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Productive efficiency and its determinants in the Community Dental Service in England.

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Abstract –

Objectives: To assess the efficiency of service provision in the Community Dental Services and its determinants in England. ***Setting and sample****:* 40 Community Dental Services sites operating across the North-West region of England. ***Basic Research Design***: A data envelopment analysis of inputs (number of surgeries, hours worked by dental officers, therapists, hygienists and others) and outputs (treatments delivered, number of courses of treatment and patients seen) of the Community Dental Services to produce relative efficiency ratings by health authority. These were further analyzed in order to identify which inputs (determined within the Community Dental Services) or external factors outside the control of the Community Dental Services are associated with efficiency. ***Main outcome measure***: Relative efficiency rankings in Community Dental Services production of dental healthcare. ***Results***: Using the quantity of treatments delivered as the measure of output, on average the Community Dental Services in England is operating at a relative efficiency of 85% (95% confidence interval 77%- 99%) compared to the best performing services. Average efficiency is lower when courses of treatment and unique patients seen are used as output measures, 82% and 68% respectively. Neither the input mix nor the patient case mix explained variations in the efficiency across Community Dental Services. ***Conclusions***: Although large variations in performance exist across Community Dental Services, the data available was not able to explain these variations. A useful next step would be to undertake detailed case studies of several best and under-performing services to explore the factors that influence relative performance levels.

Introduction

The UK Government is concerned with the efficiency and delivery of dental care and enacted legislation in April 2013 (NHS Commissioning Board, 2013) for new administrative bodies to take over commissioning responsibility in England for the two main methods of delivering primary dental care in the National Health Service (NHS): the General Dental Service and the Community Dental Service. The General Dental Service is a broad service delivered by "high-street" dentists intended to meet most of the dental needs of the general public as well as being a gatekeeper for referrals to the Community Dental Service and secondary care (hospital-based dental services). The Community Dental Service provides specialized dental services to people who are unable to access to routine dental care because of physical, mental, emotional or social impairment (or a combination of these factors). The purpose of the new policy in England was to deliver more consistent standards, higher quality services and better health outcomes for patients across England – in short, a better match of the provision of these services to local needs (The Department of Health, 2013).

The commissioning decisions for NHS service provision in England attempt to map levels of dental activity with local oral health needs. Activity is measured by units of dental activity (UDA) with each treatment episode falling into one of three treatment bands. Band One relates to the dental "check-up" and attracts one UDA, whilst routine and complex restorative treatments fall into Band Two and Three activities respectively. Band Two attracts three UDAs and Band Three treatments attract 12 UDAs. Part of the cost of the service is recovered through a system of patient co-payments, with remainder being paid by the NHS. For General Dental Service provision, the value of a UDA varies between £15 and £25 depending on the location of the "high-street" dentist, who contracts directly with their local commissioners. Dentists who work for the Community Dental Service are employed by the NHS and paid a salary. For Community Dental Service provision in England, the contract is between the local NHS Community Trust organisation and the commissioner, although the measure of activity remains the UDA. Given the types of specialised treatment provided, dentists who work for the Community Dental Service are salaried, so there is no direct link between activity and remuneration. They provide healthcare in different settings (e.g. care or housebound homes, specialist health centers, mobile clinics) for patient

groups with complex needs (e.g. learning difficulties, mobility impairments, mental health problems, dental phobias, alcohol and drug misuse, homeless persons and refugees).

The aim of this study was to assess the technical efficiency of service provision in the Community Dental Service in England and identify factors associated with variations in efficiency between different Community Dental Service sites in England.

Methods

Administrative data on the capacity and clinical activity performed by the Community Dental Service sites are held by the NHS Community Trusts administering the services. All four Community Trusts operating across the North-West region of England with a Community Dental Service service were invited to take part in the study. Three of the four Trusts consented to take part and provided information that linked healthcare inputs to outputs for all Community Dental Service sites (n=48) they operated.

As it is important to compare Community Dental Service services on a like-for-like basis, salaried dentists providing General Dental Service provision, Emergency Services and Prison Dentistry sites were excluded from the study. This left a sample of 40 Community Dental Service sites for analysis in this study. Further, we used generic indicators of the quantity of healthcare delivered as outputs of the service to allow comparability of performance across sites. These outputs are total clinical activity (measured by UDAs), patient throughput (measured by the number of courses of treatment) and population coverage (measured by the number of unique patients seen all measured for the 2013-14 fiscal year). All Community Dental Service sites routinely monitor these indictors.

The input measures were the number of surgeries that are typically in operation and number of sessions (half days) worked in a typical week by Community Dental Service dentists, Dental Care Professionals, dental nurses, managers (Clinical Director, Senior Dental Officer, Dental Team Coordinator) and administrative staff (receptionist, dental administrator, Clerical Officer). Dental Care Professionals are non-dentist members of dental teams. They are a heterogeneous group composed of Dental Nurses,

Dental Hygienists, Dental Hygiene-Therapists and Dental Therapists. Based on each profession's scope of practice, some Dental Care Professionals may perform a supplementary role (e.g. Dental Nurses) while others perform tasks otherwise undertaken by the dentist, known as role-substitution (e.g. Dental Hygienists, Dental Hygiene-Therapists and Dental Therapists) (General Dental Council, 2013). The rest of this paper refers to those dental team members that are capable of role-substitution as Dental Care Professionals.

The data were analyzed in a two-stage process. In Stage 1, Data Envelopment Analysis (DEA) was used to compute the Technical efficiency (TE) scores of each Community Dental Service site. TE refers to the physical relation between resources (capital and labour) and healthcare outcome. A technically efficient position is achieved when the maximum possible improvement in outcome is obtained from a set of resource inputs or when there is the minimum possible usage of inputs to achieve an outcome. TE estimates were bootstrapped to improve statistical accuracy in Stage 2, where site characteristics were regressed on the technical efficiency scores obtained in Stage 1 using Ordinary Least Square (OLS) regression to identify which factors are associated with efficiency scores. What follows is an overview of the methods for the first and second stages. Further details of the approach taken are found in the online appendix.

DEA has become the dominant approach to efficiency measurement in healthcare as well as for other sectors of the economy (Banker *et al*., 1989; Hollingsworth, 2008). It accommodates multiple inputs and multiple outputs into a single measure of efficiency. DEA estimates relative efficiency scores by constructing a frontier around a set of the most efficient sites (best observable practice). Those sites that lie within this frontier are allocated proportionally smaller efficiency values, the further away from the frontier they are (Banker *et al*., 1989). Optimal performance is then relative to performance observed in other Community Dental Service sites.

The Community Dental Service in England operates with constrained outputs. Total clinical activity is constrained due to the capped nature of annual funds (numbers of UDAs) assigned to each Community Dental Service site, whilst patient throughput is constrained by the size of the population that requires the

service in each locality and the capacity of the service itself. Efficiency for Community Dental Service sites in England is conceptualised as minimising the level of inputs to achieve the (constrained) outputs produced in the DEA computation. Hence, a Community Dental Service site is technically efficient and is operating at peak performance if it is producing the constrained output using the minimum quantity of inputs, such as labour, capital and technology (Farrell, 1957).

Efficiency is estimated and presented in the results section for each output measure separately, rather than creating a composite measure from two or more of the outputs. This is because different stakeholders may evaluate performance differently. For example, a Community Dental Service service might focus on the number of UDAs allocated to the service, as this places a funding constraint on the quantity of healthcare that can be delivered to meet patient demand. While NHS commissioning groups may focus on the number of patients seen, as this may indicate the number of people in the population unable to access General Dental Service provision or the gains to healthcare access from the service.

In the second-stage of the analysis, the efficiency scores were regressed onto site variables in order to identify correlates of inefficiency from a range of variables measuring the level and mix of inputs used, and patient case mix. The variation in Community Dental Service site decisions about inputs was measured by the size and composition of the dental team.

The capacity of Community Dental Service services is directly related to the level and composition of their dental teams because it is an essential input (Scheffler and Kushman, 1977) whose output would be at a level of zero if not present. Also it is an input that can be varied by Community Dental Service managers when compelled to respond to short or long terms changes in level of demand for the service or funding allocated to it. To ensure thorough examination of the associations of inputs with efficiency scores we estimated three models for the second stage analysis, each with a different measure of input mix. The first is whether a site employs any Dental Care Professionals, the second is the number of Community Dental Service dentist sessions and Dental Care Professional sessions worked on patients in a typical week (for those sites which employed Dental Care Professionals) and, to understand how

established Dental Care Professionals are within the dental team, the third model has a measure of use of Dental Care Professional sessions relative to the use of Community Dental Service dentist sessions.

Results in the second stage analysis are presented for efficiency scores calculated with the annual number of UDAs as a healthcare output (further details for this choice of model specification is found in the online appendix). Following modeling guidance (Simar and Wilson, 2011; McDonald, 2009) estimation is with an Ordinary Least Squares model on efficiency scores that have been bootstrapped to remove bias from serial correlation.

Results

Table 1 shows the distribution of efficiency scores when calculated with each healthcare output measure. There are large differences in TE among the Community Dental Service units. Averaging across the three measures, a significant number of Community Dental Service sites (39%) had only moderate TE (between 60% and 80%) in service production. In addition, a small number of Community Dental Service sites (11%) operated inefficiently (TE<60%). The distributions of efficiency scores are illustrated in three histograms in the online appendix.

Table 1 near here

Table 1 shows the mean level of productive efficiency for Community Dental Service sites in England is between 68% (number of patients seen as the outcome) and 85% (UDAs as the outcome). These results are robust to the DEA estimation methods (see online appendix).

The bivariate correlation between efficiency scores estimated with the number of UDAs as the healthcare output and those with the number of courses of treatment as output is 0.89. The correlation between UDAs and patients seen and courses of treatment and patients seen is 0.80 and 0.83 respectively. The Spearman's rank order correlation coefficients of the efficiency scores were 0.86 (UDAs – courses of treatment), 0.83 (UDAs – patient seen) and 0.85 (courses of treatment – patient seen). Together these correlation results indicate the efficiency rankings of sites were similar under the alternative measures of

output.

Table 2 near here.

Table 2 shows input usage and patient population factors associated with efficiency scores. In the full sample (Model 1), the explanatory power of the ordinary least squares method revealed that around 80% of the variation in technical efficiency could be explained by the variables used in this study. However, none of the variables reflected input usage, whilst patient population was found to be significant in explaining variations in efficiency. To explore the contribution of different members of the dental team, Model 2 and Model 3 were restricted to Community Dental Service sites that employed Dental Care Professionals and dentists (n=32). In these sites, the level of use of Dental Care Professionals is negatively associated with efficiency scores and the level of use of Community Dental Service dentists is positively associated with efficiency scores (Model 2) ($p<0.05$). Using one additional Dental Care Professional session per week was associated with a 4.7% lower efficiency score. This contrasted with higher efficiency scores associated with an additional Community Dental Service dentist session and an additional nurse session of 1.5% and 0.5% respectively (Model 2). The proportion of clinical time provided by Dental Care Professionals was not associated with variations in efficiency scores (Model 3). The population characteristics of the Community Dental Service had no influence in any of the models nor did the size of the site in terms of number of surgeries and number of administration staff.

Discussion

This study revealed wide differences in TE between Community Dental Service sites in England. Efficiency was calculated without the influence of scale efficiencies, meaning the assigned efficiency scores purely reflects the performance at each Community Dental Service site and choice of inputs in the production process at the current size; i.e., things that are directly controlled through short term managerial decisions. According to our findings, in England there is excess capacity; the amount of resources used (in terms of the number of surgeries and staff) is more than necessary to achieve the observed level of outputs. These resources could be released or used for other service developments (i.e.

producing different types of outputs such as extending services to different patient groups or developing programmes to reduce oral health inequalities). The use of three different measures of output (annual number of UDAs, number of unique patients seen and number of courses of treatment) suggests that this observation is stable and a consistent finding. Regardless of the measure, the large variation in efficiency found between Community Dental Service sites persist, with few operating on or near optimal performance.

The proportion of patients that are exempt from paying NHS co-payments in the General Dental Service and the age of patients, which are known to be markers for morbidity and a higher demand for health services in populations, are not statistically associated with the efficiency of Community Dental Service sites. This suggests the factors determining efficiency are complex and could be unique to their regional location or the organization of each service. There was however some evidence of higher levels of efficiency for sites that used relatively dentist-intensive production methods. The lack of association between the scale of production (number of surgeries, number of staffing inputs) and efficiency scores suggests there may not be gains from merging Community Dental Service sites into larger units of service provision.

The moderate level of inefficiency found in most sites, and absence of any factors strongly associated with efficiency, may be because salaried Community Dental Service dentists are not remunerated by (and hence incentivized to increase) healthcare activity. Alternatively, the findings could be an indication that some level of inefficiency in the production of oral healthcare by Community Dental Service sites in England is unavoidable. This may be because the relative “stickiness” of some inputs or if inputs are available only in “lumpy units”. For example, the success of the Community Dental Service service could lead to the treatment needs of the service population falling over time or there may be a change to the target level of output such as the ceiling number of UDAs that will be remunerated by the NHS within any one financial year. If the number of surgeries and Community Dental Service dentists working at a site are relatively inflexible inputs to adjust (“stickiness”), or if it were difficult to employ personnel on a part-time or temporary basis (“lumpy units”), excess resources would be allocated to meet new service requirements. This explanation of “stickiness” and “lumpy units” as the cause of moderate efficiency

scores in the Community Dental Service sites cannot be examined or tested in the analysis because either may be present in any sized Community Dental Service unit.

The wide difference in the level of efficiency with each output measure may be explained by gains in efficiency being generated differently depending on different output measure used. With the outcome measure of the number of courses of treatment, there will be efficiency gains for sites with shorter consultations (and similar input usage). However, while a consultation is an opportunity for contact with the healthcare professional, frequent consultations, per se, do not mean better care. In the case of efficiency scores based on the number of unique patients seen, frequently treating the same patient does not lead to efficiency gains. Instead such gains are from broadening access to service to new patients. However broadening access to the service does not guarantee that patients will be receiving the correct treatments to match their care need when they are seen. There are no indicators of the oral health needs of patients available in the data but the efficiency measure which comes closest to overcoming this limitation is an output of the annual umber of UDAs. Efficiency gains would occur when the Community Dental Service site provides more complex or costly treatments (for a similar level of input usage) because these types of treatment redeem a higher number of UDAs. Further research is needed to examine the different views of stakeholders on the appropriate outcomes measure for performance including if multiple outputs should be incorporated in a single measure. This is particularly the case in Community Dental Service provision, given the complexity in the management of the patient population.

A limitation of our analysis is that the private sector or General Dental Service service provision may substitute Community Dental Service provision by providing care for less resource-intensive adult patients (on average). This may in turn lead to bias. For example, in areas where private care or General Dental Service service provision is plentiful, the Community Dental Service may be left with patients whose needs are more resource-intensive after the private sector and General Dental Service have done their selection/cherry picking. However, we expect this bias to be slight for efficiency scores that have been calculated using an outcome measure of UDAs because it incorporates the complexity of that treatment (by generating a larger number of UDAs). Another limitation was the lack of available data to link an individual's treatment need with care provided and its effect on health. We relied on different

measures of the outcome of the Community Dental Service service (numbers of UDAs, patients seen and courses of treatment) but none of these encompasses the quality of the healthcare provided. Further, this evaluation of Community Dental Service sites accounted only for current performance, which ignores issues on how decisions over the choice of inputs may impact on long-term rather than immediate outcomes.

The evidence base examining the efficiency of Community Dental Service is weak. One study (Buck, 2000) found the average level of technical efficiency of Community Dental Service sites England was 75%. Others have examined the technical efficiency of Public Dental Service (PDS) sector, which is between 68% and 81% (depending on the model type) in Cyprus (Charalambous *et* al., 2013), 74% in Norway (Grytten and Rongen, 2000) and 70% in Finland (Widström, Linna and Niskanen, 2004). These levels of average efficiency and the large variation in efficiency scores support the findings of this study. Future research is needed to define appropriate measures that encompass both the effectiveness and the quality of Community Dental Service service provision, with a particular emphasis on health outcomes. Future evaluation of performance would benefit from using longitudinal data and a healthcare outcome adjusted for case-mix, to account for the fact that some of the Community Dental Service units may only produce effects in the long term.

Conclusions

Although large variations in performance exist across Community Dental Service sites, the data available was not able to explain these variations. A useful next step would be to undertake detailed case studies of several best and under-performing services to explore the factors that influence relative performance levels.

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Tables to be included in the text

Table 1: Distribution of Community Dental Service efficiency scores

Distribution of sample efficiency	Healthcare output measures			
	UDAs (mean = 85%)	Courses of treatment (mean = 82%)	Patients seen (mean = 68%	Average across output measures
On the production frontier (100%)	28%	20%	23%	23%
High (80% – 99%)	28%	38%	15%	27%
Moderate (60% – 80%)	35%	33%	50%	39%
Low (<60%)	10%	10%	13%	11%
Range: min, max	35%, 100%	36%, 100%	21%, 100%	21%, 100%

Table 2: OLS estimates with efficiency scores as the dependent variable

	Model 1	Model 2	Model 3

Variable	Coefficient (95% CIs)	p-value	Coefficient (95% CIs)	p-value	Coefficient (95% CIs)	p-value
Any use of Dental Care Professionals	- 0.13 (- 0.30, 0.05)	0.16	NA	NA	NA	NA
Number of Dental Care Professional sessions	NA	NA	-0.047 (-0.069, -0.025)	<0.00	NA	NA
Team composition (percentage of Dental Care Professional sessions out of dentist sessions)	NA	NA	NA	NA	-0.05 (-0.31, 0.21)	0.67
Dentist NHS sessions	0.008 (-0.006, 0.024)	0.26	0.015 (0.0009, 0.029)	0.04	NA	NA
Nurse NHS sessions	-0.004 (-0.008, 0.0006)	0.09	-0.005 (-0.009, -0.001)	0.01	-0.003 (-0.009, 0.002)	0.27
Administrative sessions	-0.009 (-0.082, 0.011)	0.42	-0.010 (-0.066, 0.024)	0.50	-0.0078 (-0.063, 0.031)	0.68
Surgeries	-0.015 (-0.062, 0.031)	0.51	0.034 (-0.014, 0.083)	0.16	0.0002 (-0.07, 0.07)	0.99
Percentage of child patients	23.2 (- 6. 5, 52.2)	0.12	38.4 (11.1, 64.2)	0.10	19.2 (-20.4, 58.3)	0.32
Percentage of adult co-payment exempt	15.1 (-47.0, 76.2)	0.64	24.1 (-37.1, 86.2)	0.43	-4.1 (-77.1, 69.0)	0.91
R squared		0.19		0.17		0.16