How to achieve optimal organization of primary care service delivery at system level: lessons from Europe

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Abstract

Objective. To measure the relative efficiency of primary care (PC) in turning their structures into services delivery and turning their services delivery into quality outcomes.

Design. Cross-sectional study based on the dataset of the Primary Healthcare Activity Monitor for Europe project. Two Data Envelopment Analysis models were run to compare the relative technical efficiency. A sensitivity analysis of the resulting efficiency scores was performed.

Setting. PC systems in 22 European countries in 2009/2010.

Main Outcome Measures. Model 1 included data on PC governance, workforce development and economic conditions as inputs and access, coordination, continuity and comprehensiveness of care as outputs. Model 2 included the previous process dimensions as inputs and quality indicators as outputs.

Results. There is relatively reasonable efficiency in all countries at delivering as many as possible PC processes at a given level of PC structure. It is particularly important to invest in economic conditions to achieve an efficient structure–process balance. Only five countries have fully efficient PC systems in turning their services delivery into high quality outcomes, using a similar combination of access, continuity and comprehensiveness, although they differ on the adoption of coordination of services. There is a large variation in efficiency levels obtained by countries with inefficient PC in turning their services delivery into quality outcomes.

Conclusions. Maximizing the individual functions of PC without taking into account the coherence within the health-care system is not sufficient from a policymaker's point of view when aiming to achieve efficiency.

Keywords: health-care system, health policy, setting of care, primary care/general practice, measurement of quality, benchmarking, measurement of quality, quality indicators

Introduction

The main goals of health-care systems are to improve population health and health equity [1]. All health-care systems in developed countries are facing common challenges, including aging population, increases in chronic and lifestyle-related diseases and rising health-care costs. Increasingly, it is argued that primary care (PC) is an important part of the answer to these challenges [2–4]. The potential of PC is based on its role as first contact care for curative, preventive, public, social and mental health problems and providing services in an accessible setting near people's homes on a continuous basis [5]. Health-care systems that have optimized the performance of these key PC dimensions can reduce unnecessary use of expensive specialized care [6–9] and seem to have healthier populations, fewer health-related disparities and lower overall costs for health care, although the evidence is not conclusive yet, particularly for the European setting [8–11]. Recently, countries have been encouraged to orient their health-care systems toward PC in the World Health Report of 2008 [4].

The importance of PC both in terms of population health and use of resources amply motivates research on PC

performance [12, 13]. Policymakers are in need of evidence to help them prioritize PC. Priority setting should be based on evidence of the optimal balance of PC dimensions to achieve their intended effects.

The application of a Primary Care Monitor by the Primary Healthcare Activity Monitor for Europe (PHAMEU) project in 31 European countries in 2009/2010 has made it possible to compare and analyze the key dimensions of PC in a standardized way [5, 14]. PC can be described as a subsystem of the overall health-care system, when taking into account its complexity (hereafter referred to as 'primary care system'). A country's PC system is structured by its governance, economic conditions and workforce development. The process of a country's PC service delivery is determined by the comprehensiveness of PC services, accessibility of PC and coordination and continuity of PC. Both the PC structure and PC services delivery process seem to affect its outcomes in terms of quality of care (see Fig. 1) [14]. Although all of these dimensions are important for population health, it is unknown which combination(s) of dimensions will achieve the best (i.e. most efficient) quality of care outcomes.

In the last three decades, a number of analytical methods have been advanced to foster efficiency analysis within the context of PC, mainly with the purpose of offering policymakers useful tools to measure the extent to which certain levels of outcome are reached in relation to the resources deployed [15–18].

Efficiency can be defined (from a policymaker's point of view) as the extent to which health goals are achieved in relation to the resources consumed.

In this article, PC efficiency is defined as the extent to which PC achieves its outcomes in relation to its structure and organization of processes. Hence, a country is (technical) efficient in delivering PC, if it uses an optimal combination of structure (measured in terms of governance, economic conditions and workforce) and organization of processes (measured in terms of comprehensiveness, access, continuity and coordination of care) to 'produce' a given level of outcomes (measured in terms of quality of care), relatively to the other countries. This article aims to identify the optimal way of organizing PC services delivery at system level. The following research questions will be answered:

- (A1) What is the optimal (most technically efficient) relationship between the structure of PC (in terms of PC governance, economic conditions and workforce development) and the PC processes delivered (in terms of comprehensiveness, access, continuity and coordination of care)?
- (A2) Is there variation among European countries in their technical efficiency (TE) at PC structure–process level (considering the relation between the PC structure arrangements and PC processes delivered)?
- (B1) What is the optimal (most technically efficient) relationship between the process dimensions of PC services delivery (in terms of comprehensiveness, access, continuity and coordination of care) and quality of care?
- (B2) Is there variation among European countries in their TE at PC process–outcome level (considering the

relation between the PC processes delivered and quality of care outcomes)?

Methods

Fig. 1 shows the study design, based on the Primary Care Framework developed by Kringos *et al.* [5, 14].

Setting and data collection

Data were derived from the PHAMEU project, which were collected based on the 94 PC indicators in 27 EU Member States, Switzerland, Turkey, Norway, and Iceland in 2009/2010. The indicators were developed based on a systematic literature review and expert consultations, measuring the existing PC structures and aspects of PC services delivery and the quality of PC services of countries [5, 14]. The indicator set for which data were collected and the data collection approach have been described in detail by Kringos *et al.* [5, 14].

For the purpose of this article, we excluded 9 countries because of a relatively high number of missing data (Cyprus, Greece, Iceland, Ireland, Malta, Romania, Slovak Republic, Slovenia and Turkey).

As for the quality dimension, we considered a limited set of PHAMEU indicators to minimize missing values including:

(i) Defined daily doses of antibiotic use in ambulatory care/1000 inhabitants/day.
  Too high amounts of antibiotics use affects the antimicrobial resistance of people and is a sign of inappropriate prescription.
(ii) Crude percentage of diabetic population aged>25 years with HbA1C>7.0%.
  Diabetes is a PC sensitive condition. The provision of a wide range of services provided by PC providers is associated with better health outcomes at lower costs.
(iii) Number of hospital admissions for people with a diagnosis of asthma/100 000 population/year.
Lower rates of hospitalization for PC sensitive conditions are strongly associated with an adequate PC system in terms of the receipt of timely, comprehensive and effective PC services.
(iv) Percentage of infants vaccinated within PC against: diphtheria, tetanus, pertussis, measles, mumps and rubella.

Preventive health-care activities are cost-effective in the PC setting and result in improved levels of population health.

Together, this indicator set represents four important areas of quality of PC: prescribing behavior of PC providers, quality of chronic diseases management, quality of diagnosis and treatment in PC and the quality of child health care (see Fig. 1).

Supplementary data, Appendix 1 provides an overview of all indicators by dimension and their rationale.
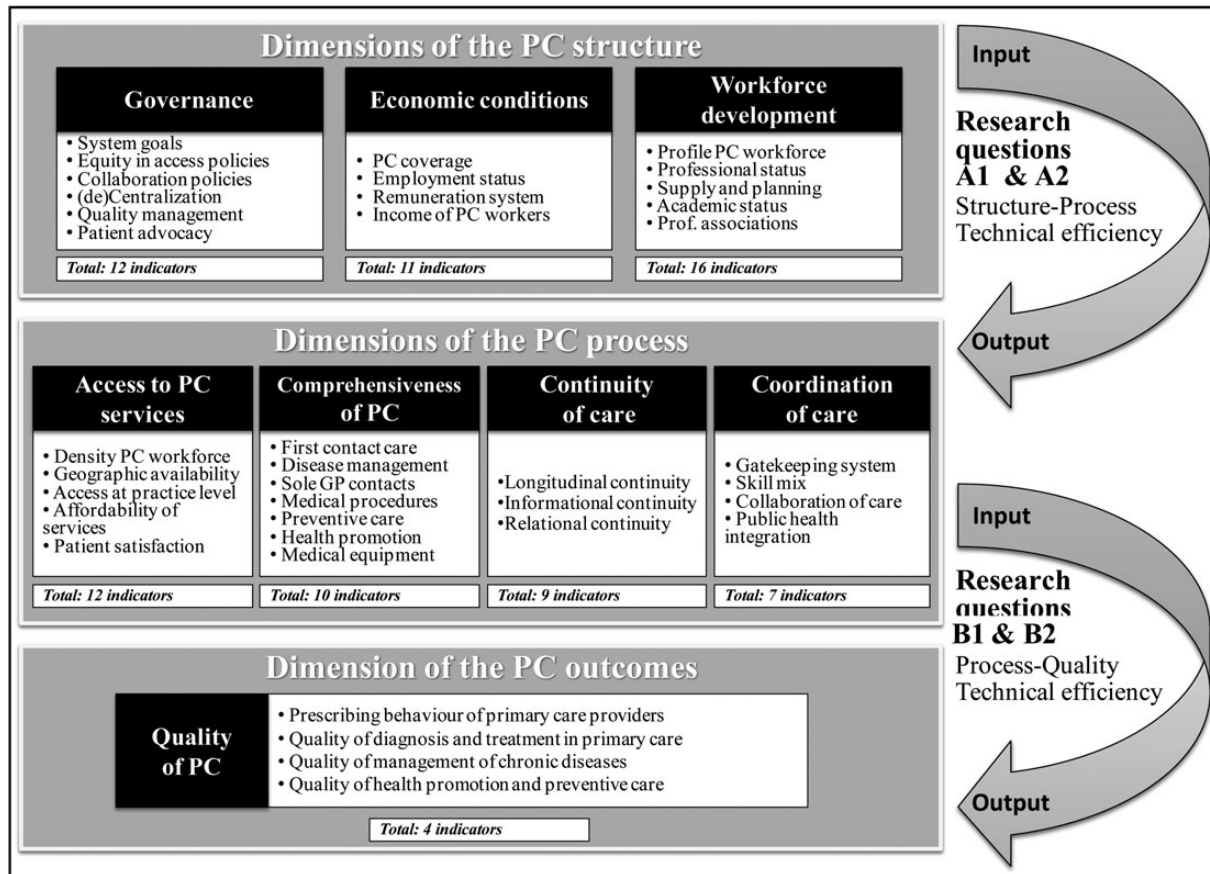
Figure 1 Study design.

Data on the strength of PC were derived from Kringos *et al.* [19] in which country data on all indicators were translated into scores indicating the PC strength of countries, ranging from one (weak) to three (strong) (see Supplementary data, Appendix 1). Based on these indicators per country, eight separate dimension scores were calculated, as reported in Table 1 (column 'current value') and Supplementary data, Appendix 2, using MLWiN 2.02 software. The dependent variable is the combination of scores for every country on the indicators belonging to that dimension. In the fixed part of the model, the dimension average is estimated together with the indicator effects (using deviation indicator coding), to control for differences in the indicator averages. In the random part, at level 1, the indicator measurement errors are modeled as separate variance terms for every indicator; this controls for differences in the standard deviation of indicators. At level 2, the effect for every country on the dimension is modeled, and this is used to calculate country dimension scores [20, 21]. The resulting scores were used in the analysis of this study.

Variables of the data envelopment analysis (DEA)

We carried out our efficiency analysis by applying data envelopment analysis (DEA) in two steps using 'DEA excel solver' software [22]: firstly, we ran a DEA model considering the three structure dimensions as inputs and the four process dimensions as outputs, followed by another DEA model considering the four process dimensions as inputs and the quality of PC as output (see Fig. 1).

In both models, the countries with the highest output/input ratios are acknowledged as optimal performers, and the frontier efficiency is built up by joining these observations into input–output space. In DEA, inefficient countries are 'enveloped' by the efficiency frontier. The statistical and methodological background of DEA has been illustrated in a number of articles [18, 23–25].

Empirical specifications of the DEA models

TE in our analysis has a dual definition.

(i) Producing the highest amount of processes from a given level of structure.
(ii) Producing the highest quality outcomes from a given combination of processes.

We made three assumptions. Firstly, we ran our DEA model under the assumption of constant returns to scale, aiming to analyze TE in the provision of PC services in each country by focusing on their 'productivity' regardless of the 'scale of operations' [26].

Table 1 Efficiency analysis: the current value, efficiency target and slacks of PC systems by country

Country Efficiency scores: DEA *a* = DEA *b* =	DEA model (a): structure–process						DEA model (b): process–outcome					
	Peer Benchmarks	Outputs/inputs	CV	Slacks	ET	Gap % (CV-ET)/CV	Peer benchmarks	Outputs/inputs	CV	Slacks	ET	Gap % (CV-ET)/CV
Austria	Czech Republic	Acc	2.27	0.00	2.36	3.97	Germany	Qua	0.82	0.00	2.65	225.25
	Latvia	Con	2.19	0.19	2.47	12.63	Hungary	Acc	2.27	0.06	2.20	−2.82
TE *a* = 96.2%	Luxembourg	Coo	1.38	0.26	1.70	23.00		Con	2.19	0.00	2.19	0.00
		Com	2.33	0.00	2.43	3.98		Coo	1.38	0.00	1.38	0.00
TE *b* = 30.7%		Gov	2.48	0.00	2.48	0.00		Com	2.33	0.17	2.16	−7.33
		Eco	2.12	0.02	2.10	−0.76						
		Wfd	1.98	0.00	1.98	0.00						
Belgium	Bulgaria	Acc	2.13	0.00	2.20	3.57	Sweden	Qua	1.82	0.00	2.91	60.30
	Sweden	Con	2.38	0.01	2.48	3.99	Luxembourg	Acc	2.13	0.03	2.10	−1.18
TE *a* = 96.6%	Switzerland	Coo	1.70	0.00	1.76	3.59		Con	2.38	0.00	2.38	0.00
	Luxembourg	Com	2.53	0.00	2.62	3.56		Coo	1.70	0.00	1.70	0.00
TE *b* = 62.4%		Gov	2.37	0.00	2.37	0.00		Com	2.53	0.02	2.50	−0.95
		Eco	2.19	0.00	2.19	0.00						
		Wfd	2.04	0.06	1.98	−2.84						
Bulgaria		Acc	2.15	0.00	2.15	0.00	Germany	Qua	1.82	0.00	2.78	53.08
		Con	2.33	0.00	2.33	0.00	Luxembourg	Acc	2.15	0.00	2.15	0.00
TE *a* = 100%		Coo	1.44	0.00	1.44	0.00		Con	2.33	0.00	2.33	−0.04
		Com	2.55	0.00	2.55	0.00		Coo	1.44	0.00	1.44	0.00
TE *b* = 65.3%		Gov	2.46	0.00	2.46	0.00		Com	2.54	0.21	2.34	−8.25
		Eco	1.9	0.00	1.90	0.00						
		Wfd	1.98	0.00	1.98	0.00						
Czech Republic		Acc	2.35	0.00	2.35	0.00	Hungary	Qua	2.82	0.00	2.85	1.28
		Con	2.41	0.00	2.41	0.00	Luxembourg	Acc	2.35	0.00	2.35	0.00
TE *a* = 100%		Coo	1.65	0.00	1.65	0.00		Con	2.41	0.06	2.36	−2.32
		Com	2.33	0.00	2.33	0.00		Coo	1.65	0.15	1.49	−9.24
TE *b* = 98.7%		Gov	2.43	0.00	2.43	0.00		Com	2.33	0.00	2.33	0.00
		Eco	2.03	0.00	2.03	0.00						
		Wfd	1.95	0.00	1.95	0.00						
Denmark		Acc	2.46	0.00	2.46	0.00	Hungary	Qua	1.82	0.00	2.95	62.39
		Con	2.43	0.00	2.43	0.00	Netherlands	Acc	2.46	0.01	2.45	−0.41
TE *a* = 100%		Coo	1.96	0.00	1.96	0.00		Con	2.43	0.00	2.43	0.00
		Com	2.40	0.00	2.40	0.00		Coo	1.96	0.39	1.58	−19.61
TE *b* = 61.6%		Gov	2.53	0.00	2.53	0.00		Com	2.40	0.00	2.40	0.00
		Eco	2.10	0.00	2.10	0.00						
		Wfd	2.24	0.00	2.24	0.00						
Estonia	Bulgaria	Acc	2.21	0.15	2.38	7.84	Hungary	Qua	1.82	0.00	2.88	58.37
	Czech Republic	Con	2.42	0.00	2.45	0.95	Luxembourg	Acc	2.21	0.00	2.21	0.00

TE a = 99.1%	Denmark	Coo	1.71	0.00	1.73	0.93		Con	2.42	0.06	2.37	−2.39
		Com	2.42	0.02	2.45	1.61		Coo	1.71	0.12	1.59	−7.24
TE b = 63.1%		Gov	2.52	0.00	2.52	0.00		Com	2.41	0.00	2.42	0.00
		Eco	2.06	0.00	2.06	0.00						
		Wfd	2.10	0.01	2.09	−0.43						
Finland	Bulgaria	Acc	2.20	0.00	2.28	3.72	Sweden	Qua	1.82	0.00	2.85	56.83
	Sweden	Con	2.32	0.06	2.47	6.41	Luxembourg	Acc	2.20	0.13	2.07	−5.90
TE a = 96.4%	Switzerland	Coo	1.74	0.00	1.81	3.73		Con	2.32	0.00	2.32	0.00
	Luxembourg	Com	2.51	0.00	2.61	3.74		Coo	1.74	0.00	1.74	0.00
TE b = 63.8%		Gov	2.38	0.00	2.38	0.00		Com	2.51	0.06	2.46	−2.23
		Eco	2.18	0.00	2.18	0.00						
		Wfd	2.22	0.06	2.17	−2.48						
France	Bulgaria	Acc	2.06	0.05	2.19	6.57	Germany	Qua	1.82	0.00	2.84	56.33
	Denmark	Con	2.33	0.00	2.43	4.16	Luxembourg	Acc	2.06	0.00	2.06	0.00
TE a = 96.0%	Sweden	Coo	1.63	0.00	1.69	4.18		Con	2.33	0.01	2.33	−0.26
	Switzerland	Com	2.47	0.00	2.57	4.17		Coo	1.63	0.00	1.63	0.00
TE b = 64%	Luxembourg	Gov	2.37	0.00	2.37	0.00		Com	2.47	0.04	2.43	−1.46
		Eco	2.12	0.00	2.12	0.00						
		Wfd	1.99	0.00	1.99	0.00						
Germany	Czech Republic	Acc	2.25	0.00	2.33	3.56		Qua	2.82	0.00	2.82	0.00
	Hungary	Con	2.38	0.00	2.47	3.53		Acc	2.25	0.00	2.25	0.00
TE a = 96.6%	Luxembourg	Coo	1.38	0.26	1.69	22.28		Con	2.38	0.00	2.38	0.00
		Com	2.34	0.04	2.46	5.26		Coo	1.38	0.00	1.38	0.00
TE b = 100%		Gov	2.41	0.00	2.41	0.04		Com	2.34	0.00	2.34	0.00
		Eco	2.15	0.02	2.13	−0.88						
		Wfd	1.99	0.00	2.00	0.05						
Hungary		Acc	2.34	0.00	2.34	0.00		Qua	2.82	0.00	2.82	0.00
		Con	2.33	0.00	2.33	0.00		Acc	2.34	0.00	2.34	0.00
TE a = 100%		Coo	1.46	0.00	1.46	0.00		Con	2.33	0.00	2.33	0.00
		Com	2.29	0.00	2.29	0.00		Coo	1.46	0.00	1.46	0.00
TE b = 100%		Gov	2.21	0.00	2.21	0.00		Com	2.29	0.00	2.29	0.00
		Eco	2.09	0.00	2.09	0.00						
		Wfd	2.06	0.00	2.06	0.00						
Italy	Czech Republic	Acc	2.27	0.01	2.46	8.24	Hungary	Qua	1.82	0.00	2.62	44.11
	Denmark	Con	2.31	0.00	2.49	7.74		Acc	2.27	0.09	2.18	−4.14
TE a = 92.8%	Poland	Coo	1.73	0.00	1.86	7.75		Con	2.31	0.15	2.16	−6.53
	Sweden	Com	2.13	0.15	2.45	14.77		Coo	1.73	0.37	1.36	−21.45
TE b = 69.4%		Gov	2.54	0.00	2.54	0.00		Com	2.13	0.00	2.13	0.00
		Eco	2.14	0.00	2.14	0.00						
		Wfd	2.08	0.00	2.08	0.00						
Latvia		Acc	2.15	0.00	2.15	0.00	Hungary	Qua	2.82	0.00	2.86	1.42
		Con	2.38	0.00	2.38	0.00	Luxembourg	Acc	2.15	0.00	2.15	0.00
TE a = 100%		Coo	1.65	0.00	1.65	0.00		Con	2.38	0.04	2.35	−1.47

(*continued*)

Table I Continued

Country Efficiency scores: DEA a= DEA b =	DEA model (a): structure–process						DEA model (b): process–outcome					
	Peer Benchmarks	Outputs/inputs	CV	Slacks	ET	Gap % (CV-ET)/CV	Peer benchmarks	Outputs/inputs	CV	Slacks	ET	Gap % (CV-ET)/CV
		Com	2.41	0.00	2.41	0.00		Coo	1.65	0.05	1.60	−3.03
TE b = 98.6%		Gov	2.46	0.00	2.46	0.00		Com	2.41	0.00	2.41	−0.04
		Eco	2.07	0.00	2.07	0.00						
		Wfd	1.87	0.00	1.87	0.00						
Lithuania		Acc	2.29	0.00	2.29	0.00	Sweden	Qua	2.82	0.00	2.85	1.17
		Con	2.30	0.00	2.30	0.00	Luxembourg	Acc	2.29	0.17	2.12	−7.37
TE a = 100%		Coo	1.98	0.00	1.98	0.00		Con	2.30	0.00	2.30	0.00
		Com	2.56	0.00	2.56	0.00		Coo	1.98	0.00	1.98	0.00
TE b = 98.9%		Gov	2.50	0.00	2.50	0.00		Com	2.56	0.08	2.48	−3.16
		Eco	2.07	0.00	2.07	0.00						
		Wfd	2.08	0.00	2.08	0.00						
Luxembourg		Acc	2.03	0.00	2.03	0.00		Qua	2.82	0.00	2.82	0.00
		Con	2.31	0.00	2.31	0.00		Acc	2.03	0.00	2.03	0.00
TE a = 100%		Coo	1.63	0.00	1.63	0.00		Con	2.31	0.00	2.31	0.00
		Com	2.42	0.00	2.42	0.00		Coo	1.63	0.00	1.63	0.00
TE b = 100%		Gov	2.16	0.00	2.16	0.00		Com	2.42	0.00	2.42	0.00
		Eco	2.05	0.00	2.05	0.00						
		Wfd	1.81	0.00	1.81	0.00						
Netherlands	Denmark	Acc	2.38	0.00	2.41	1.51		Qua	2.82	0.00	2.82	0.00
	Sweden	Con	2.26	0.14	2.44	7.83		Acc	2.38	0.00	2.38	0.00
TE a = 98.5%		Coo	2.20	0.00	2.23	1.55		Con	2.26	0.00	2.26	0.00
		Com	2.32	0.20	2.55	9.96		Coo	2.20	0.00	2.20	0.00
TE b = 100%		Gov	2.61	0.01	2.60	−0.50		Com	2.32	0.00	2.32	0.00
		Eco	2.18	0.00	2.18	0.00						
		Wfd	2.30	0.07	2.23	−2.96						
Norway	Bulgaria	Acc	2.25	0.00	2.29	1.73	Germany	Qua	1.82	0.00	2.87	57.93
	Czech Republic	Con	2.36	0.05	2.45	3.85	Hungary	Acc	2.25	0.00	2.25	0.00
TE a = 98.3%	Hungary	Coo	1.56	0.00	1.58	1.74	Luxembourg	Con	2.36	0.00	2.36	0.00
	Poland	Com	2.55	0.00	2.59	1.73		Coo	1.56	0.00	1.56	0.00
TE b = 63.3%	Luxembourg	Gov	2.52	0.00	2.52	0.00		Com	2.55	0.16	2.39	−6.28
		Eco	2.05	0.00	2.05	0.00						
		Wfd	2.06	0.00	2.06	0.00						
Poland	Bulgaria	Acc	2.35	0.00	2.35	0.00	Hungary	Qua	2.82	0.00	2.82	0.00
	Denmark	Con	2.33	0.00	2.33	0.00	Netherlands	Acc	2.35	0.01	2.34	−0.38
TE a = 100%	Hungary	Coo	1.92	0.00	1.92	0.00		Con	2.33	0.00	2.33	0.00
		Com	2.30	0.00	2.30	0.00		Coo	1.92	0.46	1.47	−23.76

			CV		ET	%			CV		ET	%
TE b = 99.9%		Gov	2.37	0.00	2.37	0.00		Com	2.30	0.00	2.30	0.00
		Eco	2.06	0.00	2.06	0.00						
		Wfd	1.97	0.00	1.97	0.00						
Portugal	Bulgaria	Acc	2.34	0.00	2.41	3.12	Hungary	Qua	2.82	0.00	2.87	1.74
	Denmark	Con	2.35	0.05	2.48	5.40	Luxembourg	Acc	2.34	0.22	2.12	−9.27
TE a = 97.0%	Hungary	Coo	1.62	0.06	1.73	6.84		Con	2.35	0.00	2.35	0.00
		Com	2.48	0.00	2.55	3.15		Coo	1.62	0.00	1.62	0.00
TE b = 98.3%		Gov	2.55	0.00	2.55	0.00		Com	2.47	0.04	2.44	−1.62
		Eco	2.11	0.00	2.11	0.00						
		Wfd	2.24	0.04	2.20	−1.97						
Spain	Bulgaria	Acc	2.44	0.00	2.50	2.21	Hungary	Qua	0.82	0.00	2.97	264.22
	Denmark	Con	2.43	0.04	2.52	3.96	Netherlands	Acc	2.44	0.18	2.27	−7.28
TE a = 97.8%	Hungary	Coo	1.84	0.00	1.88	2.23	Luxembourg	Con	2.43	0.00	2.43	0.00
	Lithuania	Com	2.51	0.00	2.57	2.19		Coo	1.84	0.00	1.84	0.00
TE b = 28.5%	Poland	Gov	2.57	0.00	2.57	0.00		Com	2.51	0.00	2.51	0.00
		Eco	2.20	0.00	2.20	0.00						
		Wfd	2.20	0.00	2.20	0.00						
Sweden		Acc	2.18	0.00	2.18	0.00		Qua	2.82	0.00	2.82	0.00
		Con	2.25	0.00	2.25	0.00		Acc	2.18	0.00	2.18	0.00
TE a = 100%		Coo	2.32	0.00	2.32	0.00		Con	2.25	0.00	2.25	0.00
		Com	2.49	0.00	2.49	0.00		Coo	2.32	0.00	2.32	0.00
TE b = 100%		Gov	2.46	0.00	2.46	0.00		Com	2.49	0.00	2.49	0.00
		Eco	2.09	0.00	2.09	0.00						
		Wfd	2.05	0.00	2.05	0.00						
Switzerland		Acc	2.17	0.00	2.17	0.00	Hungary	Qua	1.82	0.00	2.86	57.71
		Con	2.37	0.00	2.37	0.00	Luxembourg	Acc	2.17	0.00	2.17	0.00
TE a = 100%		Coo	1.63	0.00	1.63	0.00		Con	2.37	0.02	2.35	−0.68
		Com	2.42	0.00	2.42	0.00		Coo	1.63	0.04	1.60	−2.26
TE b = 63.4%		Gov	2.09	0.00	2.09	0.00		Com	2.48	0.00	2.42	0.00
		Eco	2.12	0.00	2.12	0.00						
		Wfd	2.10	0.00	2.10	0.00						
UK	Bulgaria	Acc	2.40	0.00	2.51	4.59	Sweden	Qua	1.82	0.00	2.91	60.19
	Denmark	Con	2.37	0.11	2.58	9.26	Luxembourg	Acc	2.40	0.26	2.14	−10.81
TE a = 95.6%	Lithuania	Coo	1.88	0.00	1.97	4.57		Con	2.37	0.00	2.37	0.00
	Switzerland	Com	2.52	0.00	2.64	4.60		Coo	1.88	0.00	1.88	0.00
TE b = 62.4%		Gov	2.56	0.00	2.56	0.00		Com	2.52	0.00	2.52	−0.16
		Eco	2.26	0.00	2.26	0.00						
		Wfd	2.34	0.01	2.33	−0.26						

CV, current value; ET, efficiency target; Qua, PC quality; Acc, PC access; Con, continuity of PC; Coo, coordination of PC; Com, comprehensiveness of PC; Gov, PC governance; Eco, economic conditions of PC; Wfd, PC workforce development.

Secondly, we ran an output-orientation DEA model to explore the potential expansion in the output provided while keeping input mixes invariable [27].

In DEA, weights of the performance criteria are endogenously determined in the model without the need for subjective judgments, assigning to each country its best attainable efficiency score. Therefore, no weight restrictions were made [27].

The empirical model for the efficiency of a county's PC system can be formulated as follows [23]:

$$\text{Maximize } E_{\text{PCo}} = \frac{\sum_{s=1}^{S} u_s \times y_s \text{o}}{\sum_{m=1}^{M} v_m \times x_m \text{o}}$$

Subject to

$$\frac{\sum_{s=1}^{S} u_s \times y_{si}}{\sum_{m=1}^{M} v_m \times x_{mi}} \leq 1 \quad i = 1, \dots, 31,$$

where, E_{PCo}, efficiency of PC 0; y_so, quantity of outputs s of PCo; x_mo, quantity of inputs m of PCo; u_s, weight attached to the output s—generated from the model— $u_s > 0$, $s = 1, \dots, S$; v_m, weight attached to the input m—generated from the model—$v_m > 0$, $m = 1, \dots, M$.

This mathematical problem is to maximize the efficiency of PCo by generating a set of weights (i.e. u_s and v_m) to be attached to its inputs and outputs. This is subject to the constraints that, when applied to the other PC systems under scrutiny, no one can assume efficiency scores greater than unity. Furthermore, such a set of weights cannot assume a negative value.

A core aspect of DEA is the calculation of a set of input–output targets that would turn a country with inefficient PC into an efficient one. Other useful parameters provided by DEA, which will be used in this article to investigate potential causes of inefficiency, are the slacks. Slacks are values attached to the different variables, indicating the underproduction of outputs or the overuse of inputs. Furthermore, DEA seeks out these values for each country's PC system, taking into account other countries with PC systems that use similar input–output ratios (peer systems), but at a more efficient level.

Addressing the uncertainty in modeling DEA

Because DEA measures efficiency relative to an estimate of the frontier, we used the bootstrap approach proposed by Simar and Wilson (2000), to estimate the bias-corrected measure of TE as well as confidence intervals for efficiency scores, by running 2000 bootstrap replications using 'FEAR' software [28].

Results

DEA and efficiency scores

Fig. 2 summarizes the efficiency scores of all 22 countries for both applied models. The average efficiency for structure–process is 0.98 and for process–outcome is 0.80. The former efficiency scores range between 0.93 (93%) to 1 (100%), whereas the latter shows a greater variation (standard deviation 0.233), ranging from 0.28 (28%) to 1.0 (100%).

The structure–process DEA model shows that 10 countries (Bulgaria, Czech Republic, Denmark, Hungary, Latvia, Lithuania, Luxembourg, Poland, Sweden and Switzerland) are relatively efficient in delivering their processes, using the
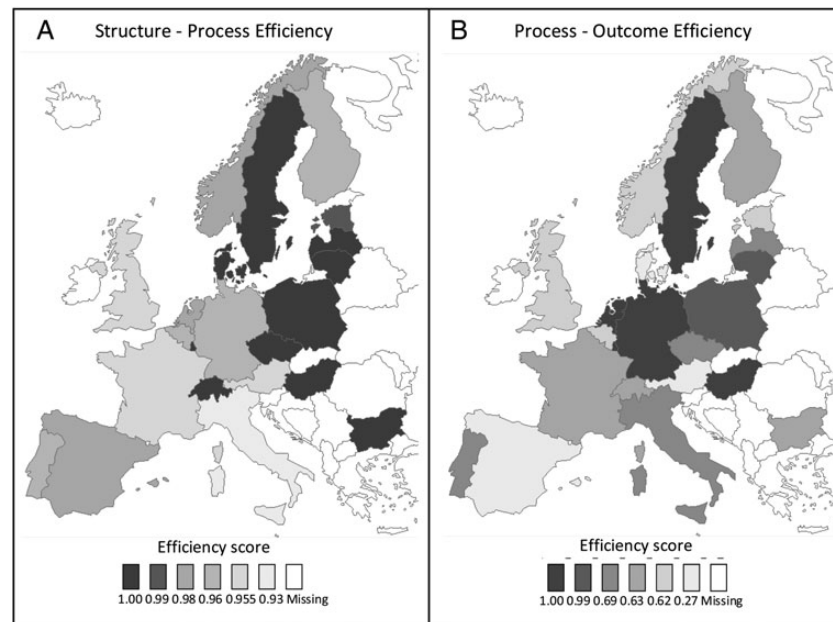
Figure 2 Summary of efficiency score. (**A**) Structure–process DEA model. (**B**) Process–outcome DEA model.

best mix of structure dimensions, with efficiency scores equal to the unity or 100% relative to the other PC systems. The most inefficient country on structure–process level was Italy, with an efficiency score of 0.93. These results point to a relatively high efficiency in all countries in delivering the maximum processes of PC at the given values of the structure dimensions.

In the process–outcome DEA model, only five countries (Germany, Hungary, Luxembourg, The Netherlands and Sweden) were found to be relatively efficient.

Fig. 3 shows the optimal mix of input–output ratios for both DEA models. As for the structure–process DEA model, the 10 best performing countries are quite different in their structure inputs: each of these PC systems differs from the other: both in terms of workforce development and governance features, whereas they seem to converge on their values for the economic condition dimension. As for the most efficient PC systems with regard to the process–outcome TE, our results suggest that although there are different degrees of coordination of care among countries, it is necessary to have a high level of PC access, comprehensiveness and continuity of care to provide the highest amounts of quality.

Analysis of the sources of inefficiency

Table 1 summarizes the set of current values by PC dimension and country, efficiency targets (indicating room for improvement of a country's value on a certain PC dimension based on the performance of peer countries), efficiency gaps (the difference between the current values and the targets as percentage of the current values) and slacks for each country's PC system as regards both of our DEA models. For example, it shows that Italy's PC system was the worst performer in using its structure dimensions to deliver processes. The results indicate that a little expansion in all the outputs (i.e. comprehensiveness, coordination, access and coordination), by maintaining the current level of input (governance,

workforce development and economic conditions) would be necessary to reach the efficiency of Italy's peer benchmarks. However, the results of Italy's process–outcome DEA exercise suggest that to be truly efficient, Italy would need to increase quality level by roughly 44%, although maintaining its levels of processes of care fixed.

Supplementary data file 1 gives a graphical example of the results shown in Table 2 for a selection of countries (i.e. Denmark, Italy and Spain) for both the structure–Process DEA model (A, on the left) and for process–outcome DEA model (B, on the right).

Bias-corrected efficiency results

Initial structure–process DEA model results for the 22 countries gave an average uncorrected TE score of 0.98, whereas the bootstrap model generated an average bias corrected score of 0.97 (see Table 2). The minimum uncorrected score was 0.93 and the maximum was 1, whereas the minimum bias corrected score was 0.92 and the maximum was 0.99. Further analysis showed that the original scores had a mean bias of −0.01 that was relatively low. With regard to the process–outcome DEA model, results reported in Table 2 show trends going in the same direction of the original DEA model; the difference between the average of the original efficiency scores (0.77) and the average of the bias-corrected TE scores (0.71) is relatively small (0.06), and the average bias estimated is acceptable (0.06) [29].

Discussion

Variation of PC efficiency at different levels

The results show variation among the 22 countries in how they structure and organize PC services delivery at system level, as well as in their relative efficiency in terms of processes delivered and quality outcomes achieved. Only a few countries (Sweden, Hungary and Luxemburg) are efficient at
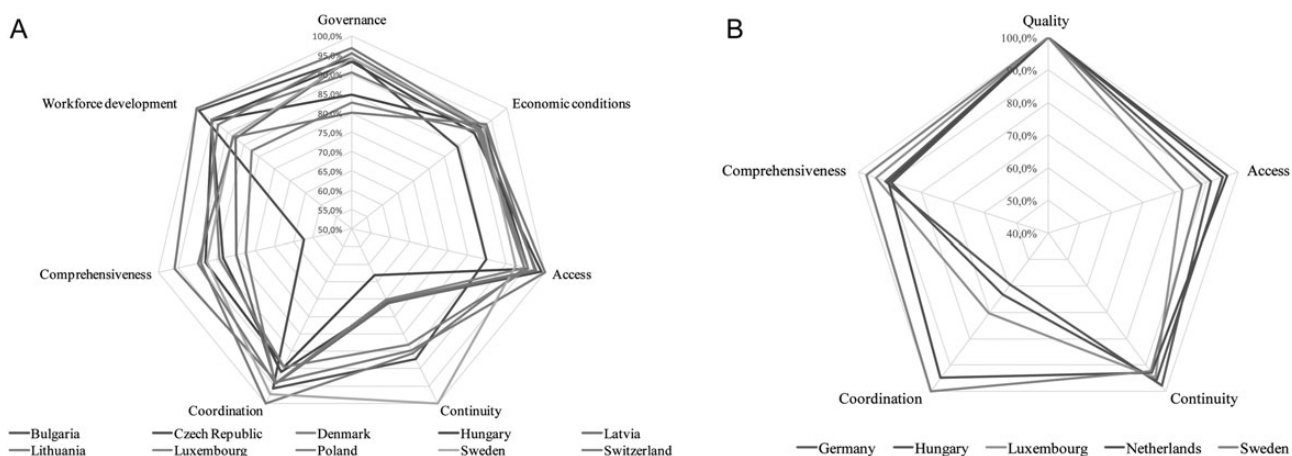

Figure 3 Best performers input–output combinations. (**A**) Structure–process DEA model. (**B**) Process–outcome DEA model.

Table 2 Bootstrapped TE results by country

	Original DEA efficiency scores	Bootstrap bias-corrected efficiency scores	CI 95% Lower bound	Upper bound	Bootstrap bias estimate	Bootstrap variance (σ) estimate
DEA model (a): structure–process						
Austria	0.962	0.952	*0.935*	*0.961*	0.010	5.960
Belgium	0.966	0.956	*0.940*	*0.965*	0.009	4.897
Bulgaria	1.000	0.979	*0.941*	*1.000*	0.021	0.000
Czech Republic	1.000	0.981	*0.956*	*0.999*	0.019	0.000
Denmark	1.000	0.982	*0.959*	*0.999*	0.018	0.000
Estonia	0.991	0.981	*0.967*	*0.990*	0.009	3.808
Finland	0.964	0.955	*0.942*	*0.963*	0.009	3.634
France	0.960	0.950	*0.935*	*0.959*	0.010	4.528
Germany	0.966	0.955	*0.940*	*0.965*	0.010	5.471
Hungary	1.000	0.980	*0.950*	*0.999*	0.020	0.000
Italy	0.928	0.919	*0.902*	*0.928*	0.010	5.088
Latvia	1.000	0.985	*0.962*	*0.999*	0.015	0.000
Lithuania	1.000	0.984	*0.964*	*0.999*	0.016	0.000
Luxembourg	1.000	0.980	*0.953*	*0.999*	0.020	0.000
Netherlands	0.985	0.974	*0.954*	*0.985*	0.011	7.851
Norway	0.983	0.973	*0.954*	*0.982*	0.010	6.214
Poland	1.000	0.980	*0.949*	*0.999*	0.020	0.000
Portugal	0.970	0.961	*0.950*	*0.969*	0.009	2.883
Spain	0.978	0.970	*0.960*	*0.978*	0.008	2.346
Sweden	1.000	0.979	*0.938*	*1.000*	0.021	0.000
Switzerland	1.000	0.979	*0.938*	*0.999*	0.021	0.000
UK	0.956	0.948	*0.938*	*0.956*	0.008	2.213
DEA model (b): process outcome						
Austria	0.307	0.277	*0.257*	*0.305*	0.031	0.000
Belgium	0.624	0.568	*0.534*	*0.619*	0.055	0.001
Bulgaria	0.653	0.580	*0.545*	*0.645*	0.073	0.001
Czech Republic	0.987	0.913	*0.861*	*0.976*	0.074	0.002
Denmark	0.616	0.575	*0.544*	*0.611*	0.040	0.000
Estonia	0.631	0.588	*0.556*	*0.626*	0.043	0.001
Finland	0.638	0.600	*0.565*	*0.633*	0.038	0.001
France	0.640	0.578	*0.544*	*0.633*	0.062	0.001
Germany	1.000	0.845	*0.806*	*0.979*	0.155	0.006
Hungary	1.000	0.882	*0.833*	*0.983*	0.118	0.003
Italy	0.694	0.651	*0.613*	*0.690*	0.043	0.001
Latvia	0.986	0.911	*0.856*	*0.976*	0.075	0.002
Lithuania	0.989	0.939	*0.891*	*0.980*	0.050	0.001
Luxembourg	1.000	0.931	*0.886*	*0.985*	0.069	0.001
Netherlands	0.633	0.581	*0.541*	*0.625*	0.052	0.001
Norway	1.000	0.935	*0.884*	*0.994*	0.065	0.001
Poland	0.983	0.924	*0.862*	*0.974*	0.059	0.002
Portugal	0.275	0.259	*0.246*	*0.271*	0.015	7.779
Spain	1.000	0.930	*0.886*	*0.984*	0.070	0.001
Sweden	0.634	0.585	*0.550*	*0.627*	0.049	0.001
Switzerland	0.624	0.595	*0.564*	*0.620*	0.029	0.000
UK	1.000	0.899	*0.848*	*0.988*	0.101	0.003

Italic value represents the 95% lower and upper bound confidence interval of the bootstrap bias-corrected efficiency scores.

turning both their PC structures into PC processes and their PC processes into quality outcomes. The majority of efficient PC systems (Switzerland, Poland, Czech Republic and Latvia), in terms of transforming their PC structures into processes, were inefficient at turning their processes into quality outcomes. The Dutch and German PC systems both have an optimal relationship between their PC process dimensions and quality of care, but are inefficient at turning their structure dimensions into an optimal mix of PC services delivery dimensions.

PC system strength versus efficiency

Kringos *et al.* [19] investigated the strength of PC across countries in terms of maximizing their PC orientation at both structure and services delivery level. When comparing the strength of countries' PC systems with their relatively efficiency, we see that some of the countries with relatively strong PC (i.e. UK, Spain, Denmark and Belgium) are not among the most efficient systems, in relative terms. Among the countries with relatively strong PC that are also relatively efficient are The Netherlands, Portugal, Finland, Lithuania and Estonia. The same is true for countries with relatively weak PC (i.e. Luxembourg, Bulgaria and Hungary) that turn out to be relatively efficient throughout their PC system. It is possible that PC systems, with for example low levels of PC structure dimensions (e.g. Hungary, Bulgaria and Latvia), are maximally efficient due to their relatively high values on PC process delivery dimensions; in other words, these PC systems are delivering the best quantity of processes they can with their moderate levels of structural resources, if compared with other PC systems in the dataset. It is relatively easier to spend one extra Euro efficiently into a (primary) health-care system in a country with a relatively low level of economic development than in a (primary) health-care system in a country with a relatively high level of economic development. This reflects the number of policy options available and the population health status that are both generally higher in countries with a more advanced economic development.

In addition, maximizing the individual functions of PC without taking into account the coherence within the system is not sufficient from a policymakers' point of view, when aiming to achieve both efficiency and strong PC.

Achieving efficiency

There is not one optimal way to organize PC to achieve efficiency in terms of structure–process and process–quality ratios. Instead, it is relative to each PC system and can be set only by establishing comparative benchmarks.

Our findings on structure–process efficiency indicate a low variation among the 22 PC systems considered. Each of the 10 most efficient PC systems adopts its own structure–process combination while sharing 2 features:

(i) They commonly focus on access and coordination of care, although differing in their levels of comprehensiveness and continuity.

(ii) They diverge both on their governance arrangements and workforce development features, although they invest a similar level of economic resources in PC.

This suggests that it is particularly important to invest in economic conditions to achieve an efficient structure–process balance.

Interestingly, only five PC systems are fully efficient on process–outcome levels, with a large variation in the efficiency levels obtained by the inefficient PC systems. The five best performers use a similar combination of access, continuity and comprehensiveness, although they differ on the adoption of coordination of PC services. The results indicate an extreme variability among the 18 inefficient PC systems in turning their process dimensions into quality outcomes.

The country-specific results from the PHAMEU project [19] provide for each country a comprehensive description of the structure, organization and outcomes of PC in their country, also in comparison with others. This, combined with the findings on critical dimensions for the efficiency of care, could be a suitable starting point for policymakers in each of the countries to further zoom in on their weak aspects to explore the causes and contemplate the need for improvement actions.

The results help policymakers to monitor the quality of their PC systems and set achievable standards aimed to improve the quality of their PC system.

Strengths and limitations

This is the first DEA study in PC applying a traditional economic method in adapted version for health services research purposes. It approaches PC in its full complexity, using a comparable and comprehensive European dataset. Because each PC system was compared with its peers to set up standards that identify pragmatic targets, policymakers can directly use the results to develop strategies to improve the current efficiency levels.

However, the composite scores on countries' PC dimensions could include some errors, depending on the data sources used [19]. DEA does not account for stochastic events (i.e. measurement error) in the data. We, therefore, adopted a bootstrap procedure, computing bias-corrected efficiency scores controlling for the robustness of the DEA scores. Furthermore, we excluded from the original study sample nine countries, and a number of quality indicators, to minimize the potential impact of missing values.

Recommendation for future research

We recommend future research to fine-tune the application of DEA in PC. This would require improvement of the development of sound quality of care indicators and other outcome indicators that are valid, measurable and subjected to PC. In addition, it is recommended that the influence of factors outside the influence of policymakers on PC system efficiency is also investigated (e.g. technological advancement and demographic features).

Conclusion

This article provides policymakers with a measurement technique for improving the quality management of their PC system, starting from the assumption that the quality of a PC system is not the sum of its functions, but rather it is based on the coherence of its structure, process and outcomes. To improve evidence-based policymaking for health system performance, there is a clear need for improvement of the PC information infrastructure of countries, particularly in the domain on quality of care.

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Supplementary material

Supplementary material is available at *INTQHC Journal* online.

References

1. World Health Organization. *World Health Report 2000: Health Systems: Improving Performance*. Geneva: World Health Organization, 2000.

2. Boerma WGW, Dubois CA. Mapping primary care across Europe. In: Saltman RB, Rico A, Boerma WGW (eds). *Primary Care in the Driver's Seat? Organisational Reform in European Primary Care*. Berkshire, England: Open University Press, 2006, 22–49.

3. Rechel B, McKee M. Health reform in central and eastern Europe and the former Soviet Union. *Lancet* 2009;**374**:1186–95.

4. World Health Organization. *The World Health Report 2008: Primary Health Care Now More Than Ever*. Geneva: World Health Organization, 2008.

5. Kringos DS, Boerma WGW, Hutchinson A *et al*. The breadth of primary care: a systematic literature review of its core dimensions. *BMC Health Serv Res* 2010;**10**:65–78.

6. Frenk J. Reinventing primary health care: the need for systems integration. *Lancet* 2009;**374**:170–3.

7. Starfield B. New paradigms for quality in primary care. *Br J Gen Pract* 2001;**51**:303.

8. Starfield B, Shi L, Macinko J. Contribution of primary care to health system and health. *Milbank Q* 2005;**83**:457–502.

9. Starfield B. Toward international primary care reform. *CMAJ* 2009;**180**:1091–2.

10. Macinko J, Starfield B, Shi L. The contribution of primary care systems to health outcomes within Organization for Economic Cooperation and Development (OECD), 1970–1998. *Health Serv Res* 2003;**38**:831–65.

11. Macinko J, Starfield B, Shi L. Quantifying the health benefits of primary care physician supply in the United States. *Int J Health Serv* 2007;**37**:111–26.

12. Amado CAF, Santos SP. Challenges for performance assessment and improvement in primary health care: the case of the Portuguese health centres. *Health Policy* 2009;**91**:43–56.

13. Murillo-Zamorano LR, Petraglia C. Technical efficiency in primary health care: does quality matter? *Eur J Health Econ* 2010;**1**:11.

14. Kringos DS, Boerma WGW, Bourgueil Y *et al*. The European Primary Care Monitor: structure, process and outcome indicators. *BMC Fam Pract* 2010;**11**:81–9.

15. Giuffrida A, Gravelle H. *Measuring Performance in Primary Care: Econometric Analysis and DEA*. York: The University of York, 1999.

16. Hollingsworth B, Dawson P, Maniadakis N. Efficiency measurement of health care: a review of non-parametric methods and applications. *Health Care Manag Sci* 1999;**2**:161–72.

17. Hollingsworth B. Non-parametric and parametric applications measuring efficiency in health care. *Health Care Manag Sci* 2003;**6**:203–18.

18. Nuti S, Daraio C, Speroni C *et al*. Relationships between technical efficiency and the quality and costs of health care in Italy. *Int J Qual Health Care* 2011;**23**:1–7.

19. Kringos DS, Boerma WGW, Bourgueil Y *et al*. *Building Primary Care in a Changing Europe*. Copenhagen: World Health Organization on behalf of the European Observatory on Health Systems and Policies (In Press), 2012.

20. Dempster P, Laird NM, Rubin DB. Maximum likelihood from incomplete data via the EM algorithm. *J R Stat Soc Series B Stat Methodol* 1977;**39**:1–38.

21. Raudenbush SW, Rowan B, Kang SJ. A multilevel, multivariate model for studying school climate with estimation via the EM algorithm and application to U.S. high school data. *J Educ Stat* 2011;**16**:295–330.

22. Zhu J. *Quantitative Models for Performance Evaluation and Benchmarking: Data Envelopment Analysis with Spreadsheets and DEA Excel Solver*. Boston: Kluwer Academic Publishers, 2002.

23. Charles A, Cooper WW, Rhodes E. Measuring the efficiency of decision making units. *Eur J Oper Res* 1978;**2**:429–44.

24. Cooper WW, Seiford LM, Tone K. *Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References, and DEA-Solver Software*. Boston: Kluwer Academic Publisher, 2000.

25. Huang YL, McLaughlin CP. Relative efficiency in rural primary health care: an application of data envelopment analysis. *Health Serv Res* 1989;**24**:143–58.

26. Thanassoulis E. *Introduction to the Theory and Application of Data Envelopment Analysis: A Foundation Text with Integrated Software*. Dordrecht: Kluwer Academic Publisher, 2001.

27. Jacobs R, Smith PC, Street A. *Measuring Efficiency in Health Care: Analytic Techniques and Health Policy*. New York: Cambridge University Press, 2006.

28. Wilson PW. FEAR 1.0: a software package for frontier efficiency analysis with R. *Socioecon Plann Sci* 2008;**42**: 247–54.

29. Simar L, Wilson PW. Sensitivity analysis of efficiency scores: how to bootstrap in nonparametric frontier models. *Manage Sci* 1998;**44**:49–61.