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Exploring the association between primary care efficiency and health system characteristics across European countries: a two-stage data envelopment analysis

Valerie Moran^{1,2*}, Marc Suhrcke^{1,2} and Ellen Nolte³

Abstract

Background Primary care is widely seen as a core component of resilient and sustainable health systems, yet its efficiency is not well understood and there is a lack of evidence about how primary care efficiency is associated with health system characteristics. We examine this issue through the lens of diabetes care, which has a well-established evidence base for effective treatment and has previously been used as a tracer condition to measure health system performance.

Methods We developed a conceptual framework to guide the analysis of primary care efficiency. Using data on 18 European countries during 2010–2016 from several international databases, we applied a two-stage data envelopment analysis to estimate (i) technical efficiency of primary care and (ii) the association between efficiency and health system characteristics.

Results Countries varied widely in terms of primary care efficiency, with efficiency scores depending on the range of population characteristics adjusted for. Higher efficiency was associated with bonus payments for the prevention and management of chronic conditions, nurse-led follow-up, and a financial incentive or requirement for patients to obtain a referral to specialist care. Conversely, lower efficiency was associated with higher rates of curative care beds and financial incentives for patients to register with a primary care provider.

Conclusions Our results underline the importance of considering differences in population characteristics when comparing country performance on primary care efficiency. We highlight several policies that could enhance the efficiency of primary care. Improvements in data collection would enable more comprehensive assessments of primary care efficiency across countries, which in turn could more effectively inform policymaking.

Keywords Primary care, Technical efficiency, Performance, Data envelopment analysis, International comparisons, European countries

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Background

Efficiency is considered a key measure of health system performance [1]. Assessments of overall system efficiency might conceal important variation between different parts of the health system, and it is important to understand how the various sectors perform in order to effectively inform decision-making by managers and policymakers [2]. Related research has tended to focus on hospitals (including different types of ownership), not least due to the availability of data [3–5] and because the hospital setting has clear boundaries [6]. Efficiency in primary care is less well understood and the imprecise boundaries and wide range of outputs mean that efficiency is more difficult to assess [2, 7, 8]. Yet, primary care is recognised to be at the core of resilient and sustainable health systems [9], with evidence pointing to its key role in improving health outcomes, health system efficiency and health equity [10, 11]. Primary care also plays an important role in the effective prevention and integrated management of the rising burden of chronic disease globally [12]. It is against this background that assessing the performance and efficiency of primary care has become ever more important [13].

Most studies of efficiency in primary care have been conducted in European countries, with a focus on technical efficiency of primary care providers, such as general practices, primary care centres or primary care teams within countries [8, 14, 15]. Only one study [16] specifically examined primary care efficiency across [22] European countries, finding that countries varied considerably in terms of their efficiency in translating care structures into processes and care processes into quality outcomes. The study provided important insights into technical efficiency as measured by primary care structures, such as governance, financing or workforce; processes (e.g. access, continuity of care) and outcomes (quality, efficiency, equity). However, it did not explore the factors that could explain variation between countries in terms of primary care efficiency. Such an analysis would allow for inferences about the likely contribution of national-level policies to improve efficiency [2].

This paper seeks to address this important research gap by investigating the relationship between health system characteristics and primary care efficiency across European countries. Specifically, we seek to explore whether a given characteristic is associated with higher or lower primary care efficiency. We examine this issue through the lens of diabetes care, which has a well-established evidence base for effective treatment, much of which can be delivered in primary care [17]. Diabetes has been proposed as a useful tracer condition to assess health system performance [18]. As efficiency analysis is inherently a comparative exercise, focusing on a single condition can

enhance the comparability of efficiency measures across countries [2] and may facilitate the identification of outputs attributable to primary care.

Methods

Definition of primary care

We defined primary care in line with the European Commission (2014) as “*the provision of universally accessible, integrated person-centred, comprehensive health and community services provided by a team of professionals accountable for addressing a large majority of personal health needs. These services are delivered in a sustained partnership with patients and informal caregivers, in the context of family and community, and play a central role in the overall coordination and continuity of people’s care.*” [19] (p. 18). Our focus is on technical efficiency, which refers to the ability to maximise outputs (or outcomes) given a set of limited inputs or resources or to minimise inputs to obtain a given level of outputs [2].

Conceptual framework of primary care performance on efficiency

We developed a conceptual framework (Fig. 1). It describes a simplified pathway from pre-diagnosis to diabetes treatment and management along the primary-secondary care continuum, along with intermediate and final outcomes of diabetes care [20]. It identifies the range of factors acting at patient, population and health system levels that can impact the journey and, ultimately, the outcomes along the care continuum.

Data

Our choice of variables was informed by the conceptual framework (Fig. 1) and data availability. We considered 18 European OECD member countries, for which relevant data on key input and output variables were available for the period 2010–2016. We merged data from ten different sources. Information on data sources, missing data and variable definition and construction is available in Supplementary file, Table S1.

Input and output variables

We sourced data on input and output variables from the OECD Health Statistics database [24]. The input variable was the number of generalist medical practitioners, per 1,000 population, a widely used measure of primary care resources.

We considered eight variables reflecting population characteristics as ‘uncontrollable’ inputs [25] as they are outside of the direct control of the primary care system, at least in the short term, specifically: prevalence of diabetes [26] and obesity [27]; smoking rates (population aged 15 years and over) [28]; per capita

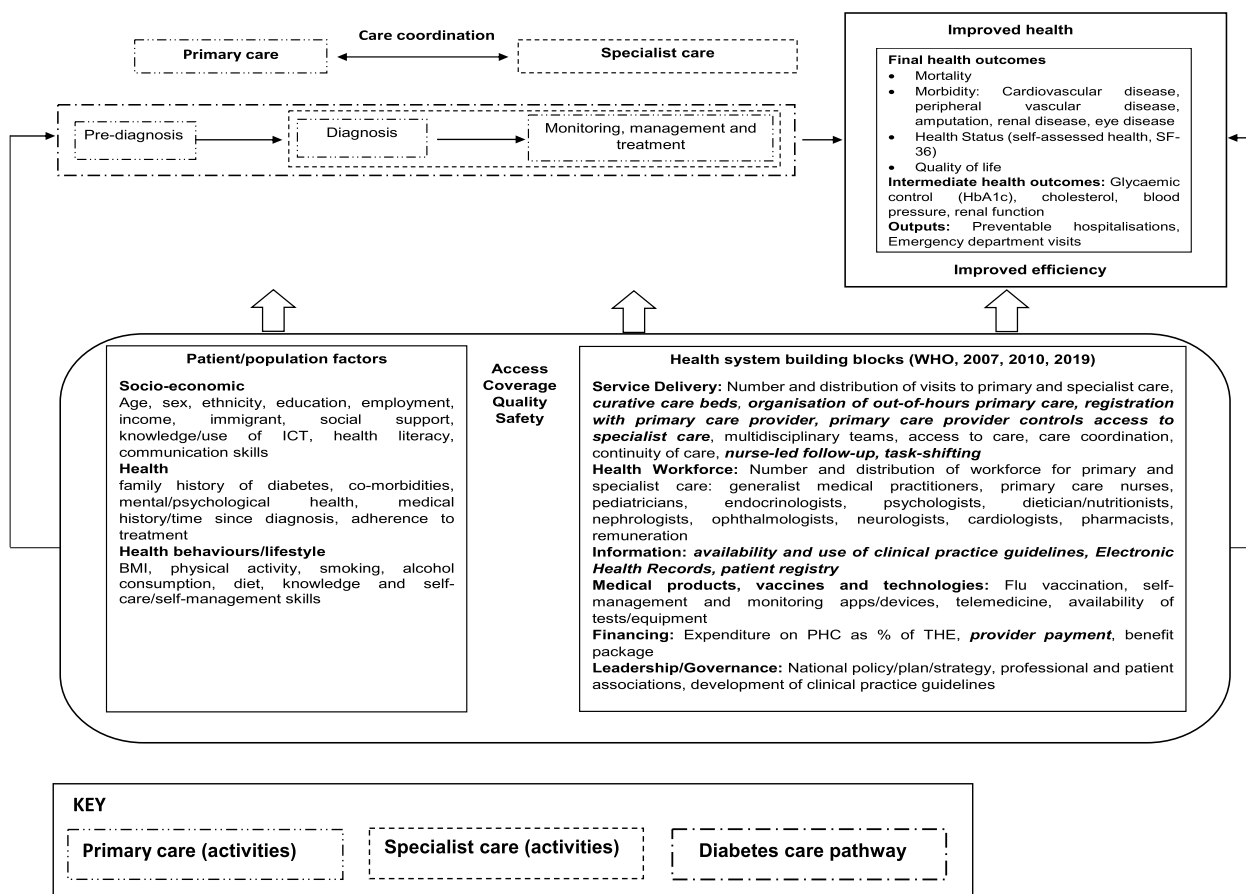


Fig. 1 Conceptual framework. *Note:* Health system characteristics included in the analysis are highlighted in bold and italic. Source: Modified based on Brown et al. [20] and the World Health Organisation [21–23]

alcohol consumption [24]; levels of deprivation [29]; educational achievement [30]; per capita income [31] and the incidence of long-term (one year and over) unemployment [31]. Countries with a higher prevalence of diabetes may have higher rates of diabetes hospital admissions [32] and amputations [33]. Obesity and smoking are risk factors for diabetes hospital admission [34], and smoking is also a risk factor for lower limb amputation [35] while alcohol use has been associated with a lower risk of hospital admission [34]. Socio-demographic factors including deprivation, education, income and unemployment have also been associated with poor diabetes outcomes [20, 36–38].

Output variables were diabetes hospital admissions per 100,000 population and admissions based on diabetes lower extremity amputation, per 100,000 population, which measure utilisation and quality of primary care [33, 39]. Both variables were adjusted for age and sex. Data envelopment analysis (DEA) (detailed explanation below in the section “Two-stage data envelopment analysis”) assumes that the measurement

of outputs implies ‘more is better’ [40] that is, larger numerical values correspond to greater production [41], suggesting that outputs should be maximised [42]. However, the interpretation of diabetes admission and amputation rates is that lower rates point to better quality of care. Therefore, we transform the output variables using the multiplicative inverse in order to incorporate them into the models as desirable outputs [42] that we wish to maximise.

Explanatory variables: Health system characteristics

Based on availability of data, we selected the following health system characteristics: number of curative care beds per 1,000 population [24], availability and use of electronic health records (EHR) by GPs [43], bonus payments for primary care providers achieving targets related to the prevention and management of chronic diseases [44], nurse-led follow-up of people with chronic conditions [44], requirement for patients to register with a primary care provider [44], requirement for patients to obtain primary care referral to specialist care [44], arrangements for out-of-hours

primary care (group of physicians on a rota basis) [44–47], existence of a diabetes registry [48], existence of government-approved evidence-based national guidelines for the management of diabetes [45, 48, 49], and task-shifting from physicians to nurses in primary care [50] (for further details see Supplementary file Table S2).

We expected a higher rate of curative care beds to be associated with lower efficiency as higher rates of beds could translate into higher rates of admissions. For the remaining variables, we expected a positive association with efficiency.

Two-stage data envelopment analysis

We used a two-stage DEA [51] to investigate the relationship between efficiency and health system characteristics. DEA is a recommended approach for measuring efficiency in the context of small sample sizes and multiple inputs and outputs [25].

First, we measured technical efficiency, using DEA, whereby efficiency is defined as the ratio of a weighted sum of outputs to a weighted sum of inputs. The DEA method chooses the set of output and input weights that maximise the efficiency of country i , subject to the constraint that the efficiency score is less than or equal to one. We assumed an output orientation, which implied that output could be increased given a specified level of input as our aim was to estimate the potential increase in primary care quality (output) that could be achieved with the available primary care resources (input). Therefore, our objective was to maximise weighted outputs conditional on weighted inputs being equal to one:

$$\text{Max}_{u,y} (u'y_0)$$

Subject to:

$$v' = 1$$

$$u'y_i - v'x_i \leq 0 \quad i = 1, \dots, I$$

$$u, v \geq 0$$

where x_i is a vector of inputs and y_i is a vector in outputs for each of the I countries [25].

Countries with the highest ratio of output to input formed the efficiency frontier. The efficiency of countries not on the frontier was assessed relative to the most efficient countries or ‘peers’ that comprised the frontier [52]. We used the Banker, Charnes and Cooper specification i.e. variable returns to scale [53], which is recommended when outputs are expressed in ratios [54].

We adjusted efficiency scores to reflect differences in population characteristics across countries, identifying population characteristics that had a statistically

significant association with efficiency and including these in the DEA models as ‘uncontrollable’ inputs’ to ensure a more meaningful comparison of countries. We first estimated a baseline model without any population characteristics; it included generalist medical practitioners as input and diabetes hospital admissions per 100,000 population and admissions for diabetes lower extremity amputation per 100,000 population as outputs. We then estimated separate DEA models for each statistically significant population characteristic to evaluate its effect on countries efficiency scores. We computed Spearman rank correlations between the efficiency estimates from the different models to assess their internal validity [3]. DEA does not account for measurement error and the efficiency frontier is an estimate of the true frontier based on our data sample. In order to adjust the efficiency estimates for sampling bias, we applied bootstrapping as proposed by Simar and Wilson [55]. We ran the bootstrap for 2,000 iterations. We computed the bias-corrected efficiency scores for each year using the *Benchmarking* package in R [56].

Second, we estimated a truncated regression with the efficiency estimates from each model as the dependent variable and health system characteristics as explanatory variables. We corrected the standard errors for sampling bias and the correlation between efficiency scores using bootstrapping with 2,000 iterations [51]. We pooled data across years to estimate the regressions. While it would be informative to model several health system characteristics variables simultaneously, we included each variable separately due to the small number of countries ($n = 18$). The regressions were estimated using the *truncreg* command in Stata 17 [57].

Ethical issues/statement

Ethics approval was not required as we used secondary data that was aggregated at the country-level.

Results

Descriptive statistics

Table 1 shows the descriptive statistics for the input, output, population and health system characteristics variables (see also Supplementary file Figures S1–S13).

Country-level efficiency

Six variables showed a statistically significant association with efficiency: the prevalence of diabetes, obesity, smoking, alcohol consumption, education and income (Supplementary file, Table S3). We estimated a model for each of these and we show the results in Table 2. Efficiency scores lay within the range of zero to one (but scores were less than one due to bootstrapping),

Table 1 Descriptive statistics of study variables

Continuous variables, n = 106^a				
Variable	Mean	Standard deviation	Min	Max
Input variable				
Generalist medical practitioners, per 1,000 population	0.99	0.46	0.33	2.74
Population characteristics (uncontrollable inputs)				
Diabetes prevalence, %	5.36	1.45	2.77	9.26
Smoking, %	27.25	4.52	18.80	37.30
Alcohol consumption, litres per capita	10.08	1.95	6.00	14.70
Obesity, % of population aged 18 years and over	21.29	2.31	17.40	27.80
Deprivation, % of population	5.92	4.30	0.50	19.80
Income per capita, US\$ PPP	44746.46	16223.48	21088.60	103723.70
Percentage of total unemployed population unemployed for one year or more	36.69	12.42	16.80	61.70
Upper second level education, % of population aged 25–64 years	43.76	11.24	20.74	66.05
Output variables				
Diabetes hospital admissions, per 100,000 population	142.42	64.91	43.80	281.10
Admission based diabetes lower extremity amputation, per 100,000 population	6.53	3.96	2.60	24.40
Estimated dependent variables				
Efficiency scores, baseline model	0.58	0.21	0.17	0.90
Efficiency scores, baseline model with diabetes prevalence	0.57	0.20	0.17	0.90
Efficiency scores, baseline model with alcohol	0.71	0.17	0.31	0.92
Efficiency scores, baseline model with obesity	0.58	0.20	0.17	0.90
Efficiency scores, baseline model with smoking	0.67	0.19	0.28	0.90
Efficiency scores, baseline model with education	0.58	0.21	0.17	0.88
Efficiency scores, baseline model with income	0.61	0.21	0.17	0.91
Health system characteristics continuous variables				
Curative care beds, per 1,000 population	3.78	1.33	2.15	6.28
Availability and use of Electronic Health Records (EHR) by GPs	2.87	0.44	1.39	3.33
Health system characteristics binary variables, n = 18				
	Number	Percentage	Min	Max
<i>Bonus payment for primary care providers</i>				
No	11	61	0	0
Yes	7	39	1	1
<i>Nurse-led follow-up of patients with chronic conditions</i>				
No	9	50	0	0
Yes	9	50	1	1
<i>Patient registration with primary care provider</i>				
Not required or incentivised	6	33	0	0
Incentivised	5	28	1	1
Required	7	39	2	2
<i>Patient referral to secondary care</i>				
Not required or incentivised	3	17	0	0
Incentivised	5	28	1	1
Required	10	56	2	2
<i>Out of hours primary care: physicians rota</i>				
No	4	22	0	0
Yes	14	78	1	1
<i>Diabetes registry</i>				
No	10	56	0	0
Yes	8	44	1	1
<i>National guidelines for the management of diabetes</i>				
No	5	28	0	0
Yes	13	72	1	1
<i>Task-shifting from physicians to nurses in primary care</i>				
None	6	33	0	0
Limited	8	45	1	1
Advanced	4	22	2	2

^a Number of countries = 18 and number of time periods = 3–7

Table 2 Country-level efficiency, average scores 2010–2016

Country	Baseline model	Baseline model with diabetes prevalence	Baseline model with alcohol	Baseline model with obesity	Baseline model with smoking	Baseline model with education	Baseline model with income
Austria	0.21	0.21	0.52	0.21	0.53	0.21	0.21
Belgium	0.58	0.57	0.70	0.61	0.78	0.58	0.57
Denmark	0.33	0.33	0.41	0.33	0.34	0.33	0.34
Finland	0.68	0.65	0.71	0.70	0.68	0.67	0.67
France	0.58	0.58	0.85	0.58	0.82	0.57	0.57
Germany	0.26	0.25	0.45	0.27	0.45	0.26	0.26
Ireland	0.76	0.75	0.85	0.73	0.82	0.77	0.76
Italy	0.81	0.77	0.85	0.80	0.84	0.80	0.78
Latvia	0.50	0.50	0.72	0.49	0.79	0.50	0.77
Lithuania	0.42	0.42	0.80	0.40	0.62	0.42	0.75
Luxembourg	0.37	0.36	0.68	0.38	0.39	0.36	0.37
Netherlands	0.80	0.80	0.87	0.80	0.85	0.79	0.81
Norway	0.57	0.57	0.60	0.58	0.59	0.57	0.58
Poland	0.74	0.74	0.82	0.74	0.79	0.74	0.75
Portugal	0.56	0.65	0.63	0.56	0.57	0.73	0.81
Spain	0.80	0.77	0.83	0.77	0.79	0.74	0.78
Sweden	0.75	0.75	0.79	0.75	0.78	0.76	0.76
United Kingdom	0.83	0.74	0.83	0.74	0.84	0.79	0.82

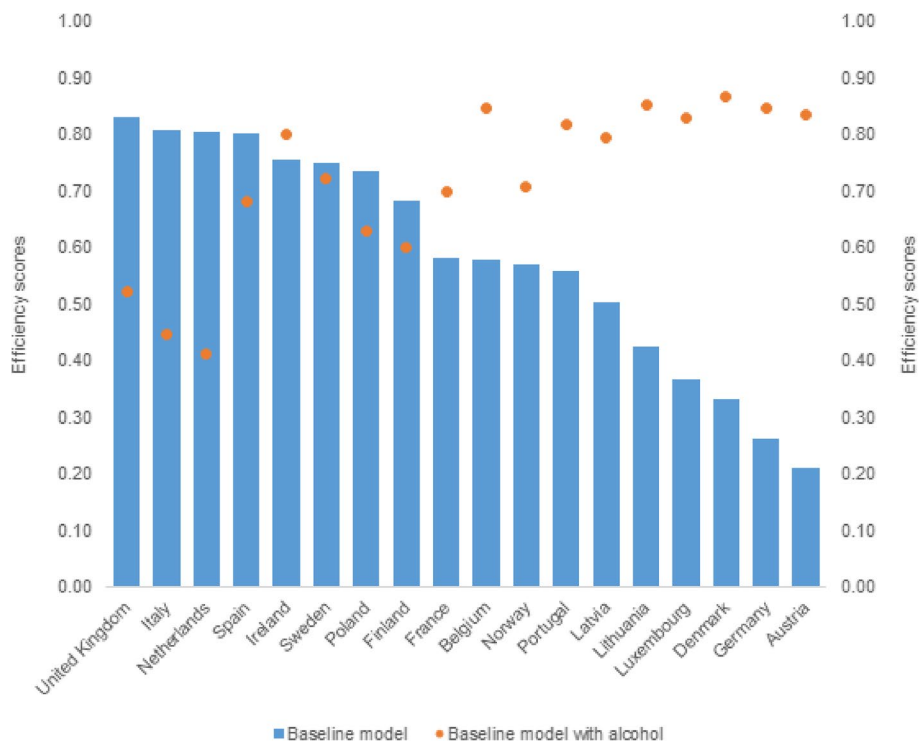


Fig. 2 Efficiency scores from baseline model and model adjusted for alcohol consumption, average 2010–2016

with a higher score indicating higher efficiency. For example, in the baseline model, Austria and Germany had the lowest efficiency scores, while Italy and the

United Kingdom (UK) had the highest scores. These differences are likely driven by differences in diabetes admission and amputation rates, which were

Table 3 Association of efficiency with health system characteristics

Health system characteristics	Baseline model	Baseline model with diabetes prevalence	Baseline model with alcohol	Baseline model with obesity	Baseline model with smoking	Baseline model with education	Baseline model with income
Curative care beds, per 1,000 population	-	-	-	-	-	-	-
Availability and use of Electronic Health Records (EHR) by GPs	+	+	n.s.	+	n.s.	+	n.s.
Bonus payment: Yes (Reference = No)	+	+	+	+	+	+	+
Nurse-led follow-up: Yes (Reference = No)	+	+	+	+	+	+	+
Registration: Incentive (Reference = No incentive or obligation)	-	-	-	-	-	-	-
Registration: Required (Reference = No incentive or obligation)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	+
Referral: Incentive (Reference = No incentive or obligation)	+	+	+	+	+	+	+
Referral: Required (Reference = No incentive or obligation)	+	+	+	+	+	+	+
Out of hours primary care: physicians rota: Yes (Reference = No)	-	-	n.s.	-	n.s.	-	-
Registry: Yes (Reference = No)	n.s.	n.s.	-	n.s.	-	n.s.	n.s.
Guidelines: Yes (Reference = No)	n.s.	+	n.s.	n.s.	n.s.	n.s.	n.s.
Task-shifting: Limited (Reference = No task-shifting)	+	+	n.s.	+	+	+	+
Task-shifting: Extensive (Reference = No task-shifting)	+	+	+	+	+	+	+

Note: +: positive statistically significant association, -: negative statistically significant association, n.s.: not statistically significant

comparatively high for Austria and Germany but relatively low for Italy and the UK (Supplementary file, Figures S2 and S3).

Adjusting for different population characteristics improved the efficiency of countries although patterns varied. Most countries saw an improvement in efficiency scores after adjustment for alcohol consumption and smoking (Fig. 2). Portugal was the only country where adjusting for diabetes prevalence increased the primary care efficiency score (from 0.56 to 0.65) as did adjusting for education. These observations are perhaps not surprising, since, for example, Portugal had the second-highest prevalence of diabetes and the lowest proportion of people with educational attainment to upper secondary level (Supplementary file 2 Figures S4 and S9). Similarly, levels of alcohol and tobacco use have traditionally been high in countries such as Austria, France, Germany, Lithuania and Luxembourg (Supplementary file Figures S5 and S7). Adjustment for income

improved the efficiency score for several countries, most notably Latvia, Lithuania and Portugal. Adjustment for obesity changed efficiency scores only marginally, except in the United Kingdom, which had the highest level of obesity (26%) in the sample (Figure S6 in Supplementary file).

While the inclusion of different population characteristics changed country rankings to some extent, the Spearman rank correlations were relatively high (ranging from 0.63 to 0.97; also Table S4 in Supplementary file), suggesting a good degree of internal validity and relatively consistent country rankings across the models.

Associations of efficiency and health system characteristics

Table 3 shows the results of the regression analysis investigating associations between health system characteristics and primary care efficiency across countries

(see Table S5 in Supplementary file for quantitative results).

We found that bonus payments for the prevention and management of chronic conditions and nurse-led follow-up were positively associated with efficiency in all models as was an incentive or requirement for primary care referral to specialist care. Task-shifting from physicians to nurses in primary care was positively associated with efficiency in all models except for limited task-shifting in the model adjusted for alcohol. There was also a positive association with efficiency for the availability of evidence-based national guidelines for diabetes, but only in the model adjusted for diabetes prevalence. Similarly, positive associations with efficiency for the availability and use of EHR by GPs were found for the baseline model and the models adjusting for diabetes prevalence, obesity and education. Conversely, higher rates of curative care beds were associated with lower efficiency in all models, as were incentives for patients to register with a primary care provider. The existence of a diabetes registry was negatively associated with efficiency in the models that included alcohol consumption and smoking. There was a negative association between efficiency and out-of-hours primary care provided by a rota of physicians in all models except for the models that adjusted for alcohol consumption and smoking.

Discussion

In this paper, we investigated the efficiency of primary care systems in European countries and explored the associations between efficiency and health system characteristics. Primary care efficiency scores improved when a range of population characteristics were taken into account. We found that bonus payments, nurse-led follow-up of people with chronic conditions, and an incentive or requirement for patients to have a referral from primary to specialist care were associated with increased efficiency whereas the number of curative care beds and incentives for patients to register with a primary care provider reduced efficiency. For other health system variables, associations were less consistent.

Our finding that bonus payments were associated with higher efficiency aligns with other evidence suggesting that incentive payments in primary care, such as pay-for-performance schemes targeted at the management of chronic conditions, is associated with reduced resource use [58, 59] and gains in efficiency [60]. Likewise, the positive association between nurse-led follow-up of people with chronic conditions and efficiency, and task-shifting from physicians to nurses in primary care is also reflected in the wider literature suggesting that substitution of physicians by nurses in primary care can

have a positive effect on health outcomes and patient satisfaction, although the effect on costs, health system outcomes, and quality of life is less conclusive [61–64]. Similarly, the association of a requirement to obtain a primary care referral to specialist care with higher efficiency aligns with previous studies [65, 66] that reported higher efficiency scores for OECD countries that had primary care gatekeeping arrangements in place.

Somewhat counterintuitively, evidence of an association between patient registration with a primary care provider and efficiency was mixed, with compulsory registration significantly positive only in the model that adjusted for income while voluntary registration using incentives was negatively associated with primary care efficiency in all models. Patient registration has been linked to enhancing care continuity and coordination [67], which, in turn, has been linked to improved patient outcomes [68] and lower service use and cost [69]. However, the nature and extent of how countries define and implement ‘patient registration’ varies substantially [70], and it is likely that the variable as conceptualized in the data source [44] used in this study captures some other mechanism that would explain our finding.

We also found some evidence that EHR availability and use may be associated with improved efficiency, although this applied to certain models in our study only. There is limited evidence, mostly from the United States, which points to the potential of EHR to increase efficiency in some contexts [71] while other studies have highlighted the negative impacts of inadequate design of EHR systems [72, 73].

A higher rate of curative care beds was associated with reduced efficiency. This finding is perhaps unsurprising as hospital beds built are likely to be used (‘Roemer’s Law’ [74–77]) although the relationship between hospital bed capacity and use is more complicated. For example, in an international comparative study Van Loenen et al. [78] found hospital bed supply to be strongly associated with admission rates for uncontrolled diabetes and long-term complications. They also highlighted the possibility of reverse causation, finding that countries that had a stronger primary care orientation also had lower hospital bed supply. Moreover, the price of hospital services varies widely across countries [79], which may have implications for efficiency.

We further found a negative association between efficiency and the organisation of out-of-hours primary care using a rota of physicians in all models except those that adjusted for alcohol consumption and smoking. A physician rota for out-of-hours primary care was the most common organisational model in our sample. Alternative approaches such as general practice co-operatives may be more efficient [80], but this model was not widespread

and there may be insufficient statistical power to detect a positive association. A recent review [81] of national diabetes registries found that most registries served to monitor and improve the quality of diabetes care and that national registries may also help to achieve efficiency gains by identifying the causes of variation in outcomes. We did not find evidence to support this observation.

The study period covers six years (2010–2016), which coincided with primary care reform efforts in several countries that may be associated with efficiency. For example, in 2010, the Netherlands introduced a bundled payment for diabetes care provided in primary care settings. Evaluations showed that the reform led to improved care coordination and adherence to quality guidelines, improvements in clinical outcomes, and a reduction in the use of specialist care and associated costs [82]. Since the introduction of a new payment system for GPs in 2015, the bundled payment accounts for around 15% of GP income [83]. Similarly, Denmark introduced a bundled payment system in primary care for diabetes patients in 2007, but this was discontinued in 2014 due to low participation by GPs [84]. Evaluations have found that bundled payment models were associated with increased efficiency compared to separate payment for different services [85]. Therefore, we might expect that bundled payment would be positively associated with primary care efficiency. However, we are unable to test this hypothesis based on available data.

The implementation of austerity measures, following the 2007–08 financial crisis and subsequent global recession, may have affected primary (and secondary) care access and efficiency. However, it is difficult to investigate these changes given the diversity of responses across countries, encompassing changes to public funding, health coverage and health service planning, purchasing and delivery [86]. Additionally, an examination of the relationship between efficiency and quality regulations and regulatory actors was beyond the scope of this study.

While we included a variable measuring task-shifting from physicians to nurses in primary care, we did not consider the substitution of specialist care to primary care. A review of interventions involving the transfer of (elements of) services from specialist to primary care found some evidence of a reduction in the utilisation of specialist care but a lack of information on costs [87]. Evidence suggests that the relocation of specialists to primary care settings is associated with shorter waiting lists and times and improved patient satisfaction [88] as well as lower costs [89].

Not all countries in our study provide universal access to primary care. In Ireland, eligibility for free primary care services is based on age and income and less than half of the population meet the relevant criteria. Evidence

suggests that people not eligible for free primary care are more likely to report unmet need for health care [90], and to forgo preventative [91], and chronic care [92]. While Irish government policy has prioritised universal primary care, modelling suggests that significant numbers of additional GPs would be needed to meet the increased demand arising from the introduction of universal primary care. One proposed solution to address the potential shortage of GPs is increased nurse substitution [93] and our findings of a positive relationship between task-shifting and efficiency would lend support to this policy.

While the time period of our study does not cover the COVID-19 pandemic, some of our results have relevance for the changes in health care delivery that were adopted in response to the pandemic. For example, the use of digital health tools increased substantially during the pandemic [94]. We found that the availability and use of one such tool (EHR) was associated with increased efficiency. A key finding of our study, namely that task-shifting from physicians to nurses in primary care was associated with increased efficiency, is very likely to remain significant given the continued efforts of countries to move to more systematic use of the non-physician workforce in primary care.

Strengths and limitations

We used two indicators on the quality of primary care for diabetes, admissions and lower extremity amputation for diabetes. These are widely used in health system performance comparisons as indicators of the quality of diabetes care [95] and have also been used in a previous study [96] measuring the efficiency of diabetes care at a national level. National studies have also used more refined measures of diabetes care including diabetes-related medication [97, 98], the number of diabetic patients with a complete diabetes annual review [97] and a composite indicator of diabetes prevention and quality [96]. However, data on such indicators across countries and over time are currently unavailable. While focusing on a single condition facilitated the identification of appropriate outputs and cross-country comparisons, it is important to note that it does not reflect the wide range of activity undertaken in primary care and therefore our results would not be representative of primary care as a whole. Nevertheless, our results on the positive relationship between certain health system characteristics and efficiency may be relevant for other chronic conditions managed in primary care. Bonus payment and nurse-led follow-up are measured in relation to chronic illness in general and not specifically diabetes. Similarly, an incentive or requirement to receive a referral from primary to specialist care, and task-shifting from physicians to nurses are not restricted to a certain disease or patient population. While the OECD

collects data on generalist medical practitioners according to a standardized definition, countries may differ in the extent to which their national data collection systems adhere to this definition, which may contribute to some of the differences across countries. As highlighted in our conceptual framework, nurses and other health care professionals play an important role in the care of people with diabetes, including in primary care settings. The OECD Health Statistics database includes data on nurses and pharmacists but does not distinguish between care settings. The lack of comparable data on nurses and other health professionals working in primary care settings, across countries and over time should be addressed in international databases. The exclusion of other primary care professions as inputs in the DEA models may have led to potential bias arising from the underestimation of the efficiency estimates [99, 100]. Many countries are implementing new models of delivering primary care using a team-based approach [11] and research suggests that collaborative and team-based care may improve clinical outcomes for diabetes care [101], and reduce the use of acute care for patients with chronic illness [102]. However, heterogeneity in the composition of primary care teams and the lack of comparable data across countries restricted consideration of the relationship between team-based care and efficiency. We pooled data over time in order to increase the sample size and the reliability of our results but a potential drawback is that we overlook change in efficiency over time. Nevertheless, our approach is in line with previous studies in the healthcare context [3, 103, 104].

Conclusions

This study contributes to the evidence base on measuring the efficiency of primary care systems across countries and their relevant correlates and explanatory factors. Differences in efficiency across countries were driven, to a considerable degree, by population differences but our findings also suggest that countries might achieve greater efficiency by implementing systematic efforts for enhancing the management of chronic diseases in primary care supported by bonus payments, nurse-led patient follow-up, and appropriate referral systems. There is a need to improve and extend current data collection in order to produce a set of core indicators that would enable more comprehensive assessments of primary care efficiency across countries. Future qualitative, in-depth country case study research could also provide useful additional insights into the features of those countries that this study revealed as better performers on efficiency.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12913-023-10369-y>.

Below is the link to the electronic supplementary material. **Additional file 1: Table S1.** Input, outputs and population characteristics variables. **Table S2.** Health system characteristics variables. **Table S3.** Association between efficiency and population characteristics. **Table S4.** Correlations between models. **Table S5.** Truncated regression results. **Table S6.** Results of log likelihood ratio tests for inclusion of year variables (time fixed effects). **Figure S1.** Generalist medical practitioners, per 1,000 population, average 2010-2016. **Figure S2.** Diabetes hospital admissions per 100,000 population, average 2010-2016. **Figure S3.** Admission based diabetes lower extremity amputation, per 100,000 population, average 2010-2016. **Figure S4.** Diabetes prevalence, percentage of population (age-standardised), average 2010-2016. **Figure S5.** Alcohol consumption, litres per capita, average 2010-2016. **Figure S6.** Prevalence of obesity among adults aged 18 years and over, (%), average 2010-2016. **Figure S7.** Smoking, percentage of population aged 15+, average 2010-2016. **Figure S8.** Severe material deprivation, percentage of population, average 2010-2016. **Figure S9.** Upper secondary level education, % of population aged 25-64 years, average 2010-2016. **Figure S10.** Income per capita, US\$ Purchasing Power Parity, average 2010-2016. **Figure S11.** Percentage of total unemployed population unemployed for one year or more, average 2010-2016. **Figure S12.** Curative care beds, per 1,000 population, average 2010-2016. **Figure S13.** Availability and use of Electronic Health Records by GPs, average 2010-2016.

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Authors' contributions

Conception and design: VM and EN. Acquisition of data: VM. Analysis and interpretation of data: VM, EN, MS. Drafting of the manuscript: VM and EN. Critical revision of the manuscript for important intellectual content: VM, EN, MS. Statistical analysis: VM. Obtaining funding: VM, EN, MS.

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Availability of data and materials

The datasets used and analysed during the current study are available from the following websites: OECD Health Statistics: <https://stats.oecd.org/Index.aspx?ThemeTreeId=9> Institute of Health Metrics and Evaluation: <https://www.healthdata.org/> WHO Global Health Observatory: <https://www.who.int/data/gho> The World Bank: <https://data.worldbank.org/> Eurostat: <https://ec.europa.eu/eurostat/data/database> OECD Education at a Glance: https://www.oecd-ilibrary.org/education/data/oecd-education-statistics_edu-data-en

Declarations

Ethics approval and consent to participate

No ethics approval was required as data aggregated at the country-level is used.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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