the labour market. Bell et al. (2013) showed that differences in labour market opportunities affect potential criminal activity of various migrant groups. Sá (2014) estimated a negative immigration effect on house prices due to native mobility responses. Dustmann and Frattini (2014) demonstrated that European immigrants made a positive fiscal contribution, while the fiscal contribution of non-European immigrants was negative before 2000.

capacity constraints and their impact on patient outcomes (Kleiner, 2019; Stukel et al., 2012).

Despite its limitations, the evidence presented here shows that hospitals with characteristics linked to higher AMI mortality rates tend to have a higher average share of foreign-trained physicians. This positive and significant association is driven by smaller hospitals and those with lower quality and limited infrastructure. Hence, it underscores the need to factor in both hospital quality and the ability to provide timely treatment when assessing the implications of foreign staff on patient outcomes. In settings like the English NHS, which have historically relied on immigrant doctors to address staff shortages and meet domestic demand, it is essential to ensure that foreign-trained doctors are effectively utilised; particularly in underperforming and resource-constrained providers. This is especially critical given the persistent shortages of medical staff which can be exacerbated by external shocks, and the increased demand for healthcare during unexpected events such as pandemics. The remainder of this paper is structured as follows. Section 2 presents the data sources used in the empirical analysis and provides a preliminary descriptive analysis. Section 3 outlines the empirical strategy. Section 4 discusses the results. Section 5 concludes.

2. Data

2.1. Data sources

The primary dataset is sourced from the NHS Hospital and Community Health Service (HCHS) statistics, obtained under a licence agreement with the Health and Social Care Information Centre (HSCIC). It includes headcounts and FTEs of doctors, broken down by hospital and medical specialty from 2009 to 2014.[11] Doctors working in NHS hospitals were trained in 137 different countries, but to prevent individual identification these countries had to be grouped. The groups were constructed based on factors such as geography, economic and political conditions, culture, language, ties to the UK, and the quality of medical training. The resulting country groups include: (i) all countries excluding the UK, (ii) European Economic Association (EEA) excluding the UK, (iii) non-EEA, (iv) South European Union (EU), (v) EU Accession, (vi) South Asia, (vii) Anglosphere excluding the UK, (viii) non-Anglosphere, (ix) Arab countries, (x) sub-Saharan Africa, (xi) English speaking countries excluding the UK, (xii) non-English speaking countries, (xiii) countries with colonial ties to the UK, and (xiv) countries -excluding the UK- with at least one institution ranked in the top 100 medical schools worldwide (Table A1).[12] There were 88 medical specialties in the data, e.g. cardiology, general pathology, emergency medicine etc. Also, there was information on the headcounts for joiners, leavers, and the staff stability index, i.e., the percentage of staff that remains in place over a given period.[13]

Information on patient outcomes comes from the Health and Social Care Information Centre (HSCIC) and it is based on Hospital Episode Statistics (HES); an administrative database covering all patient admissions in English hospitals, together with patients' demographics, method of admission, and medical conditions. The main outcome here is AMI mortality, i.e. the number of deaths within 30 days of an emergency admission to hospital following an AMI episode for patients 35–74 years old (2009–2014). Other mortality measures include the overall death rate, death rates by method of admission (elective or non-elective), place of death (inside or outside hospital), socioeconomic status (defined by the patients' classification into quintiles of the Index of Multiple Deprivation), and diagnosis group code. Also, deaths within 30 days from a non-elective surgery, deaths within 30 days from an emergency stroke admission, and deaths associated with fractured proximal femur were considered.[14]

Information on hospital-level time-varying heterogeneity is drawn from HES N and NHS England (2009–2014). This refers to hospital size, case-mix, total number of episodes, total number of admissions, number of admissions by gender and age, number of emergency admissions, number of elective admissions, mean length of stay, mean waiting time, mean age of admitted patients, distribution of finished consultant episodes (FCE) by intervention, distribution of finished admission episodes by primary diagnosis, distribution of FCEs by main consultant specialty, and number of total, general and acute beds. Data on nurse headcounts is available through the NHS Hospital and Community Health Services Non-Medical Workforce Census provided by the HSCIC. Information from Foundation Trust Consolidation (FTC) accounts data (provided from the Office for National Statistics) is used to control for financial performance. Controls for the local population are constructed using the Labour Force Survey available at the Local Authority District (LAD) level under a special licence agreement.[15] Weighted shares of females, population by gender in fifteen age groups, those holding A GCSE A level, unemployed, inactive, employed, immigrants were calculated for each LAD over the period. Finally, the mean wage for each LAD was calculated using the Annual Survey of Hours and Earnings (ASHE).[16] Local wages can affect the quality of staff a hospital can attract and retain (Propper and Van Reenen, 2010). Combined, these variables should capture differences in local amenities that could affect the allocation of foreign doctors across areas.

2.2. Descriptive statistics

Table 1 provides descriptive statistics for the period 2009–2014. Shares of foreign doctors are calculated as the number of non-UK doctors over the total number of doctors in each hospital-year cell. The share of foreign doctors is 36.7 %, slightly decreasing over time. Doctors from EEA countries constitute 6.5 % of the total headcount, and their share has been increasing. The same trend is observed for doctors from South EU and EU Accession countries, possibly due to push factors in their home countries, though both groups represent around 2 % of the total.[17] Doctors from South Asia (mainly India and Pakistan) form a larger

[11] Information on country of qualification was not available before 2009. Data were provided as headcount and FTE snapshots as at the last day of September, December, March, and June each year.

[12] Those schools were selected based on the 2016 Quacquarelli Symonds (QS) World University Rankings. One concern could be that top-ranked institutions may not fully represent the average quality of medical education in each country, and that grouping countries by their median-ranked institution might provide a more accurate reflection. To address this, the median-ranked institution from the QS list was chosen for each country. Ranking countries by the overall score of their median medical school produced a list that significantly overlaps with the original, reassuring that the group of countries used here is representative of those outside the UK that, on average, offer the highest quality of medical education.

[13] This can control for staff retention. For example, if there were 50 doctors in a hospital at some point and after a few months 40 of them remained in post, then that hospital's staff stability index over that period equals to 0.8.

[14] Death counts less than 5 were suppressed due to disclosure control rules. However, this should not be expected to affect the results. First, the estimation sample consists of hospitals with more than 10,000 admissions, therefore this guarantees that specialist providers are excluded from our data (we also performed additional checks for that using the provider codes and names). Second, there are no significant differences in the share of foreign doctors between the estimation sample and the one with non-missing information on outcomes. Third, similar sample selection rules have been applied in other studies (e.g. Gaynor et al., 2013). Fourth, the robustness of the results was checked using estimation techniques that take account of this truncation.

[15] Local Authority Districts are subnational administrative divisions in England, overseen by a local government body.

[16] To avoid issues related to lower female labour market participation and part-timers, median annual gross wages for full-time males were used.

[17] As shown by Castro-Pires et al. (2023), the share of European doctors in English NHS hospitals kept increasing even after the Brexit referendum in 2016.

Table 1
Shares of foreign-trained doctors by country of medical qualification.

	All medical specialties		Medical specialties involved in treatment of AMI patients	
	Mean (std.dev.) [1]	2009–2014 % change [2]	Mean (std.dev.) [3]	2009–2014 % change [4]
Outside the UK	.367 (.098)	-5.03	.311 (.106)	−2.87
EEA (excl. UK)	.065 (.026)	35.20	.068 (.044)	47.78
Outside the EEA	.261(.098)	-12.37	.232 (.097)	−10.92
South EU	.018 (.013)	75.88	.021 (.020)	79.30
EU Accession countries	.023 (.012)	74.61	.026 (.017)	83.34
South Asian countries	.168 (.077)	-14.04	.145 (.073)	−14.67
Anglosphere countries (excl. UK)	.017 (.010)	-13.05	.014 (.025)	−15.49
Arab world countries	.039 (.018)	-5.72	.039 (.022)	−0.95
Sub-Saharan Africa	.032 (.013)	-9.27	.028 (.018)	0.03
English speaking countries (excl. UK)	.220 (.080)	-13.08	.191 (.082)	−12.19
Non-English-speaking countries	.109 (.033)	10.91	.112 (.045)	17.66
Countries with former colonial ties to the UK	.234 (.090)	-12.97	.202 (.088)	−11.66
Countries with ≥1 medical school in world's top-100 (excl. UK)	.039 (.022)	2.04	.037 (.037)	14.73

Source: Health and Social Care Information Centre (HSCIC).
Notes: 2009–2014 data. Means refer to period averages. Estimation sample is hospitals with non-missing values on deaths within 30 days after an emergency non-elective procedure (848 hospital-year observations). Shares are calculated as the headcount of foreign doctors over the total headcount of doctors in each hospital-year cell. Statistics are weighted by the total number of doctors in each hospital-year cell.

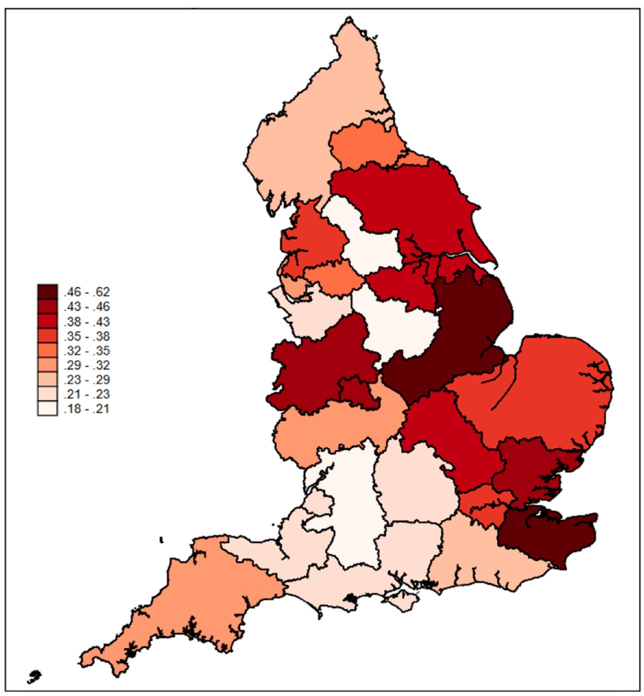

Fig. 1. Regional distribution of foreign-trained doctors.
Notes: 2014 data. The share of foreign-trained AMI doctors is calculated as the headcount of doctors trained outside the UK and practising specialties involved in AMI treatment over the total headcount of doctors in those specialties. Regions follow the NHS Area Teams classification (25 regions).
Source: Health and Social Care Information Centre (HSCIC), ONS Geography.

group, but their share declined by 14 %. The share of doctors from Anglosphere countries is small and declining, as is the share of those trained in English-speaking countries, while the share from non-English-speaking countries is increasing. The share of doctors trained in countries with top medical schools is small, slightly increasing, and not correlated with the total share of all foreign doctors; the correlation coefficient is −0.12. These trends are roughly similar when considering specialties typically involved in AMI treatment. In this case, shares were calculated as the number of non-UK doctors in those specialties over the respective headcount of doctors. Shares of doctors from Arab and African countries remained stable. Also, the share of those trained in top school countries substantially increased, but it is small and not correlated with the share of all foreign doctors in AMI specialties, i.e. the correlation coefficient is -0.02. Shares of overseas-trained doctors in AMI specialties vary significantly across hospitals, ranging from 9 % to 67 %.[18] Fig. 1 maps this variation at the regional level, demonstrating that UK-trained doctors are more prevalent in the southwest, while those trained abroad are more concentrated in the east and north.

For each specialty typically involved in AMI treatment, Table 2 presents the average shares of overseas-trained doctors. This dimension is critical as the overall share of foreign doctors in a hospital can differ from the share of those practising specific specialties. Nearly 70 % of doctors in all AMI specialties were trained in the UK, except for cardiothoracic surgery, where half doctors were trained abroad (18.5 %

[18] When all medical specialties are considered, the share of foreign physicians across hospitals ranges between 15 % and 75 %.

Table 2
Doctors by country of medical qualification and medical specialty.

	Acute internal medicine [1]	Cardiothoracic surgery [2]	Cardiology [3]	Emergency medicine [4]	General medicine [5]	General surgery [6]	Intensive care medicine [7]
UK	.692	.492	.702	.696	.723	.675	.753
Non-UK	.308	.508	.298	.304	.277	.325	.247
EEA	.056	.185	.078	.056	.048	.070	.079
Non-EEA	.248	.315	.210	.237	.215	.243	.158
South EU	.016	.095	.022	.009	.016	.026	.029
EU Accession	.024	.051	.028	.024	.021	.024	.022
South Asia	.153	.182	.138	.142	.138	.152	.102
Anglosphere	.007	.019	.019	.016	.007	.014	.018
Arab world	.035	.074	.038	.029	.033	.053	.019
Sub-Saharan Africa	.027	.027	.019	.037	.025	.025	.020
English speaking	.190	.232	.177	.199	.173	.195	.141
Non-English speaking	.115	.272	.116	.098	.092	.121	.098
Colonial ties	.211	.252	.179	.204	.185	.219	.144
Top-100 med schools	.033	.102	.042	.034	.022	.039	.060

Source: Health and Social Care Information Centre (HSCIC).
Notes: Means refer to period averages (2009–2014). Estimation sample is hospitals with non-missing values on deaths 30 after an emergency procedure (848 hospital-year observations). For each medical specialty, shares are calculated as the headcount of doctors from each group of countries over the total headcount of doctors in each hospital-year cell. Statistics are weighted by the total headcount of doctors in each hospital-year cell.

Table 3
Descriptive statistics on hospital outcomes.

	Mean [1]	Std. dev. [2]	Min [3]	Max [4]	2009–2014 % change [5]	Observations [6]
AMI death rate	.054	.021	.016	.174	−12.2	596
Number of AMI deaths	13.8	7.3	6	43	8.58	596
Number of AMI admissions	285.8	164.2	45	1,007	21.34	596
Overall death rate	.033	.007	.010	.059	1.1	843
Total number of deaths	1,964.9	844.5	82	4,653	10.8	843
Total number of admissions	61,277.1	27,781.5	2,560	183,899	10.5	843

Source: Health and Social Care Information Centre (HSCIC).
Notes: Data are for 2009-2014. AMI death rate is the number of deaths within 30 days of an emergency admission to hospital following an AMI episode (patients 35-74 years old) over the total number of emergency AMI admissions in a hospital-year cell. Overall death rate is the total count of deaths (from all causes) over the total count of admissions in each hospital-year cell.

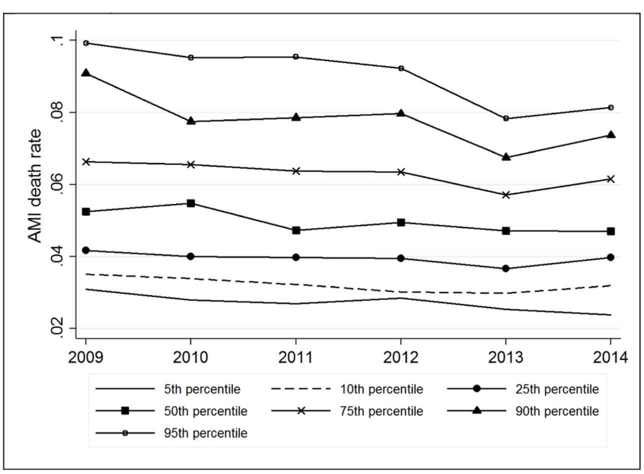

Fig. 2. AMI mortality rate over time.
Notes: 2009–2014 data. Annual AMI death rates are calculated as the total number of deaths within 30 days following an emergency AMI admission (patients 35–74 years old) over the total number of AMI admissions in each hospital.
Source: Health and Social Care Information Centre (HSCIC).

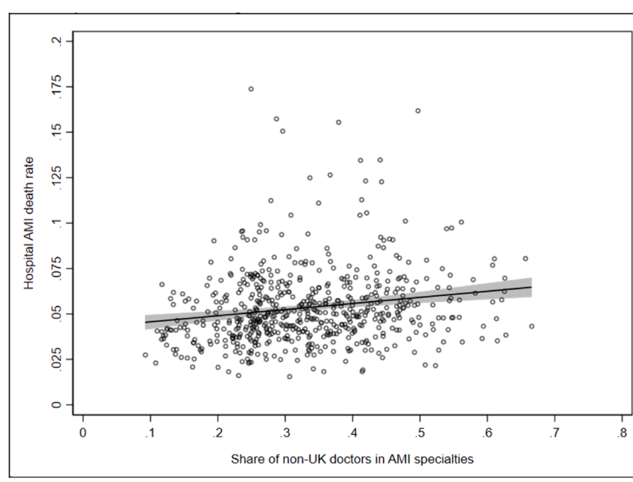

Fig. 3. AMI mortality and shares of foreign-trained doctors (2009–2014).
Notes: 2009–2014 data. Each dot represents a hospital-year cell. The solid line is a linear fit and the shaded area is the 95 % CI. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. AMI death rates are calculated as the total count of deaths within 30 days following an emergency AMI admission (patients 35–74 years old) over the total number of AMI admissions in a hospital-year cell.
Source: Health and Social Care Information Centre (HSCIC).

in Europe and 18.2 % in South Asia). Compared to other specialties, cardiothoracic surgery has a high presence of surgeons trained in countries with top medical schools (around 12 %). In other specialties, and particularly in acute internal medicine and cardiology, most foreign physicians come from outside Europe.

Descriptive statistics on hospital outcomes are presented in Table 3. While AMI mortality is declining, it varies significantly across hospitals. Fig. 2 illustrates the trend in AMI mortality over time, with a more pronounced decline observed in the upper part of the distribution and a more moderate decrease in the lower percentiles. Despite the overall decline, the variation across hospitals persisted, with mortality rates ranging from 2 % to 13 % in 2009 and from 2 % to 12 % in 2014. This persistence is largely due to the relatively stable number of AMI deaths per hospital over the period, with an 8.6 % increase (from an average of 13.4 deaths in 2009 to 14.5 in 2014), while the number of AMI admissions rose more substantially by 21 % (from an average of 260 admissions in 2009 to 315 in 2014). In contrast, overall mortality varied less across hospitals and remained stable throughout the period, with both the number of deaths and the total number of admissions increasing by 11 %.

In Fig. 3, AMI death rates for each hospital-year cell were plotted against the respective shares of foreign physicians in related specialties; the total number of observations over the 2009–2014 period is 580. The over-imposed linear prediction (along with its shaded 95 % confidence interval) suggests a positive association between the two variables considered. The empirical analysis that follows will formally test for this relationship after controlling for characteristics that vary at the hospital and the local level, as well as for hospital and time fixed effects.

3. Empirical strategy

The relationship between hospital quality and the share of foreign doctors is empirically tested using the following model specification:

$$y_{iht} = a_0 + a_1 F_{iht} + a_2 X'_{iht} + a_3 Z'_{ht} + \mu_h + \delta_t + u_{iht} \quad (1)$$

where y_{iht} denotes the AMI mortality rate in hospital i, located in the h-th LAD at year t. F_{iht} is the share of doctors in AMI-related specialties who obtained their medical qualification outside the UK. Hence, the parameter of interest is a_1. X'_{iht} is a vector of time-varying hospital-level characteristics controlling for hospital heterogeneity and patient case mix, Z'_{ht} is a vector controlling for the composition of local population and for time-varying characteristics at the LAD level, μ_i and δ_t are hospital and time fixed effects, respectively, and u_{iht} captures any residual variation. Moreover, models include hospital fixed effects, μ_h, that control for permanent differences between hospitals and areas (e.g., unobserved hospital quality, property prices, commute conditions, physical endowments etc.). They also include variables that can be thought of affecting the original allocation and subsequent internal mobility of doctors, i.e., AMI staff stability index, local area wage level, and immigration. Finally, models control for hospital characteristics, e. g., share of occupied beds, number of emergency admissions, nurses-to-doctors ratio, financial performance, ambulance response times etc. All variables are in logs, and standard errors are clustered by hospital. If the conditional independence assumption, $E[F_{iht}, u_{iht}|X_{iht}, Z_{ht}, \mu_h] = 0$, is satisfied, then the parameter a_1 measures the relationship between AMI mortality and the share of foreign doctors at the hospital level.

Nevertheless, the concern that foreign physicians may not be randomly distributed across hospitals cannot be completely ruled out; hence the results should not be read as causal. The endogenous clustering of immigrants across regions is a common problem in the literature. Shift-share instrumental variables approaches are usually adopted, under the assumption that immigrants locate in areas exhibiting higher densities of previously settled immigrants from their own country of origin (Card, 2001; Lazear, 2000). The underlying idea is that networks influence location decisions of newly arrived immigrants because they facilitate job and property search, and assimilation into the host area (Castro-Pires, 2023; Sá, 2014).[19] However, recent research has shown that this strategy is not likely to identify causal effects as it conflates biases from short- and long-term responses to local shocks (Jaeger et al., 2018). There could be some scope for endogeneity regarding the possible relocation of foreign doctors within the UK but given the relatively short period covered here this should not be a big problem. Therefore, the results based on Eq. (1) should not necessarily be interpreted as causal.

4. Results

4.1. Baseline results

Table 4 presents the baseline results. AMI death rates are regressed on the share of overseas-trained AMI doctors. Unconditional on hospital fixed effects and time-varying characteristics, the estimated coefficient (column 1) is positive and significant at the 1 % level. This is consistent with the graphical evidence in Fig. 3. However, AMI mortality may be influenced by unobserved, time-invariant hospital characteristics. For example, hospitals with weaker management, poorer infrastructure, and limited resources may be more likely to employ foreign doctors, possibly due to higher staff turnover and the need to prevent understaffing that would lead to worse outcomes. To address concerns about omitted variable bias and ensure that the baseline findings do not simply reflect broader hospital-wide characteristics, the model specification in column 2 includes hospital fixed effects. In this specification, identification stems from within hospital variation in the share of overseas-trained physicians in specialties involved in the treatment of heart-attacks. For instance, the timing of doctor retirements, maternity and other types of leave among staff, or the nationality distribution of the applicant pool when a hospital is hiring might introduce such sort of variation. Conditional on hospital fixed effects, the estimated coefficient of foreign doctors remains positive and statistically significant. Moreover, its increase compared to column 1 suggests that the initial estimate was biased downward. This pattern indicates a negative correlation between the share of foreign AMI doctors and hospital fixed effects. That is, hospitals with better inherent, time-invariant characteristics (e.g. better management, infrastructure etc.) that contribute to lower baseline AMI mortality tend to have lower shares of non-UK AMI doctors, on average. Conversely, in hospitals with poorer unobserved characteristics that result in higher baseline AMI death rates, the share of AMI doctors

[19] Shift-share approaches are more suitable when considering low-skilled immigrants, or those seeking less specialised jobs and are not fluent in the host country's language; hence they tend to locate close to individuals from their native country (Lazear, 1999). For example, the 2001 share of EU national residents in the area was found to be a good predictor of the current allocation of European nurses across NHS hospitals (Castro-Pires et al., 2023). Doctors, however, represent a small and highly specialised fraction of the local labour market (Giuntella et al., 2015); especially when considering specific medical specialties as in this paper. Hence, their allocation should not be expected to be strongly driven by past settlement patterns. Highly skilled professionals compete in the international medical labour market, and they should be more flexible and willing to accept job offers from hospital regardless their location, i. e. whether those hospitals are located (or not) near ethnic enclaves. Otherwise, they face the risk of human capital depreciation if they remain in their country of origin. Nevertheless, an instrumental variable specification was estimated through two-stage least squares (2SLS). Using individual-level LFS data from 2001 onwards, F_{iht} was sequentially instrumented with the historical shares of foreign doctors, medical workers, and all healthcare sector workers in the LAD each NHS hospital is located. However, past settlement patterns of doctors or workers in the healthcare sector were not good predictors of the current allocation of doctors; either their total share or those trained in specific parts of the world. All first stage F-stats were quite small; critical values ranged between 2 and 4.

Table 4
Foreign doctors and AMI hospital mortality.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Share of non-UK AMI doctors	.226*** (.057)	.284** (.131)	.261** (.125)	.275** (.132)	.279* (.142)	.317* (.180)	.250*** (.063)	.217*** (.072)
Local area characteristics	No	No	No	Yes	Yes	Yes	Yes	Yes
Hospital characteristics	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Hospital fixed effects	No	Yes	Yes	Yes	Yes	Yes	No	No
Year fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NHS area fixed effects	No	No	No	No	No	No	Yes	Yes
NHS area × year fixed effects	No	No	No	No	No	No	No	Yes
Observations	593	593	584	580	321	236	580	580
Hospitals	128	128	127	127	102	102	127	127

Source: HSCIC, LFS, ASHE
Notes: OLS estimates. 2009–2014 data. All variables are in logs. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. In columns 5 and 6, the model is estimated using 2-year and 3-year differences, respectively. Standard errors (in parentheses) are corrected for heteroskedasticity and clustering by hospital. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % level, respectively.

trained overseas is higher, on average. The standard error of the coefficient for foreign doctors increases in specifications including hospital fixed effects. This indicates that, in addition to the negative association between unobserved hospital quality and the share of foreign doctors, the share of foreign doctors shows limited variation within hospitals, remaining relatively stable over time. Specifically, the within-hospital standard deviation is 0.030, much lower than the between-hospital standard deviation of 0.106. In other words, some hospitals have consistently higher shares of foreign doctors, compared to others, and these shares do not vary significantly within individual hospitals over the period under study, even after accounting for hospital fixed effects.

Models in columns 3 and 4 control for time-varying heterogeneity at the hospital and the local area level, respectively. The number of observations varies across columns due to missing data on hospital and local-level characteristics, affecting a few providers over different years. Relatively to column 2, controlling for time-varying heterogeneity leads to a small reduction in the estimated coefficient of non-UK AMI doctors, implying that the influence of foreign doctors on hospital quality was partially capturing the influence of observable hospital and local area characteristics. An issue with time-varying hospital characteristics is that they could be endogenous functions of the share of foreign doctors themselves. For example, hospitals might be able to spend more (less) on other assets and infrastructure if the cost of recruiting and maintaining foreign doctors is lower (higher). However, the positive association between AMI mortality and the share of foreign doctors holds when the model only includes hospital fixed effects (column 1) that might be correlated with both AMI mortality and the share of foreign doctors. The same is true when only hospital fixed effects and time-varying demographic and socioeconomic variables at the local level are included as controls; the estimated coefficient of the foreign doctors' share is equal to 0.272 and significant at the 5 % level. Columns 5-6 rely on time-series variation and use 2-year and 3-year differences to estimate the relationship between heart attack mortality and dependence on foreign-trained physicians. The estimated coefficients are similar in sign and magnitude; however, they are noisier due to smaller sample sizes given that 2-year and 3-year differences were used. Finally, although controlling for a rich set of observables, AMI mortality could still be influenced by unobserved, time-varying heterogeneity. To account for this while avoiding collinearity issues, specifications in columns 7-8 include NHS area fixed effects, but not hospital fixed effects, and NHS area-year interactions.[20] The sample size remains the same as in column 4, while the estimated coefficients are significant at the 1 % level, albeit slightly decreased in magnitude. This suggests that time-varying heterogeneity, at least at the local area level, could partially explain the observed relationship, however, the estimated elasticity points to similar conclusions regarding the association between foreign-trained AMI doctors and AMI mortality.

The preferred model specification, in column 4, suggests that conditional on observed time-varying characteristics and fixed effects, increasing the share of foreign AMI doctors by 1 % is associated with a 0.28 % increase in AMI death rate, on average. Given the sample means of the AMI death rate (0.053) and the number of emergency AMI admissions (286), the estimated coefficient from the preferred model specification suggests that a 1 % increase in the share of non-UK AMI doctors is associated with an approximate increase of 0.042 heart attack deaths, on average, in a hospital with 286 patients admitted for heart failure within a year ($= 0.275\% \times 0.053 \times 286$). This finding is small; however, it is robust across a series of specifications and functional forms.[21] Moreover, this estimate is in line with those reported in studies using AMI mortality as an outcome. For instance, Gaynor et al. (2013) estimated that a 1 % increase in a hospital's market power leads to a 0.29 % rise in AMI mortality, while Propper and Van Reenen (2010) found that a 1 % increase in the hospital's outside wage is associated

[20] NHS areas refer to NHS Area Teams, which are sub-divisions of the NHS responsible for delivering healthcare services to their local populations. Before a restructuring in 2020, there were 25 NHS Area Teams.

[21] Several functional forms and model specifications were tested; and all results are available upon request from the author. For example, to avoid the use of log-linearised models (Santos-Silva and Tenreyo, 2006), Poisson regressions were run; the estimated coefficient was 0.304 (std. err. $= 0.139$). A fractional response model for bounded dependent variables (logit) was also considered (Papke and Wooldridge, 1996, 2008). The estimated coefficient was 0.320 and significant at the 5 % level. Moreover, the count of AMI deaths (instead of AMI death rates) was used as the dependent variable to avoid any transformation of the outcome variable. The model was estimated using Poisson and it additionally controlled for the (logged) number of emergency AMI admissions. The estimated coefficient was 0.229 and significant (std. err. $= 0.126$). Another concern could be that the dependent variable is truncated, i.e., information for hospitals with ≤ 5 AMI deaths was not provided. However, this ensures that there are no specialist hospitals in the estimation sample; the minimum value of total AMI admissions is 45 and the minimum value of total admissions is more than 12,000. Still, to ensure that there are no biases from this selection rule, the model was estimated using truncated Poisson regression; the estimated coefficient was 0.271 (std. err. $= 0.154$). For robustness, the dependent variable was set equal to 0 whereas AMI death counts were not provided; and the sample size increased to $N = 799$ hospital-year observations. This did not affect the results either; the estimated coefficient was 0.304 (std. err. $= 0.139$). Finally, results were similar to baseline estimates when I (i) run models on the sample of hospitals used in the differences estimation in columns 5-6, (ii) restricted the sample to a balanced panel of hospitals observed every year and (iii) used only hospitals that were observed for at least 4 and 5 years in the data. Also, while the full model specification controls for staffing variables (nurses-to-doctors ratio and staff stability index), the estimated coefficient of the share of foreign doctors is nearly identical ($b = 0.272$; std.err $= 0.131$) when the logged count of all AMI doctors is included as an additional regressor.

Table 5
Foreign doctors and AMI mortality by region and hospital size.

	Baseline result	London interaction	Excluding London	Hospital size interaction	Large hospitals	Medium & small hospitals
	[1]	[2]	[3]	[4]	[5]	[6]
(Log) share of non-UK AMI doctors	.275** (.132)	.288** (.136)	.264** (.133)	.363** (.161)	.033 (.235)	.371** (.164)
(Log) share of non-UK AMI doctors × London indicator	-	−446 (.534)	-	-	-	-
(Log) share of non-UK AMI doctors × large hospital indicator	-	-	-	−.298 (.299)	-	-
Local area characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Hospital characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Hospital fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	580	580	528	580	194	386
Hospitals	127	127	114	127	36	91

Source: HSCIC, LFS, ASHE
Notes: OLS estimates. 2009-2014 data. AMI death rate (log) is the dependent variable. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. Standard errors (in parentheses) are corrected for heteroskedasticity and clustering by hospital. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % level, respectively.

with a 0.52 % higher AMI mortality rate. In relation to the NHS choice-policy reforms of 2006, Cooper et al. (2011) demonstrated that AMI mortality declined 0.31 percentage points faster per year for patients treated in more competitive markets. However, Moscelli et al. (2018) reported insignificant effects on AMI and stroke mortality rates, though they observed a 0.62 % reduction in mortality for hip fracture patients. Friedrich and Hackmann (2021) showed that a 1% reduction in nurse employment led to a 0.25 % increase in the AMI mortality rate, with no significant effect on overall mortality.

As noted earlier, these findings should not be interpreted as causal. The use of hospital-level data limits the ability to examine the full range of factors influencing variations in the share of foreign-trained doctors within and between hospitals. A deeper understanding of these dynamics would require more detailed, doctor-level data over an extended period, enabling the exploration of exogenous factors such as timing of retirements, different types of leave, and the nationality distribution of applicants each time a hospital is hiring – factors that can impact staffing independent of hospital performance. Another potential concern is that hospitals' hiring and retention decisions systematically depend on past patient outcomes. While these factors could indeed influence staffing decisions, addressing this issue rigorously would require a longer time series to mitigate risks of overfitting, limited degrees of freedom, and insufficient temporal variation. Nonetheless, to empirically assess this hypothesis using the available data, the share of non-UK AMI doctors was regressed on hospital characteristics, fixed effects, and lagged AMI death rates (by one or two years). The results showed that the estimated coefficients for the lagged AMI rates were not statistically significant. The same was true when the logged count of all AMI doctors was used as the outcome variable instead.[22] However, since this paper does not explore these factors in depth, findings should be viewed as descriptive.

Apart from model specifications and functional forms, there were also robustness checks regarding the explanatory variable of interest. First, apart from those specialties considered as being typically involved in AMI treatment (Table 2), additional medical specialties were also included while constructing the share of AMI-related doctors, i.e. anaesthesiologists, general surgeons and general medical practitioners. This did not affect the results compared to the preferred model specification; the estimated coefficient of non-UK AMI doctors was similar. Moreover, to check the validity of the choice to calculate the share of foreign AMI doctors using only related specialties and address concerns about spurious correlations, Eq. (1) was re-estimated but using the overall share of foreign doctors instead, i.e., regardless of their medical specialty. The results did not support a relationship between AMI mortality and the overall share of foreign doctors. The estimated coefficient was equal to 0.210 and quite noisy (std. err. = 0.280). The magnitude and size of the estimated coefficient of non-UK AMI doctors was also dominated in a horse-ride regression controlling for both the overall and the AMI-specific shares. Thus, regressing cause-specific outcomes on the overall share of foreign doctors, regardless of their medical specialty, can be problematic. Instead, specialty-specific measures of foreign-trained physicians should be preferred. The overall share of foreign doctors might fluctuate due to changes in the headcounts of various medical specialties that are not directly related to the specific quality measure being analysed, potentially leading to biased estimates.[23] Moreover, the overall share of foreign doctors includes those working in AMI-related specialties; hence the two measures may be correlated. Results from additional falsification tests are discussed in Section 4.2.

Table 5 presents results on the heterogeneity of the association between AMI mortality and foreign physicians. Column 1 reports the baseline result from the preferred specification. To examine whether there is regional variation, the share of non-UK AMI doctors is interacted with a dummy variable equal to 1 for hospitals located in London (column 2). The coefficient of foreign doctors is close to the baseline one, and the coefficient of the interaction term is negative but not statistically significant. When London hospitals are excluded from the sample, in column 3, the estimated coefficient is close to the baseline one. Columns 4-6 explore heterogeneity based on hospital size. Hospitals were grouped by their volume of admissions into large, and medium and small ones, following the NHS National Patient Safety Agency (NPSA) classification. The period average of AMI admissions was 333 in large

[22] Findings were similar when the total sample was split based on hospitals' residual AMI mortality and the relationship was separately estimated for hospitals in the upper and lower halves of the residual distribution (following the procedure described in Section 4.3).

[23] In further checks, I calculated cause-specific mortality rates using information on deaths and admissions by diagnosis group (140 groups in total). The HSCIC made data for those 140 diagnosis groups publicly available only for years 2013–2014, hence they could only be used for a shorter period compared to the baseline panel (2009–2014). Each mortality rate was regressed on the overall share of foreign doctors and the usual set of fixed effects and time-varying hospital and local area controls. There was no consistent evidence that the overall (regardless of medical specialty) share of non-UK doctors is systematically related to specific conditions. The coefficient of the overall share of foreign doctors was negative when looking at certain types of cancer-related mortality (stomach, gastrointestinal organs, kidney and urinary organs, and multiple myeloma), and positive for some heart-related conditions (heart valve disorders and acute myocardial infarction). However, sample sizes were small. Degrees of freedom varied between 48 & 139, and all estimated coefficients were noisy. Results are available from the author upon request.

Table 6
Foreign doctors by region of training and AMI mortality.

	Total sample [1]	Excluding London [2]	Large acute hospitals [3]	Medium & small hospitals [4]
(Log) share of AMI doctors trained in:				
EEA	.079 (.057)	.090 (.056)	−.153 (.116)	.156** (.063)
Non-EEA	.205 (.134)	.191 (.138)	.335 (.273)	.151 (.151)
South EU	.028 (.030)	.034 (.031)	−.072** (.033)	.057 (.037)
EU Accession	.014 (.035)	.038 (.037)	−.084 (.056)	.065 (.040)
South Asia	.057 (.091)	.050 (.097)	.088 (.197)	.029 (.105)
Anglosphere	.057 (.036)	.036 (.036)	.057 (.052)	.056 (.048)
Arab	.036 (.047)	.034 (.036)	.094 (.109)	.013 (.055)
Sub-Saharan	.096** (.042)	.087** (.040)	.063 (.089)	.106** (.048)
English speaking	.208* (.112)	.193* (.112)	.172 (.203)	.195 (.139)
Non-English speaking	.134 (.086)	.134 (.088)	-.052 (.200)	.198** (.095)
Colonial ties	.174 (.106)	.185* (.108)	.307 (.216)	.125 (.130)
Top 100 med schools	.054 (.046)	.047 (.049)	-.053 (.170)	.096 (.059)
Observations	580	528	194	386
Hospitals	127	114	36	91

Source: HSCIC, LFS, ASHE
Notes: OLS estimates. 2009–2014 data. AMI death rate (log) is the dependent variable. Shares of AMI doctors trained in each country group are calculated as the number of AMI doctors obtained their medical qualification in that country group over the total headcount of AMI doctors in each hospital-year cell. The reported coefficients come from separate regressions. All models control for the full set of hospital and local level characteristics, and hospital and year fixed effects. Standard errors in parentheses are corrected for heteroskedasticity and clustering by hospital. Asterisks ***, ** and * denote statistical significance at the 1%, 5% and 10% level, respectively.

hospitals and 263 in medium and small acute hospitals. Columns 4-5 suggest that the share of non-UK doctors in large hospitals does not relate to AMI mortality. The baseline relationship is driven by small and medium hospitals, in column 6. The estimated coefficient, significant at the 5 % level, indicates that increasing the share of foreign doctors treating AMI patients in medium and small hospitals by 1 % is associated with a 0.37 % increase in AMI mortality. Considering that the period average of the AMI death rate those hospitals was 0.055, this implies that a 1 % increase in the share of non-UK AMI doctors in those hospitals is associated with an approximate increase of 0.054 deaths from heart attacks, on average.

The results in Tables 4 and 5 were based on the overall share of foreign AMI doctors, irrespective of the country where they obtained their medical qualification. Despite the regional variation in that share (Fig. 1), the distribution of foreign AMI doctors when comparing London and non-London hospitals (grouping together all other English regions) is similar. The mean share of non-UK AMI doctors is 33 % (std. dev. = 11 %) and 35 % (std. dev. = 10 %) in hospitals located outside and inside London, respectively. However, calculating shares of foreign doctors specific to the region of medical training reveals notable patterns. Doctors trained in Europe, South EU, Anglosphere countries, and countries with highly ranked medical schools are more concentrated in London hospitals. In contrast, those trained outside the EEA, in South Asia, in Arab countries, and in countries with former colonial ties to the UK are significantly fewer in London.[24] The literature is pointing towards the operation of environmental and organisational fixed effects, but there might be some implications associated with a place (region) of training fixed effect. Although such mechanisms cannot be adequately disentangled without linking detailed doctor-level data directly to patient outcomes, Table 6 checks for variation with respect to the region of training of foreign AMI doctors. Hence, headcounts of AMI doctors qualified in specific regions of the world (the country groups in Table 2) were divided by the total headcount of AMI doctors in each hospital-year cell. Each coefficient in Table 6 comes from a separate regression. Results are shown for the total sample, by region and hospital size. For the total sample of hospitals (column 1) and the sample of hospitals located outside of London (column 2), there are statistically significant results when considering doctors trained in sub-Saharan countries, English-speaking countries and countries having colonial ties with the UK. Regarding the sub-sample of large hospitals (column 3), AMI mortality is lower in hospitals with higher shares of AMI doctors trained in South EU countries. This is also the case for hospitals with higher shares of European doctors, and doctors from countries with highly ranked medical schools although those point estimates are very noisy. Finally, when considering the sub-sample of small and medium-sized hospitals (column 4), all point estimates are positive. Moreover, the associations with AMI mortality are statistically significant at the 5 % level when considering shares of AMI doctors trained in EEA, sub-Saharan, and non-English-speaking countries.

4.2. Falsification tests

Since specific medical specialties are involved in AMI treatment, AMI mortality should not systematically vary with the proportion of foreign-trained doctors in specialties entirely unrelated to heart attack care. To rule out concerns about such spurious correlations, a series of falsification tests were conducted, demonstrating that AMI mortality is associated only with the share of foreign-trained doctors in relevant specialties. As discussed in Section 4.1, it is not linked to the overall proportion of foreign doctors across all specialties in a hospital, and it should not be linked to the share of foreign doctors in specific, unrelated specialties either. Otherwise, the baseline findings could merely reflect random variation or broader hospital-wide hiring patterns rather than an association specific to AMI treatment. For example, obstetrics and gynaecology is a specialty rather unlikely to be involved in emergency AMI admissions. Hence, the share of obstetricians trained abroad over the total headcount of obstetricians in each hospital-year cell was calculated. Table 7 presents the results for various samples. Panel A considers all acute hospitals. Column 1 reports the baseline coefficient. In column 2 the share of AMI-treating doctors was replaced with the share of non-UK obstetricians and gynaecologists. The sample size is slightly different as this medical specialty was not available in all hospitals treating AMI admissions. The estimated coefficient is small, negative, and not significant. In column 3 both the shares of AMI and maternity doctors trained outside the UK are included. Again, foreign obstetricians do not explain variation in AMI mortality. On the other hand, the coefficient of non-UK AMI doctors is close to the baseline point estimate. The same exercise is done for hospitals outside London (panel

[24] Comparisons were performed on the sample of AMI-treating hospitals. Each region-specific share of non-UK doctors was regressed on a London hospital indicator and a set of year fixed effects. Regressions were weighted by the total headcount of doctors and the standard errors were clustered by hospital.

Table 7
Foreign doctors and AMI mortality: Falsification tests.

	Baseline results	Obstetricians & gynaecologists		Paediatricians		Orthopedicians		Clinical radiologists		Gastroenterologists	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
	Panel A: Total sample										
(Log) share of non-UK AMI doctors	.275** (.132)	-	.250*	-	.272**	-	.251*	-	.240*	-	.227*
			(.137)		(.137)		(.134)		(.132)		(.134)
(Log) share of non-UK doctors from unrelated specialty	-	−.072	−.079	.014	.009	.031	.015	−.022	−.020	.004	.003
		(.114)	(.107)	(.019)	(.020)	(.089)	(.087)	(.089)	(.187)	(.009)	(.009)
	Panel B: Excluding London										
(Log) share of non-UK AMI doctors	.264** (.133)	-	.230*	-	.285**	-	.240*	-	.236*	-	.208
			(.138)		(.137)		(.136)		(.134)		(.132)
(Log) share of non-UK doctors from unrelated specialty	-	−.058	−.060	−.081	−.113	.018	−.002	−.069	−.067	.010	.009
		(.116)	(.110)	(.100)	(.103)	(.092)	(.091)	(.090)	(.088)	(.011)	(.011)
	Panel C: Large acute hospitals										
(Log) share of non-UK AMI doctors	.033 (.235)	-	.043	-	.022	-	.036	-	.020	-	.031
			(.226)		(.245)		(.229)		(.234)		(.230)
(Log) share of non-UK doctors from unrelated specialty	-	−.196	−.198	.054	.049	−.232	−.232	−.058	−.057	−.023	−.024
		(.231)	(.230)	(.231)	(.239)	(.267)	(.267)	(.195)	(.197)	(.028)	(.027)
	Panel D: Medium and small hospitals										
(Log) share of non-UK AMI doctors	.371** (.164)	-	.343**	-	.371**	-	.332*	-	.310*	-	.320*
			(.176)		(.168)		(.167)		(.163)		(.170)
(Log) share of non-UK doctors from unrelated specialty	-	.025	.024	.009	.002	.101	.078	.016	.017	.010	.009
		(.137)	(.125)	(.019)	(.020)	(.093)	(.088)	(.076)	(.074)	(.009)	(.009)
Hospital & local area controls	Yes	Yes		Yes		Yes		Yes		Yes	
Hospital & year fixed effects	Yes	Yes		Yes		Yes		Yes		Yes	

Source: HSCIC, LFS, ASHE
Notes: OLS estimates. 2009–2014 data. AMI death rate (log) is the dependent variable. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. The shares of non-UK doctors from an unrelated specialty are calculated as the headcount of doctors in that specialty trained abroad over the total headcount of doctors in that specialty in each hospital-year cell. All models control for the full set of hospital and local level characteristics, and hospital and year fixed effects. Standard errors in parentheses are corrected for heteroskedasticity and clustering by hospital. Asterisks ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % level, respectively.

B), large hospitals (panel C), and medium and small ones (panel D). Coefficients for foreign AMI doctors in columns 2-3 confirm the relationship being driven by small hospitals and those located outside London.

Paediatrics is another unrelated specialty, particularly because AMI death rates are calculated only for patients 35–74 years old. In column 4, the share of non-UK AMI doctors is replaced with that of overseas-trained paediatricians. Again, there is no association with AMI mortality; the estimated parameter is practically zero. More importantly, the coefficient of foreign AMI doctors has the same sign and magnitude when shares of both specialties are included (column 5). This result is confirmed in panels B-D where the sample is split by region and hospital size. The same conclusion is drawn when performing similar placebo tests with foreign physicians from other unrelated specialties, i.e. orthopaedic surgeons (columns 6-7), clinical radiologists (columns 8-9) and gastroenterologists (columns 10-11). Overall, these placebo regressions confirm the hypothesis that AMI deaths do not systematically vary with shares of foreign doctors practising unrelated specialties. In a final falsification test, the share of foreign doctors practising all medical specialties not involved in AMI treatment (88 in total) was used. The results (available upon request) support the baseline scenario. The estimated coefficient of the share of foreign doctors practising all other (non-AMI) specialties was −0.184 and not statistically significant. When both non-AMI and AMI-related shares were controlled for, the effect was driven by the latter; the coefficient for foreign non-AMI doctors was negative and not significant.

So far heart attack mortality has been used as an outcome, which is a reliable measure of hospital quality for reasons earlier discussed. When considering other death rates as outcomes, there is no evidence of a relationship between hospital performance and the share of overseas-trained physicians. Appendix Table A2 presents those results. In column 1, the overall mortality rate (encompassing deaths from all causes) is regressed on the share of all overseas doctors, calculated as the headcount of doctors from all medical specialties trained abroad over the total headcount of doctors in each hospital-year cell. The estimated coefficient is not significant. This is also the case when considering mortality rates by admission type (elective or non-elective) and place of death (inside or outside the hospital within 30 days of discharge), in columns 2-5.[25] Mortality outcomes that are not linked to certain conditions do not accurately reflect a hospital's performance in managing specific conditions, such as heart attacks. Higher overall mortality doesn't necessarily reflect poor AMI care, especially if a hospital tends to treat more severely ill patients or those with multiple comorbidities. Also, total mortality can be influenced by many causes that do not respond to better treatment, i.e. they are not amenable to more timely and effective care (Gaynor et al., 2013). Additionally, variation in the overall death rate might be driven by deaths from causes unrelated to the specialties that influence changes in doctor headcounts. Consequently, using mortality rates and staffing variables across all specialties can distort the analysis. Even when considering mortality from all non-elective admissions as an outcome, the results may be noisy results due to the inclusion of various specialties and medical conditions. Therefore, a weaker (or no) relationship should be expected.[26] A similar pattern is observed when regressing all-cause mortality from non-elective surgeries on the share of non-UK surgeons. In this case, the medical specialties considered include cardiothoracic surgery, general

[25] Results are robust to various specifications and functional forms. Using death rates that are specific to the socio-economic status of patients (as measured by the Index of Multiple Deprivation) did not show any significant relationship with the overall share of foreign-trained doctors. All results are available upon request.

[26] In their study on the impact of hospital competition on patient outcomes, Gaynor et al. (2013) also considered death rates from all non-elective admissions as an alternative outcome to AMI mortality. Their results were much weaker as compared to those using AMI mortality as the dependent variable.

surgery, neurosurgery, paediatric surgery, orthopaedic surgery, vascular surgery, and acute internal medicine. In column 6, the estimated coefficient is close to zero and not significant. Furthermore, the results did not reveal a link between foreign doctors in specific specialties and hospital quality when alternative condition-specific mortality rates were considered. For example, in the case of stroke death rates (column 7), the share of foreign doctors was calculated based on headcounts from specialties directly involved in stroke treatment, such as neurology, neurosurgery, and acute internal medicine (Meretoja et al., 2017).[27] The relationship between stroke death rates and foreign doctors was not significant (column 7). Similarly, no significant relationship was observed when regressing death rates associated with fractured proximal femur on the shares of foreign-trained orthopaedic surgeons (column 8).[28] Overall, these falsification tests provide further credibility to the baseline evidence, reinforcing that the observed baseline association is specific to the treatment of heart attacks rather than reflecting broader, hospital-wide hiring trends that are similar across all medical specialties within a hospital.

4.3. Hospital quality and AMI treatment

Incorporating hospital fixed effects into the models and conducting falsification tests help ensure that the baseline evidence is not driven by spurious correlations arising from hospital-wide hiring practices or other broad organisational factors. However, despite their robustness, findings may still reflect a selection process specific to the treatment of heart attack admissions rather than a genuinely causal effect. For example, hospitals with higher AMI mortality may struggle to attract and retain domestically trained AMI specialists due to factors such as poor reputation, high turnover, or resource constraints. As a result, they may rely more heavily on overseas-trained staff to fill critical gaps in these specialties and mitigate worse patient outcomes given those constraints. This suggests that the observed relationship may stem from systematic differences in the hiring and retention of AMI specialists across hospitals with varying performance levels in terms of heart attack treatment, rather than from a direct effect of foreign-trained doctors on AMI mortality. Indeed, the results in Table 4 implied that the share of foreign doctors tends to be higher in hospitals of lower (unobserved) quality. If such a selection process is at play, the estimated relationship between AMI mortality and the share of foreign AMI doctors, should be stronger in lower-quality hospitals and weaker in higher-quality ones.

To test this hypothesis, hospital quality is approximated by the predicted fixed error component after regressing AMI mortality on the usual set of observables plus time and hospital fixed effects but excluding the share of foreign AMI doctors. A lower (higher) residual value should indicate higher (lower) hospital quality in terms of heart attack treatment. Using the fixed error component, hospitals were ranked into quartiles and Eq. (1) was separately estimated for each quartile.[29] The results of this heterogeneity analysis are in Table 8. Columns 2, 4, 6 and 8 report the estimated coefficient for each quartile. As expected, the AMI mortality rate significantly increases across the residual distribution (based on a regression of AMI mortality on quartile indicators and year fixed effects). For hospitals binned within the first two and fourth quartiles, the coefficients of foreign AMI doctors are positive, similar in magnitude, but not statistically significant. However, in the third quartile, the coefficient increases and becomes significant, indicating a stronger association in hospitals within this range of the residual distribution.[30] Consistent with the baseline findings, columns 1, 3, 5 and 7 of Table 8 show that the share of foreign AMI doctors (especially those from non-EEA countries) increases from the first to the fourth quartile of the residual AMI quality distribution. This suggests that those doctors are disproportionately employed in worse performing hospitals that rely more on overseas-trained staff. Meanwhile, the average annual number of heart attack admissions declines across the residual quality distribution, with 59–64 % of total AMI cases each year being treated in higher-quality hospitals. Similarly, the percentage of emergency AMI admissions (over the total non-elective admissions) also decreases across the residual quality distribution. Both the decreasing proportion of AMI admissions and the absolute number of AMI cases in worse-performing hospitals highlight the importance of specialisation in achieving better outcomes. In other words, hospitals that handle fewer heart attack admissions may have less experience or fewer resources to deliver optimal care, hence amplifying the challenges faced by foreign-trained AMI doctors working in such settings. Therefore, even though the relationship between overseas-trained physicians and AMI mortality is significant only for hospitals binned within the third quartile, i.e. those that treat fewer heart attack admissions, this result should not be overlooked, as those hospitals may serve specific populations that have limited access to higher-quality care.

When considering shares of foreign AMI doctors specific to the region of their training, those trained in Europe, South EU, Anglosphere countries, and countries with top-quality medical schools are nearly equally distributed across residual quartiles. However, there is a positive and significant coefficient when considering those from EEA countries working in hospitals in the third quartile of the residual distribution. On the other hand, shares of doctors trained in non-EEA, South Asia, Arab world, and sub-Saharan Africa countries, are higher in the upper two

[27] Similarly to when AMI mortality was used as outcome, a broader set of medical specialties was also considered, i.e. including emergency medicine, internal medicine, cardiology, rehabilitation medicine, but the results were similar.

[28] These results hold regardless the hospital's location and size. Moreover, death rates related to non-elective surgeries, strokes, and fractured proximal femur (columns 6-8) in Appendix Table A2, were not correlated with the total share of non-UK doctors either. Moreover, the zero effects when considering these alternative mortality rates hold when outcome-specific shares of foreign doctors (in columns 6-8) were replaced by shares of foreign doctors from unrelated specialties, i.e. those in columns 2–11 in Table 8. In all cases, the estimated coefficients of the shares of foreign doctors practising unrelated specialties were very close to zero and not significant, and so were the estimated coefficients of the shares of foreign doctors practising specialties related to each outcome in horse-riding regressions. All results are available upon request from the author.

[29] Dickson (2013) followed a similar approach to evaluate the impact of education on wages.

[30] These results hold when weighting each hospital-year observation by caseload, defined as the number of AMI cases per hospital. As in Table 8, the coefficients of foreign-trained doctors are statistically significant only for hospitals in the third quartile of the residual distribution. Specifically, the estimated coefficients (standard errors) are as follows: 0.617 (0.208) for non-UK doctors, 0.206 (0.078) for EEA doctors, 0.126 (0.050) for South EU doctors, 0.192 (0.105) for doctors from Arab countries, and 0.481 (0.128) for doctors from non-English-speaking countries. The coefficients for all other region-specific shares of overseas doctors remain similar to those in Table 8 but are not statistically significant as well. There are no implications of residual hospital quality when considering other outcomes, i.e. death rates from strokes, non-elective surgeries, and fracture proximal femur. As in the AMI case, the outcome-specific fixed error component was estimated, and Eq. (1) was run separately for each quartile of the residual distribution. Stroke-related mortality increases with the residual quantile; however, the share of stroke-treating foreign doctors remains relatively stable, ranging from 29 % to 35 %. Similarly, there was no evidence that foreign-trained medicals in condition-specific specialties are related to the other two death rates, regardless how their hospital ranks in terms of quality. Results are available from the author upon request.

Table 8
Foreign doctors and AMI mortality by quartile of the AMI mortality residual distribution.

	1st quartile		2nd quartile		3rd quartile		4th quartile	
	Mean [std. dev.] [1]	Coefficient (std. err) [2]	Mean [std. dev.] [3]	Coefficient (std. err) [4]	Mean [std. dev.] [5]	Coefficient (std. err) [6]	Mean [std. dev.] [7]	Coefficient (std. err) [8]
AMI death rate	.039 [.012]	-	.047 [.012]	-	.056 [.013]	-	.065 [.026]	-
Number of AMI admissions	378 [148]	-	296 [177]	-	251 [130]	-	171 [126]	-
% of AMI admissions	.118 [.068]	-	.095 [.061]	-	.085 [.032]	-	.081 [.056]	-
(Log) share of AMI doctors trained in:	-	-	-	-	-	-	-	-
Outside the UK	.283 [.084]	.165 (.257)	.331 [.112]	.173 (.270)	.347 [.088]	.457* (.255)	.424 [.122]	.251 (.399)
EEA	.061 [.030]	.028 (.145)	.068 [.039]	−.028 (.101)	.063 [.029]	.187** (.078)	.073 [.041]	.247* (.131)
Non-EEA	.211 [.076]	.147 (.278)	.252 [.099]	.254 (.268)	.273 [.076]	.146 (.240)	.336 [.134]	.154 (.320)
South EU	.020 [.018]	−.062 (.059)	.022 [.021]	.027 (.047)	.015 [.011]	.119* (.051)	.021 [.025]	.070 (.101)
EU Accession	.023 [.016]	−.086 (.068)	.028 [.020]	−.051 (.074)	.029 [.017]	.057 (.060)	.034 [.016]	.105 (.077)
South Asia	.135 [.058]	−.053 (.181)	.160 [.075]	.091 (.248)	.174 [.056]	−.012 (.201)	.221 [.103]	−.082 (.151)
Anglosphere	.013 [.010]	.052 (.089)	.014 [.011]	.086 (.085)	.009 [.007]	.076 (.069)	.010 [.009]	.137 (.146)
Arab	.038 [.021]	.050 (.090)	.043 [.023]	−.022 (.121)	.048 [.018]	.135 (.108)	.056 [.035]	.097 (.142)
Sub-Saharan	.024 [.014]	.040 (.054)	.029 [.015]	.165** (.080)	.033 [.017]	.073 (.102)	.039 [.021]	.164 (.164)
English speaking	.174 [.062]	.134 (.192)	.205 [.081]	.310 (.269)	.219 [.065]	.105 (.256)	.271 [.109]	.039 (.223)
Non-English speaking	.101 [.041]	−.026 (.151)	.118 [.046]	.097 (.147)	.121 [.042]	.392*** (.127)	.142 [.044]	.242 (.292)
Colonies	.186 [.069]	.222 (.176)	.216 [.084]	.264 (.283)	.237 [.065]	.083 (.222)	.297 [.126]	.102 (.272)
Top 100 med schools	.034 [.020]	.086 (.112)	.035 [.026]	.015 (.092)	.027 [.015]	.123 (.088)	.033 [.034]	.003 (.143)
Hospital & local area controls	-	Yes	-	Yes	-	Yes	-	Yes
Hospital & year fixed effects	-	Yes	-	Yes	-	Yes	-	Yes
Observations (Hospitals)	178 (32)		144 (32)		148 (32)		110 (31)	

Source: HSCIC, LFS, ASHE
Notes: OLS estimates. 2009-2014 data. AMI death rate (log) is the dependent variable (columns 2, 4, 6, 8). Shares of AMI doctors trained in each country group are calculated as the number of AMI doctors obtained their medical qualification in that country group over the total headcount of AMI doctors in each hospital-year cell. All models control for the full set of hospital and local level characteristics, and hospital and year fixed effects. Standard errors in parentheses are corrected for heteroskedasticity and clustering by hospital. Standard deviations in brackets. In columns 2, 4, 6 and 8 each cell is a separate regression. In columns 1, 3, 5 and 7 statistics for AMI death rates are weighted by the total number of AMI admissions in each hospital-year cell. The percentage of AMI admissions is calculated over the total number of non-elective admissions. Asterisks ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % level, respectively.

quartiles of the residual distribution. Regarding doctors trained in sub-Saharan Africa, their association with AMI mortality is sizeable and significant when considering hospitals in the second quartile of the residual quality distribution. Also, the coefficient for doctors trained in non-English-speaking countries is large and significant at the 1 % for the sub-sample hospitals in the third quartile. With respect to other hospital characteristics, nearly 40 % of large hospitals are observed in the bottom quartile (about 52 % in the left part). Also, 56 % of London hospitals, 76 % of teaching hospitals and 56% of Foundation Trusts are in the bottom half of the residual quality distribution.[31]

The fact that the association between heart attack mortality and the share of AMI doctors becomes stronger in lower-performing hospitals could be related to specific conditions related to the quality of treatment AMI patients receive in those hospitals, rather than the intrinsic quality of foreign-trained physicians. According to medical research, more than 20 % of the variation in AMI mortality is attributed to differences in treatment quality (Chung et al., 2015). Therefore, the results could be driven by hospitals that are lagging in terms of optimal AMI treatment provision. One source of information regarding AMI treatment is the Myocardial Ischaemia National Audit Project (MINAP), managed by the National Institute for Cardiovascular Outcomes Research (NICOR). Information is collected every time professional help is being asked for, e.g. an emergency call, self-presentation at an Emergency Department or transfer from another hospital.[32] Based on the results of an electrocardiogram, patients are split into those with an ST-elevation myocardial infarction (STEMI), and the non-ST-elevation myocardial infarction ones (nSTEMI). Compared to the nSTEMI patients, STEMI ones are in higher short-term risk as they suffer from a complete blockage of a coronary artery and need immediate treatment to re-open it.[33] Timely provision of all possible aspects of care leads to improved hospital performance (Simms et al., 2013). According to guidelines from the National Institute for Health and Care Excellence (NICE), a coronary angioplasty (primary Percutaneous Coronary Intervention; pPCI) is the preferred treatment.[34] Ideally, STEMI patients should receive a pPCI as soon as possible in a hospital with a designated Heart Attack Centre (HAC).[35] MINAP data report the percentage of patients who received pPCI within 90 min of arrival at a HAC (door-to-balloon time), and the percentage of those received it within 150 since help was called for (call-to-balloon time).

To investigate whether variation in treatment affects AMI mortality and what the implications for the relationship with foreign AMI doctors are, MINAP data were merged into the hospital-level panel used for the

[31] Foundation Trusts are NHS organisational units that have a certain degree of independence, allowing for more flexibility in financial and operational management to better meet their local demand of healthcare.

[32] More information on MINAP is available here: www.nicor.org.uk/national-cardiac-audit-programme/myocardial-ischaemia-minap-heart-attack-audit/.

[33] MINAP records most STEMI patients in English hospitals. Data collection for nSTEMI patients (i.e., the share of those admitted to cardiac wards and the share of those seen by a cardiologist) is not complete and varies substantially across providers. Hence, nSTEMI patients are under-represented in the MINAP data. For instance, in financial year 2013/14, there were 80,724 heart attacks recorded in MINAP; 39 % of them were STEMI and 61 % were nSTEMI. In general, nSTEMI patients face a lower early death risk, they are more difficult to be diagnosed, and they do not need emergency treatment. Therefore, they are not always admitted to specialised care units (cardiac care wards), and they are not always treated by cardiologists.

[34] The use of thrombolytic treatment in the management of heart attack is declining. In 2013 only 2 % of STEMI patients received it; mostly when timely pPCI is not possible, e.g. in remote locations. The role of paramedics and care received in the ambulance might still be important, however, those incidences are quite few (MINAP 2014; Gershlick et al., 2013).

[35] Patients with heart attacks characterised by ST-elevation are taken by ambulance directly to the catheter laboratory of the nearest HAC, often bypassing smaller hospitals and the Accident and Emergency (A&E) department of the receiving hospital.

main analysis.[36] Since MINAP was only available for 2012–2014, the starting point was to verify that the graphical evidence in Fig. 3, which covers the entire period (2009–2014), also holds when using data from the shorter period for which MINAP data is available. Fig. A1 confirms the positive correlation between AMI mortality and the share of foreign-trained AMI doctors when limited to data covering only the 2012–2014 period. Moreover, Fig. A2 shows that AMI mortality (a) decreases with the share of patients received a pPCI within 90 min from their arrival to a HAC (panel A), and (b) increases with the time until treatment (panel B). Hence, availability of timely provision of pPCI reduces AMI mortality, and this holds regardless the patients' pathway between asking for help and receiving that treatment. In Table A3, AMI mortality is significantly lower in hospitals capable to provide a pPCI within 90 min compared to the rest of hospitals (panel A), and regardless how patients were admitted to those hospitals, i.e. directly or through transfer from another hospital (in panels B and C, respectively). Moreover, the share of foreign AMI doctors is higher by 6.5 p.p., on average, in hospitals without a designated HAC to provide timely treatment.

When hospitals are split based on whether appropriate treatment is available, AMI mortality increases with the share of foreign AMI doctors only in hospitals without a HAC (Fig. A3, panels b, d, and f). Whereas appropriate treatment is available, heart attack mortality slightly declines with the share of foreign AMI doctors. This is true both for direct admissions (panels a and c) and admissions transferred to a HAC from another hospital (panel e). A final heterogeneity analysis using combined information from the baseline hospital panel and the MINAP data for the sub-period that this is possible (2012–2014) validates this graphical evidence. Table 9 displays the results. Consistent with Fig. A1, column 1 reports a positive and significant coefficient of non-UK doctors in AMI-related specialties when using a shorter period. That coefficient is smaller and not significant when the sample is restricted to hospitals capable of providing pPCI within 90 min of arrival to their HAC (column 2). A positive and significant association between AMI mortality and foreign AMI doctors is only observed for hospitals not providing timely pPCI (column 3). In other words, when effective interventions are available and promptly administered, disparities linked to staffing are not linked to AMI mortality.

Specifications in columns 4-5 include a binary variable indicating whether hospitals provide pPCI to AMI-admitted patients within 90 min of arrival at their HAC, along with its interaction with the share of foreign-trained AMI physicians. Column 4 suggests that hospitals providing timely pPCI have lower AMI mortality rates, as shown in Fig. A2. The coefficient of the foreign doctors' share slightly decreases, compared to column 1, and becomes non-significant, indicating that when provision of treatment is explicitly considered the relationship between AMI mortality and foreign doctors is not different from zero on average, i.e. in hospitals that provide pPCI within 90 min of arrival at their HAC and those that do not. Including an interaction term between these two variables, in column 5, isolates the association between AMI mortality and the share of foreign AMI doctors in hospitals where timely provision of pPCI is not provided, i.e. when the pPCI dummy variable is switched off. In this case, the estimated coefficient of the share of foreign doctors is significant and identical to the one estimated using only the sub-sample of hospitals not providing pPCI, in column 3. Also, provision of recommended treatment significantly reduces hospital AMI mortality; the coefficient of the pPCI dummy variable is negative and significant. Consistent with the graphical evidence in Fig. A3, the interaction term enters with a negative sign indicating that the association between AMI mortality and foreign doctors is slightly negative whereas timely pPCI

Table 9
Foreign doctors, AMI mortality and provision of treatment.

	All hospitals [1]	Hospitals providing pPCI within 90 min of arrival at HAC [2]	Rest of hospitals [3]	All hospitals [4]	All hospitals [5]
(Log) share of AMI non-UK doctors	.147** (.075)	.098 (.102)	.223** (.114)	.119 (.077)	.221** (.106)
Hospitals providing pPCI within 90 minutes of arrival at HAC (0/1)	-	-	-	−.232*** (.062)	−.408** (.166)
Interaction term	-	-	-	-	−.157 (.139)
Hospital controls	Yes	Yes	Yes	Yes	Yes
Region controls	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes
Observations	286	143	143	286	286

Source: Health and Social Care Information Centre (HSCIC); Myocardial Ischaemia National Audit project (MINAP) provided by the National Institute for Cardiovascular Outcomes Research (NICOR).
Notes: OLS estimates. 2012–2014 data. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. AMI death rates are calculated as the total count of deaths within 30 days after an emergency AMI admission (for patients aged 35–74 years old) over the total number of AMI admissions for each hospital and year. Hospitals providing pPCI within 90 minutes of a patient's arrival at their designated HAC are flagged with a binary (0/1) indicator. The interaction term refers to the interaction between the binary indicator and the (log) share of non-UK AMI doctors.

provision is available; however, it is imprecisely estimated. Therefore, there is no strong evidence that the association between AMI mortality and foreign physicians in related specialties significantly differs depending on whether pPCI is provided timely or not. These patterns hold regardless of how patients were admitted to a HAC, i.e. directly or they were transported from another provider (panels A and B, respectively, in Table A4). The results in Tables 9 and A4 are robust to the exclusion of hospital-level controls that could be thought of as functions of the foreign doctors' share; for example, if hospital-level controls are not included in the model, the estimated coefficient that corresponds to column 1 of Table 9 is equal to 0.159 and significant at the 5 % (std. err. = 0.070). Again, these findings offer an overview of the patterns observed in the data without necessarily implying causal links. Since the endogeneity of the share of foreign doctors cannot be completely ruled out, it follows that the interaction term can also be subject to this problem. Bun and Harrison (2019) discuss this issue and suggest some functional form identification solutions.

Overall, Table 9 suggests that providing timely and appropriate treatment significantly reduces AMI mortality and should be explicitly accounted for while investigating the relationship between patient outcomes and staff variables. In the sub-period where data on treatment timeliness is available, the positive association between AMI mortality and the share of foreign doctors in relevant specialties is statistically significant only in hospitals unable to offer timely pPCI at their HAC. This reinforces earlier results, indicating that this association is stronger in lower-quality hospitals, i.e. those with higher residual AMI mortality, and that foreign doctors are more prevalent in hospitals with characteristics that result in higher AMI death rates. This underscores the role of advancements in care delivery and access to preferred treatments in promoting consistent patient outcomes across hospitals of varying quality and workforce composition.

[36] It should be noticed that there are only data for hospitals provided pPCI at least 10 times within the year; the remaining ones are assumed not to be offering this sort of treatment. Also, information is not provided for all nSTEMI patients because some hospitals lack the resources to provide data for them, and those patients are less likely to be admitted to cardiac wards (MINAP 2014).

5. Conclusions

The English NHS has long depended on recruiting overseas-trained medical and clinical staff to meet rising service demand and to address shortages in the domestic workforce. Evidence from the medical literature suggests that, compared to UK-trained doctors, those trained abroad perform worse – on average – in annual competency reviews, they have a lower likelihood of passing skills assessments, and they are more likely to be referred for further investigation when inquiries about their performance arise. As a result, concerns about their fitness to practice and their impact on patient outcomes have attracted significant attention. While recent studies have examined the impact of foreign nurses on NHS hospital performance, there is no direct evidence on what foreign-trained doctors imply for hospital quality. This paper attempted a first empirical investigation of this question.

The main part of the analysis was based on a hospital-level panel covering the period 2009–2014. The hospital outcome considered here was heart attack (AMI) mortality, a reliable and commonly used quality measure in the literature. Accordingly, the explanatory variable of interest was the share of foreign-trained doctors working in specialties typically involved in the treatment of patients admitted with heart attack. To control for hospital and local area characteristics that can be linked to both AMI mortality and the share of foreign doctors, several administrative data sources and surveys were put together. Overall, the results suggested a positive association between death rates associated with emergency heart attack admissions and the share of foreign doctors practising related medical specialties. This finding was robust to the inclusion of hospital and local area characteristics, hospital fixed effects and group-specific time trends. Several placebo tests confirmed both the validity and specificity of this finding. The association between AMI mortality and the share of foreign doctors in related specialties was found to be statistically significant only in smaller hospitals, and hospitals of poorer unobserved quality, i.e. those ones in the third quartile of the AMI death rate residual distribution. Using information for a shorter period (2012–2014) regarding timely treatment provision, indicated that the observed association between AMI mortality and foreign-trained physicians holds only in hospitals not being capable to timely provide the preferred type of treatment to their most vulnerable patients. Additionally, the share of foreign AMI specialists was higher in those underperforming and resource-constrained hospitals, suggesting that structural challenges and hospital characteristics may drive hiring and reliance on overseas-trained medical doctors rather than those doctors causing worse outcomes.

Hence, the findings presented here should be viewed as descriptive rather than causal. The share of foreign AMI doctors depends on hospitals' hiring decisions, which may be influenced by past patient outcomes, resource constraints and other structural challenges, implying that a selection process can be at play. Hospitals that struggle with healthcare delivery may be more likely to recruit foreign-trained physicians, making these hiring patterns a potential indicator of unobserved hospital quality. However, exogenous factors -such as the timing of doctor retirements, various types of leaves, or shifts in the nationality distribution of applicants every time a hospital is recruiting- can also drive changes in the share of foreign doctors, independent of hospital performance. In the hospital-level panel used here the variation in the share of foreign-trained physicians is considerably higher between hospitals rather than within hospitals. However, a limitation of this study is that – due to the nature of the data used – it does not thoroughly delve into the factors driving that variation between and within hospitals, leaving this issue open for future research. In any case, demonstrating any performance differences between home-trained and overseas-trained doctors will be challenging; there are numerous, complex factors affecting patient outcomes that cannot be reduced to a safe conclusion of whether quality of care systematically varies with the place of medical qualification (Esmail and Simpson, 2017).

Despite its descriptive nature , the main messages of this study are that (a) the share of foreign doctors is higher, on average, in hospitals with lower unobserved quality and in those with characteristics associated with higher AMI mortality rates, and (b) the positive association between AMI mortality and the share of foreign-trained doctors working in related specialties appears to be statistically significant in those hospitals. The results are conditional on staffing variables, therefore despite the negative association between the share of foreign doctors and AMI mortality, patient outcomes might have been even worse if those hospitals remained understaffed. Therefore, resource-driven hiring and retention of foreign-trained medical staff is essential in helping those hospitals address shortages in domestic labour supply and other constraints. At the same time, despite the positive association between patient outcomes and the share of foreign-trained physicians, it is crucial to consider hospital quality and the capability to provide the required type of treatment. Timely access to appropriate treatment is crucial, because it enhances the workforce's ability to improve delivery of care. Encouragingly, treatment options have advanced to a point where the preferred treatment can be effectively administered by doctors or hospitals of any unobserved quality. Therefore, for countries like the UK that traditionally have been destinations of physicians trained abroad, it is important to identify areas and hospitals in which those members of staff might not be used in the best effective way while providing healthcare services. In the aftermath of Brexit and the COVID-19 pandemic, this issue is of paramount importance.

During the preparation of this work, the author used ChatGPT, an AI language model, to assist with improving grammar and language clarity. The author has reviewed and edited the content as needed after using this tool and takes full responsibility for the content of the publication.

CRediT authorship contribution statement

Ioannis Laliotis: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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Appendix

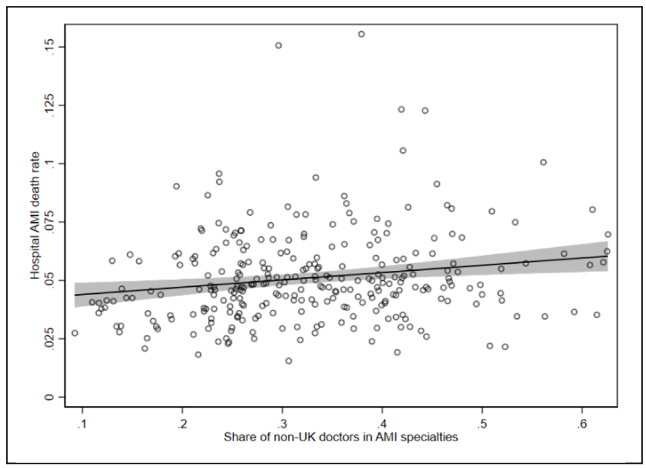

Fig. A1. AMI mortality and shares of foreign-trained doctors (2012–2014).
Notes: 2012–2014 data. Each dot represents a hospital-year cell. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. AMI death rates are calculated as the total count of deaths within 30 days after an emergency AMI admission (for patients aged 35–74 years old) over the total number of AMI admissions in a hospital-year cell.
Source: Health and Social Care Information Centre (HSCIC).

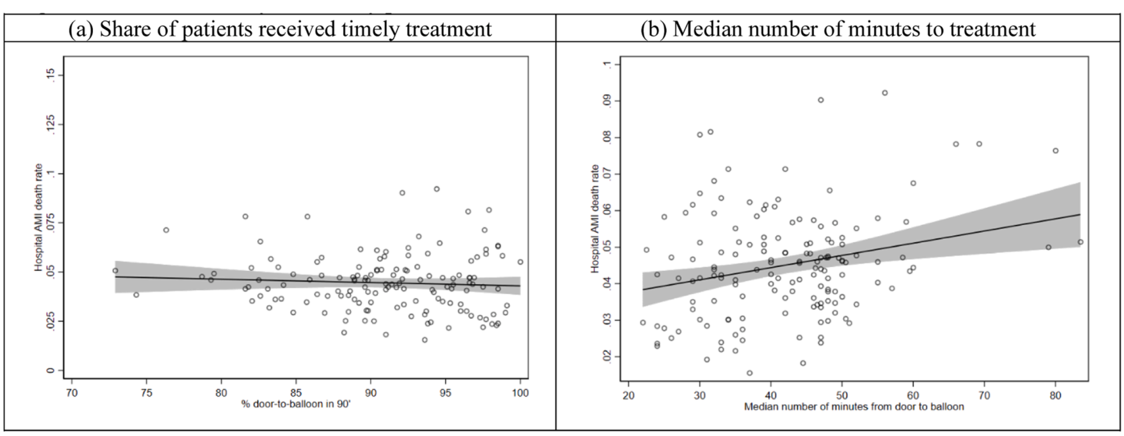

Fig. A2. AMI mortality and timely provision of treatment
Notes: 2012–2014 data. Each dot represents a hospital-year cell. Panel (a) plots the share of patients who received a pPCI within 90 minutes of arrival at a Heart Attack Centre (HAC) over all eligible patients. Panel (b) plots the median number of minutes required for eligible patients (either directly admitted to a HAC or transferred from another hospital) to receive treatment.
Source: Health and Social Care Information Centre (HSCIC); Myocardial Ischaemia National Audit project (MINAP) provided by the National Institute for Cardiovascular Outcomes Research (NICOR).

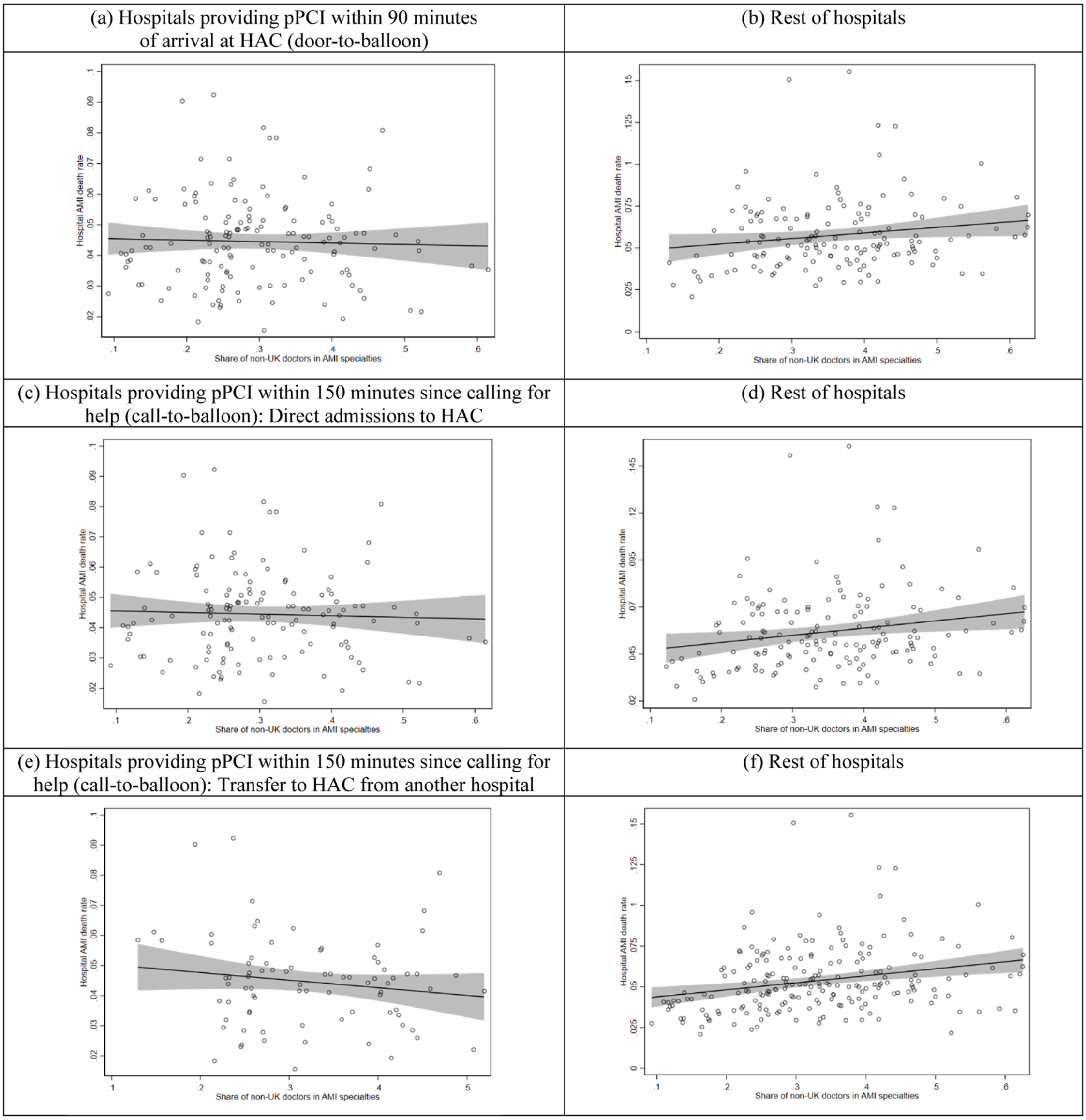

Fig. A3. Foreign doctors, AMI mortality and treatment provision

Notes: 2012–2014 data. Each dot represents a hospital-year cell. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. AMI death rates are calculated as the total count of deaths within 30 days after an emergency AMI admission (for patients aged 35–74 years old) over the total number of AMI admissions in a hospital-year cell.

Source: Health and Social Care Information Centre (HSCIC); Myocardial Ischaemia National Audit project (MINAP) provided by the National Institute for Cardiovascular Outcomes Research (NICOR).

Table A1
Countries in each group.

Country group	Abbreviation	Countries
European Economic Association (excluding UK)	EEA	Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Malta, Netherlands, Norway, Poland, Portugal, Ireland, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland
South European Union	South EU	Greece, Italy, Portugal, Spain
EU Accession countries	EU Accession	Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia
South Asian countries	South Asia	Afghanistan, Bangladesh, India, Nepal, Pakistan, Sri Lanka
Anglosphere countries (excluding UK)	Anglosphere	Australia, Canada, New Zealand, Ireland, USA
Arab world countries	Arab	Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, Yemen
Sub-Saharan Africa countries	Sub-Saharan	Angola, Burkina Faso, Burundi, Cameroon, Ivory Coast, Congo, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Liberia, Malawi, Mali, Mauritius, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zaire, Zambia, Zimbabwe

(*continued on next page*)

Table A1 (*continued*)

Country group	Abbreviation	Countries
Countries where English is an official language (excluding UK)	English speaking	Antigua, Australia, Bangladesh, Belize, Burundi, Cameroon, Canada, Cayman Islands, Commonwealth of Dominica, Cook Islands, Ethiopia, Fiji, Gambia, Ghana, Grenada, Guyana, Hong Kong, India, Israel, Kenya, Liberia, Malawi, Malaysia, Malta, New Zealand, Nigeria, Pakistan, Papua New Guinea, Philippines, Ireland, Rwanda, Sierra Leone, Singapore, South Africa, Sri Lanka, St. Kitts & Nevis, St. Lucia, Sudan, Tanzania, Uganda, USA, Zambia, Zimbabwe
Countries having colonial ties with the UK	Colonies	Afghanistan, Antigua, Australia, Bahrain, Belize, Canada, Commonwealth of Dominica, Egypt, Fiji, Gambia, Ghana, Grenada, Guyana, India, Iraq, Israel, Jordan, Kenya, Kuwait, Malawi, Malaysia, Malta, Mauritius, Myanmar, New Zealand, Nigeria, Pakistan, Qatar, Sierra Leone, South Africa, Sri Lanka, St. Kitts & Nevis, St. Lucia, Sudan, Tanzania, Uganda, United Arab Emirates, USA, Yemen, Zambia, Zimbabwe
Countries with ≥1 medical school in world's top 100 (excluding UK)[a]	Top-100 medical schools	Australia, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Hong Kong, Italy, Japan, South Korea, Netherlands, New Zealand, Norway, Ireland, Singapore, Spain, Sweden, Switzerland, Taiwan, USA

Notes: These are the individual countries that could be identified in the staff-in-post and turnover data provided by the Health and Social Care Information Centre (HSCIC). To keep the length of the table relatively small, non-EEA, non-Anglosphere and non-English-speaking country groupings are not reported. However, those groups consist of all other countries not included in each respective group presented here (plus some other countries not reported). [a] Based on the 2016 Quacquarelli Symonds (QS) World University Rankings.

Table A2
Foreign doctors and other measures of hospital mortality.

Death rate used as outcome:	Overall [1]	Elective admissions [2]	Non-elective admissions [3]	In-hospital [4]	Outside hospital [5]	Non-elective surgeries [6]	Strokes [7]	Fractured proximal femur [8]
Overall share of non-UK doctors	.055 (.054)	−.278 (286)	.030 (.052)	.051 (.072)	−.038 (.099)	-	-	-
Share of non-UK stroke doctors	-	-	-	-	-	-	.000 (.002)	-
Share of non-UK surgeons	-	-	-	-	-	.023 (.049)	-	-
Share of non-UK orthopaedicians	-	-	-	-	-	-	-	−.018 (.069)
Observations	692	548	548	551	551	822	698	762
Hospitals	146	141	141	141	141	142	128	133

Source: HSCIC, LFS, ASHE
Notes: OLS estimates. 2009-2014 data. All variables are in logs. In columns 1-5, the share of non-UK doctors is calculated as the headcount of all doctors trained abroad over the total headcount of doctors in each hospital-year cell. In columns 6-8, shares of non-UK doctors are calculated as the headcount of outcome-specific-related doctors trained abroad over the total headcount of outcome-specific-related doctors in each hospital-year cell. All models control for hospital and local area characteristics, and for hospital and year fixed effects. Standard errors (in parentheses) are corrected for heteroskedasticity and clustering by hospital. ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % level, respectively.

Table A3
AMI mortality and share of foreign AMI doctors by type of treatment.

	AMI mortality Mean (std. err.)	Share of non-UK AMI doctors Mean (std. err.)	Observations
Panel A			
Hospitals providing pPCI within 90 minutes of arrival at HAC (door-to-balloon)	.045 (.001)	.295 (.008)	143
Rest of hospitals	.058 (.002)	.359 (.009)	143
Panel B			
Hospitals providing pPCI within 150 minutes since calling for help (call-to-balloon): Direct admission to HAC	.044 (.001)	.300 (.009)	135
Rest of hospitals	.057 (.002)	.351 (.009)	151
Panel C			
Hospitals providing pPCI within 150 minutes since calling for help (call-to-balloon): Transfer to HAC from another hospital	.045 (.002)	.322 (.010)	82
Rest of hospitals	.054 (.001)	.330 (.008)	204

Source: Health and Social Care Information Centre (HSCIC); Myocardial Ischaemia National Audit project (MINAP) provided by the National Institute for Cardiovascular Outcomes Research (NICOR).
Notes: 2012-204 data. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. AMI death rates are calculated as the total count of deaths within 30 days after an emergency AMI admission (for patients aged 35-74 years old) over the total number of AMI admissions for each hospital and year. Means and standard errors (in parentheses) refer to the result of two-sample *t*-tests. In each panel, the total number ($N = 286$) of hospital-year observations in the 2012-2014 panel of hospitals.

Table A4
Foreign doctors, AMI mortality and provision of treatment by type of admission

	All hospitals [1]	Hospitals providing pPCI within 150 minutes [2]	Rest of hospitals [3]	All hospitals [4]	All hospitals [5]
Panel A: Direct admissions to HAC					
(Log) share of AMI non-UK doctors	.147** (.075)	.115 (.106)	.221** (.097)	.136* (.075)	.239** (.085)
Hospitals providing pPCI within 150 minutes	-	-	-	−.219*** (.058)	−.421** (.156)
Interaction term	-	-	-	-	−.173 (.120)
Observations	286	135	151	286	286
Panel B: Transfers to HAC from another hospital					
(Log) share of AMI non-UK doctors	.147** (.075)	.066 (.195)	.218*** (.072)	.180*** (.075)	.250*** (.069)
Hospitals providing pPCI within 150 minutes	-	-	-	−140** (.059)	−.406* (.210)
Interaction term	-	-	-	-	−.225 (.171)
Observations	286	82	204	286	286
Hospital controls	Yes	Yes	Yes	Yes	Yes
Region controls	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes

Source: Health and Social Care Information Centre (HSCIC); Myocardial Ischaemia National Audit project (MINAP) provided by the National Institute for Cardiovascular Outcomes Research (NICOR).
Notes: 2012–2014 data. The share of non-UK AMI doctors is calculated as the headcount of AMI doctors trained abroad over the total headcount of AMI doctors in each hospital-year cell. AMI death rates are calculated as the total count of deaths within 30 days after an emergency AMI admission (for patients aged 35–74 years old) over the total number of AMI admissions for each hospital and year. Hospitals providing pPCI within 150 min are flagged with a binary (0/1) indicator. The interaction term refers to the interaction between that binary variable and the (log) share of non-UK AMI doctors.

(Fig. A1, Fig. A2, Fig. A3, Table A1, Table A2, Table A3, Table A4)

Data availability

The authors do not have permission to share data.

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