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An Analysis of Specialist Surgeons and their Practices

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Abstract

A purposive sample of South African doctors provided data for the analysis of revenues, costs and earnings associated with specialist surgical medicine. Empirical analysis of the data, based on both nonparametric and parametric regression, finds that practice revenues increase by, on average, between R690 and R1050 per new patient, while costs increase by between R690 and 750 per patient. The total number of surgeries performed is not a consistently significant predictor of revenues, although it is a consistently cubic determinant of costs. In terms of total earnings, the total number of patients tends to decrease earnings, while the number of new patients increases earnings. Due to the low response rate in the survey, there is a a need to conduct further research into this topic, to provide better information to both specialists and the South African Department of Health, which sets pay packages for public sector health workers.

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1 Introduction

For many years, health officials in developing countries have worried about the permanent migration of skilled health professionals to more developed countries. Recently, researchers have examined the reasons for emigration to places like Canada (Labonté, Packer and Klassen, 2006), the United States (Hagopian, Thompson, Fordyce, Johnson and Hart, 2004), and the United Kingdom (Eastwood, Conroy, Naicker, West, Tutt and Plange-Rhule, 2005). Mullan (2005) presents similar data for the United States, Canada and the United Kingdom as the previous three studies, as well as further information for Australia.

American Medical Association data from 2002 and Canadian Medical Association data from 2003 reported in Hagopian et al (2005) finds 3788 South African trained doctors working in either the United States or Canada. Mullan (2005) finds an additional 3233 South African trained doctors working in the United Kingdom and Australia. According to World Health Organization data, also reported in Hagopian et al (2005), 23 844 South African trained doctors remained in South Africa. In other words, a large number have left. *The Lancet* (2000) reports that South Africa incurs a cost of nearly $37 million, due to the migration of health.

South Africa, like many other countries, has introduced some policies to retain the services of doctors trained in the country, and entice many of those who are abroad to return. For example, there is a Certificate of Need for newly trained doctors and those trained abroad stipulating that

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some of their service should be undertaken in areas of need. Furthermore, the Health Professionals Council of South Africa does not recognize overseas training unless the doctor practices for at least some period of time in an underserved area. Economically, the certificate of need requirement could drive potential young doctors to consider a different career path entirely, while the requirement for recognition of overseas learning is likely to delay if not put an end to a doctor's plans to return.[1]

According to the above figures, brain drain is a reality in South Africa, and it has cost the country dearly. Furthermore, the two policies seeking to redress brain drain, by raising the costs of pursuing a career in medicine and the costs of returning to the country, are not likely to have their intended consequences. Therefore, alternative policies are needed. However, in order to pursue alternative policies, there is a need to have a better understanding of the reasons behind physician emigration.[2] To this end, the South African Medical Association (SAMA), in conjunction with the Foundation for Professional Development (FPD), sponsored a study of private specialist clinics in Gauteng Province, South Africa.

Although the main purpose of the studies supported by SAMA and the FPD is to further understand physician emigration from South Africa, and, especially, the economic and social realities associated with private practice in South Africa, the objective of this research is to describe a few aspects of the economic realities associated with private practice in South Africa.[3] Specifically, this research examines the profitability and returns to experience for specialist physician practitioners in Gauteng, a province with one of the highest concentrations of specialist doctors in the country. Generally, the supply-side of the health sector in South Africa has not been extensively studied, partly due to the lack of data that is available. Studies that do exist have examined the efficiency of public health care delivery, primarily in specific regions, finding low levels of efficiency.[4]

To the best of our knowledge, no one has examined health care delivery within the private sector, which is examined here.[5] Through the further understanding of profitability and returns to experience, this research provides information on the financial rewards associated with the practicing of specialist medicine in South Africa, and could, along with further concentrated examination of health care professional attitudes towards practicing medicine in South Africa, help construct policies that keep doctors, specialist or otherwise, in South Africa.

The remainder of the paper is structured in the usual fashion. In Section 2, we provide a short examination of the relevant economic theory. We then consider our empirical strategy, in Section 3. Following the empirical methodology, Section 4 contains a description of the survey and data used in the analysis. The results from the empirical analysis are presented in Section 5. We conclude our discussion in Section 6.

2 Economic Theory

This research considers the profitability of specialist doctor practices, and, further, provides estimates of the returns to specialist experience. Profits are specified as a function of output, q. Although the

[1] A cohort study by de Vries and Reid (2003) suggests that targeting admissions to include more candidates from underserved regions would lead to increased physician service to these underserved regions, since many are likely to return to their home regions.

[2] As reported by Labonté et al (2006), The World Bank has noted a severe data gap when it comes to information on developing country health workers. Labonté et al (2006) interview seven South African émigré doctors, as well as a number of Canadian health organizations and stakeholder organizations. In their study, they identified a number of push factors, including: low salaries, non-payment of salaries, significant stress and exceedingly large patient-health care provider ratios.

[3] Our survey only covers doctors working in South Africa, and, therefore, cannot provide direct evidence related to emigration choices pursued by South African doctors.

[4] Zere, McIntyre and Addison (2005) find low levels of efficiency in the Cape, while Kirigia, Sambo and Scheel (2001) and Kirigia, Lambo and Sambo (2000) find low levels of efficiency in Kwazulu-Natal. In Gauteng, Kibambe and Koch (2007) find additional evidence that public health care delivery is inefficient.

[5] In a related paper, Koch and Slabbert (2010) consider productivity across a range of specialty practices in Gauteng Province of South Africa.

most appropriate measure of output is the improvement in the health of the patient, this measure of output is not available, a standard refrain in the health production literature (Hollingsworth, 2003). Since our data does not contain any indicator of the improvement in patient health, our analysis, instead, focuses on patient throughput in the form of the total number of patients served, the number of new patients seen by the specialist, and the total number of surgeries performed by the specialist.

Profits for our practice are a simple function of revenues and costs, each of which are a function of a vector of outputs, q, as in equation (1).

$$\pi(q) = R(q) - C(q) \tag{1}$$

In general, revenues, R, are expected to be a convex combination of prices and units of output, and that convex combination is expected to be linear.

$$R(q) = \sum_{j=1}^{J} p_j q_j \tag{2}$$

Costs, C, on the other hand are not expected to be linear in output. Output, which is a function of the inputs, may or may not be driven by constant returns to scale technology. If inputs are purchased in a competitive input market, output costs would follow a linear combination of the inputs. Under that scenario, assuming revenues exceeded costs, revenues would exceed costs regardless of the output choice, and, therefore, specialists would take on every additional patient or surgery that was available to them. More realistically, specialist time is limited, such that the opportunity cost of an additional patient or surgery would rise as the time constraint binds, leading to costs that are convex in output and an optimal size for the specialist practice. Therefore, we do not specify any specific functional form for $C(q)$, and, therefore, it is plausible that profits are also a nonlinear function of outputs; see equation (3) and the descriptions surrounding nonparametric regression.

Specialist practice profits, derived from (1), can then be combined with reported salaries to calculate a measure of income for the specialist. Economic theory suggests that income (or earnings) is a function of education, experience and ability. However, our data comes from specialist physicians, such that education is reasonably similar across all observations, although the type of specialty differs. Unfortunately, neither ability nor an instrument for ability is available in the data, which leaves experience and specialty as the only theoretically relevant variables for which we have information. We use these variables to estimate specialist returns to experience.

3 Empirical Methodology

The data, to be described below, contains a wide range of information from a small sample of specialist doctor practices. We make use of data on practice type, practice revenues, practice costs, practice outputs and physician experience to explore the cost, revenue and profit functions for the practice. We conclude by examining returns to physician experience. The empirical methodology includes both nonparametric and parametric regression, primarily linear regression, which has been informed by the nonparametric results.

Consider the nonparametric regression function in equation (3), assuming that $m(x)$ is the conditional mean of Y given $X = x$, where X is a vector of covariates that could be either continuous or discrete.[6]

$$Y_i = m(X_i) + u_i, i = 1, ..., n \tag{3}$$

[6] We will assume that the data is drawn identically and independently, although there are a few concerns regarding the representativeness of the sample, which we discuss below.

In what follows, we consider nonparametric estimation of (3), allowing for mixed data, i.e., data that is both continuous and discrete, as outlined by Racine and Li (2004). Generally, nonparametric analysis only includes continuous regressors; however, our data also includes an unordered categorical variable – type of specialty. Although it is possible to split the data in different categories, and nonparametrically estimate the functions (3) for each specialty, the limited number of observations in the data, would raise serious efficiency concerns. Racine and Li (2004) propose a natural extension of Aitchison and Aitken (1976). For categorical data – in our case, there are three specialty types – a categorical variable kernel is specified.

$$k(X_i, x, h) = \begin{cases} 1-h & if\ X_i = x \\ \frac{h}{2} & \text{otherwise} \end{cases} \tag{4}$$

The smoothing parameter, or bandwidth, is restricted to lie well within the unit interval; in this case, since there are only three categories, specifically $h \epsilon [0, 2/3]$. For continuous data, on the other hand, a number of different univariate kernels are available, such as the Gaussian and Epanechnikov kernels. In this analysis, we have chosen to employ the second-order Gaussian kernel, where $z = (X_i - x)/h$, and the smoothing parameter, h, is restricted to be positive and finite.

$$k(z) = \frac{\exp(-z^2/2)}{\sqrt{2\pi}} \tag{5}$$

Defining $r \geq 1$ as the number of dependent variables, continuous and discrete, in the model, the kernel function, K, can be represented by a product kernel.

$$K(X_i, x, h) = K(\frac{X_i - x}{h}) = k(\frac{X_{i1} - x_1}{h_1}) \times ... \times k(\frac{X_{ir} - x_r}{h_r}) \tag{6}$$

The nonparametric estimator follows an approach that is similar to weighted least squares regression, except that the analysis is performed within small windows of the data, as defined by the bandwidth. The estimator is specified in (7).

$$\hat{m}(x) = \frac{\sum_{i=1}^{n} y_i K(X_i, x, h)}{\sum_{i=1}^{n} K(X_i, x, h)} \tag{7}$$

There are a number of benefits that can be derived from a nonparametric regression. In particular, since the function is not defined *a priori*, the analyst can allow the data to determine the functional form, which can then be used to inform an appropriate linear regression. Importantly, especially when there is limited data, as is the case in this analysis, imposing an appropriate functional form will lead to more efficient estimates than is possible in the fully nonparametric regression. However, the benefits derived from not defining the functional form come at the cost of potential bias in the estimates, and, generally, that bias depends on bandwidths, which shrink as n increases, although local linear regression has better bias properties than the local constant regression in many instances (Fan and Gijbels, 1996).

Since bandwidths determine the size of the window used in the calculation of the nonparametric estimator, appropriate bandwidths are paramount. In this research, bandwidths are estimated via least squares cross-validation; see Hall, Racine and Li (2004). Cross-validation, which follows a jackknife structure, yields optimal bandwidths, under certain conditions.[7] Defining $\bar{m}_{-i}(x)$ as the solution to equation (7) with the i^{th} observation removed, the bandwidths are optimally chosen, via the routine in equation (8).

$$V(h) = \frac{1}{n}\sum_{j=1}^{n}[y_j - \bar{m}_{-i}(x)] \tag{8}$$

[7] In most applications, optimal bandwidths differ significantly from the plug-in bandwidths, and, given computing power, cross-validated bandwidths can often be calculated. The conditions are require that $h_l \to 0$, while $nh_1 \cdots h_m \to \infty$, Li and Racine (2007).

The consistency and efficiency of nonparametric regressions are theoretically justified under asymptotic theory. However, the survey data available for this analysis is not extensive.[8] Given the small sample sizes, raising potential concerns over the small sample properties of the nonparametric estimates presented, the empirical analysis was extended to include parametric (linear in parameters) specifications suggested by the nonparametric regression results.

Empirically, when considering profits and, especially, returns, one worry that arises is whether or not there are omitted variables that might be correlated with the regression error. In this analysis, the most likely endogenous unobserved covariate is the ability of the specialist, especially the administrative ability. Specialists receive much of their income from third-party insurance firms. These payments could be accessed more easily for administratively capable specialists, or for those with other abilities that cannot be observed in the data. Despite that concern, it is not possible to control for endogeneity in the analysis.

4 Data

This analysis is based upon a purposive survey collected during 2007 and 2008. The survey was sent to all registered private specialist physicians in Gauteng. Specialist physician participation in the study was both voluntary and anonymous. The survey queried doctor and clinic characteristics, including costs and revenues. Our analysis focuses only upon single doctor practices and makes use of information related to practice type, costs, revenues and the doctor's experience. An analysis of practice productivity is undertaken elsewhere.

4.1 Data Collection

Originally, 260 specialist physicians were contacted, and requested to complete a confidential survey. The survey/questionnaire (Appendix B) was designed to collect information related to practice expenditures. Similar research of this nature conducted in South Africa and around the world was helpful in determining the appropriate questions and the appropriate process for surveying specialist practitioners.[9] A number of guidelines related to questionnaire construction were also followed, especially those suggested by Leedy and Ormond (2001) and Joubert, Bam and Cronje (1999). In order to conform to their suggestions, the questionnaire was kept short and simple; the questions were not leading; the questions were ordered from simple to important, and concluded with sensitive questions.

Question 1 dealt with the practice and its patient profile, including practice size, attention to patient comfort, the number of patients, consultation length, number of surgeries, etc. Question 2 provided a breakdown of all the practice expenditures during the month. More specific questions related to the doctor's personal and professional profile were addressed in Question 3, while the most sensitive questions related to revenue were requested in Question 4. Descriptive statistics from our respondents are reported in Appendix A.

The questionnaires were sent to potential respondents by registered post. The parcels contained a covering letter (explaining the premise and potential benefits of the research and, importantly, ensuring confidentiality of the reported information), the questionnaire and an envelope with prepaid postage to minimise respondent costs. The option to fax responses through to FPD offices was offered, as well.

In order to increase the number of responses, potential respondents were contacted by telephone, fax and e-mail to remind and encourage participation. The responses were tallied and the questionnaires were sent out again in three months to those who did not respond, initially. In order to

[8] In some estimation samples, there are only 43 observations.

[9] Research by Weiss (2002, 2003), Brentnall (2007) and Needleman (2005) were important contributions to the structure of the questionnaire.

further increase buy-in into the research, the South African Orthopaedic Association (SAOA) and the Vascular Society of Southern Africa (VASSA) were contacted and invited to take part in the research. The response to their introduction into the research process was highly satisfactory, as it added an additional twenty respondents.

4.2 Data Concerns

Of the original surveys, responses were received from 69 specialists representing a response rate of 26.5%. There were 15 vascular surgeons, 45 orthopedic surgeons, five neurosurgeons and four cardiothoracic surgeons. Most practices were single physician practices – only three practices contained more than one physician – so the analysis was limited to single physician clinics. Only data with complete information was used, further reducing the analysis sample size, although the number of complete observations depends upon the empirical model being estimated.

Despite this response rate being much higher than the 5% managed by Brentnall (2007), she received a total of 5869 responses compared to our 69. The small number of responses could raise concerns about the reliability of the results reported herein. The low response rate could be attributable to participation reluctance and the method of data collection used. Future research of this nature might consider using registered post to distribute the questionnaires (as was done here) together with e-mail distributions as was done by Weiss (2002, 2003), or through other web-based interfaces. Also, face-to-face interviews and greater buy-in from various specialists or special interest groups could help increase the response rate.

In addition to broad concerns over the response rate, a non-zero set of respondents submitted incomplete questionnaires. The omission of particular information could have been due to the sensitive nature of these questions or for other reasons, and may have created sources of bias in the analysis. For example, tax avoidance could lead to an understatement of practice profit or, alternatively, an overstatement of practice costs. The purchase of motor vehicles, fuel and cell phone expenses, *inter alia*, for personal use, could decrease profits and, *ceteris paribus,* reduce tax liability. Behavioural choices of this nature are problematic in this research, since they directly affect reported profits. Therefore, we always note the number of complete responses used in the analysis, and further accept that our results are only relevant for the respondents for which we have complete and truthful information.

With any voluntary questionnaire, there will always be concerns over sample selection. Unfortunately, it is not possible to examine, through external data sources, whether the respondents were significantly different from the population of specialists in Gauteng, in general. However, we can report on some concerns that we have observed. Specifically, only eight respondents (11.5%) had been in private practice for five years or less, whereas 37 (53.6%) had been in private practice for fifteen years or more, implying that very few inexperienced practitioners responded. Further, only two respondents were under the age of 40 (both 37); there were only two female respondents and all, but five, respondents were white, adding to our concerns about the possibility of selection. Therefore, all of our reported results are only accurate for the respondents, and cannot be generalized to the population of specialist physicians practicing in Gauteng or beyond.[10]

5 Results

In this section, we describe the results of the empirical analyses, nonparametric and parametric. The nonparametric model allows for mixed data, although mixed data is not always used, and the nonparametric models, due to the sparseness of the data, are used to suggest functional forms for linear models. The nonparametric bandwidths are determined via least squares cross-validation, while the underlying kernels are the second order Gaussian kernel for continuous data and a categorical kernel

[10] The rest of the data used in the analysis is presented in Appendix Table A1.

for discrete data. The nonparametric estimates are computed using the np package (Hayfield and Racine, 2008), installed in R (R Core Development Team, 2008). Bootstrapped standard errors of the estimates are calculated, and cross-sections of the nonparametric results are graphed to illustrate the estimated relations.[11] We have also trimmed the data, for presentation in the figures, removing the top and bottom 10% to alleviate concerns over the sparseness of the data.[12]

5.1 Specialist Practice Revenues

As previously noted, the accounting and economic definitions of revenues for a firm are determined by a simple summation of the price of each output multiplied by the quantity of each output. In the first part of our empirical analysis, we consider whether or not that definition holds, and provide estimates of the per unit price. For the 53 specialist practices, for which we had revenue data, revenues averaged 135 963 per month (SD = 79 871).

Figure 1 presents the nonparametric regression results. For the continuous data, the solid line represents the conditional relationship between each output measure and the practice's total receipts, while the dotted lines present bootstrapped estimated standard errors. However, for the discrete data, circles represent the nonparametric estimates, while the bars represent the confidence intervals for the estimates. As can be seen in the figure, a linear relationship between total revenues and each unit of output cannot be rejected.[13] Further, given the confidence bands surrounding the estimated relationship, it is also not possible to reject the hypothesis that there is no relationship between revenues and outputs.

Given the linearity suggested by the nonparametric regression, linear regressions between revenues and output were also estimated, in order to determine if the outputs are, in fact, associated with revenues. A number of alternative specifications were estimated, all of which are presented in Table 1. In all cases, the regression was significant, meaning that there is an underlying relationship between revenues and outputs; however, the only consistent pattern arising from the regressions is that the number of new patients served significantly increases revenues. Depending upon the specification, each additional patient is worth between R689 and R1250 of additional revenue. Furthermore, average revenues were estimated to be on the order of R70 000 to R78 000. If that average is broken down by specialty, orthopedic surgeons and other surgeons are estimated to earn more, on average, than vascular surgeons. Theoretically, however, revenues should only be a function of outputs, and, as such, should not include an intercept. Both models 1 and 2, reported in the table, are consistent with that structure, although model 1 implies an intercept term, due to the fact that there are only three specialties. Therefore, in line with theory, model 2 results are preferred, and model 2 implies that each additional surgery earns the surgeon an additional R800, while each new patient earns the surgeon an additional R1050.

5.2 Specialist Practice Costs

In addition to empirically examining the relationship between revenues and output at the practice level, we also examined the relationship between costs and output. In addition to the nonparametric model, a number of linear specifications were also examined. For the 66 practices for which we had cost data, total costs per doctor at each practice average 108 933 per month (SD = 73 950). As with the revenue regressions, reported above, we first estimate a nonparametric regression to see if costs are constant, increasing or decreasing with output. Unlike revenues, costs have both a fixed and a

[11] See Figures 1-4. Since a few of the regressions include up to three independent variables, the overall relationship would require a four-dimensional plot, and therefore, a cross-section plot is, instead, illustrated.

[12] The regressions continue to make use of all of the data; however, the illustrations only present the results for a subset of the data. We thank an anonymous reviewer for the suggestion.

[13] The R^2 from the nonparametric regression is 0.26, suggesting a fairly good fit from such a small cross-section, while the estimated bandwidths are 669091589, 1062139349, 52.29 and 0.67, for surgeries, total patients, new patients and specialty types, respectively.

variable component, and, therefore, an intercept should be included in the regression to account for the average fixed cost of output. The nonparametric regression is presented in Figure 2, and the figure includes bootstrapped standard errors of the relationship, while the linear regression results are presented in Table 2.

As can be seen in Figure 2, the nonparametric relationships between costs and outputs appears to be cubic in the number of surgeries, linear for both the total number of patients and the number of new patients and quite similar across specialty.[14] However, it is also quite clear in Figure 2, as it was in Figure 1, that there is a fair bit of noise in the nonparametric regressions, such that a number of other relationships cannot be ruled out. The linear cost regression, the specification of which was informed by the nonparametric results, does support the nonparametric analysis. Three model specifications were examined, and the regressions results for each specification are presented in Table 2. Each of the three results is consistent, with respect to the costs borne by the specialist's practice. New patients increase costs, on average, between R695 and R750, while there is a pronounced cubic relationship between surgeries performed and total costs, while the number of new patients is not associated with costs. However, regardless of specification, average fixed costs in our sample of specialist surgeon practices are estimated to be insignificant.

5.3 Specialist Earnings

In our next empirical analysis, we combine, at least in part, the preceding two analyses to consider the relationship between profits and output. However, rather than calculating simple profits, we calculate profits, to which we add back the doctor's reported salary. In other words, we create a measure of income for the practicing specialist, on the assumption that the majority of profits from single specialist practices are paid back to the specialist. Specialist income, according to this measure, averages 64 807 (SD=65 569) for our sample of 40 specialists. We further regress income on the previously discussed measures of output. As before, we apply nonparametric regression to inform the functional specification, and we follow-up that nonparametric regression with linear specifications, a number of them, implied by the nonparametric results. The estimated relationship from the nonparametric regression is illustrated in Figure 3.

The nonparametric results illustrated in Figure 3 suggest that income is quadratic, and concave, in the number of surgeries, degreasing, and quadratic, in the total number of patients and linear in the number of new patients.[15] However, as with the revenue and cost regressions, the data is rather sparse, such that the bootstrapped standard errors also suggest that a number of other empirical relationships cannot be ruled out. Therefore, we also impose the suggested functional form, within a series of linear regressions, to determine if the nonparametric relationship can be more precisely estimated by assuming a parametric function. Those regression estimates are presented in Table 3.

The results in Table 3 are based on numerous specifications; however, the first three columns, models 1 through 3, allow for average incomes, and specialty-specific effects. In these regressions, there is a quadratic relationship, decreasing in its derivative, across the number of total patients, but a linear and increasing relationship between earnings and the number of new patients. Depending upon whether or not average earnings are split across all specialties, either average earnings per month are approximately R132 850 per month or they range from R92 300 to R 147 380 per month.

[14] The R^2 from the nonparametric regression is 0.66, an even better fit than for the revenue regression, while the estimated bandwidths are 8.2, 42910328, 9092821 and 0.33, for surgeries, total patients, new patients and specialty type, respectively.

[15] The R^2 from the nonparametric regression is 0.74, suggesting exceptional fit for such a small cross-section, while the estimated bandwidths were 16.2, 68.7, 47.8 and 0.5 for surgeries, total patients , new patients and type of specialty, respectively.

5.4 Returns to Experience

Finally, we make use of our previously calculated measure of specialist income to consider returns to experience for these specialists. Our measure of each doctor's income is regressed, parametrically and nonparametrically, against the doctor's years of experience in the doctor's current practice, while also controlling for specialty. The nonparametric regression is illustrated in Figure 4, and the quadratic linear regression results are presented in Table 4.

As can be seen in Figure 4, the relationship between years of experience in the current practice and doctor's income is seemingly quadratic in nature, at least for these responding specialist doctors.[16] The linear regression results, reported in Table 4, which allow for experience and its square, do not suggest a particularly noticeable relationship, unless an intercept is not included; however, it is not obvious that a specification without an intercept is particularly reasonable. In general, the regressions of earnings against experience do not suggest that experience is an important determinant of earnings.[17]

6 Concluding Remarks

The research reported in this paper is based on a purposive survey of Gauteng-based specialist doctors, primarily surgeons. The survey was undertaken between 2007 and 2008, with the support of the South African Medical Association and the Foundation for Professional Development, whose interest in the survey was partly driven by the need to understand emigration of South African doctors. Although neither the survey nor the empirical analysis directly addressed emigration, since all of the responding specialists are still based in South Africa, the survey and analysis provide information on revenues, costs and income. Specialists can use these results to determine if they are doing better or worse than average. Furthermore, government can use these results to better inform their pay policies for specialists working in the public sector.

The results of the analysis show that new patients and the number of surgeries performed drive revenues. The same factors drive costs, although the shape of the relationship differs. In terms of income, both new patients and total patients are the most important factors, which is interesting, because the total number of patients is not empirically related to either costs or revenues. Finally, specialist income has not been empirically linked to earnings, at least for this sample of Gauteng surgeons.

Unfortunately, the response rate was low, resulting in low precision in most of the regressions. Furthermore, since the survey relied upon voluntary response, and voluntary response might be driven by factors that cannot be included in the empirical analysis, the results can be generalized neither to all specialists operating in Gauteng nor to all specialists operating in South Africa.

Therefore, we conclude by arguing that further research is needed in this area, as is the need for access to more data. Creating incentives for participation would have the potential to increase the amount of data available for analysis, although such incentives could also affect the analysis. One option would be for the South African Medical Association to set-up a website upon which all doctors, and not just specialists, can record information related to their practices, possibly requiring submission in order for the doctor to keep their medical license updated. Although it might not be ethical to require submission for license maintenance, it would be possible to award Continuing

[16] The nonparametric regression including specialty type is available upon request.; however, specialty type, as in all of the previous nonparametric regressions, is not related to earnings. Regardless of whether or not specialty is included, the R^2 of 0.05 from the regression is rather low. The cross-validated bandwidth for years of experience at the current place of employment is 11.8, and that for the specialty is 0.67.

[17] Regressions were also run for different measures of experience, including years qualified to practice and years operating in private practice. In each case, the results were similar; the results are available from the authors upon request. Given the fact that the majority of the doctors in the sample were operating in the same practice the entire time, the similarity of results across various measures of experience is not surprising.

Professional Development points for their participation. By providing an incentive to participate, it would be possible to collect much more data than we are currently able to access.

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Figure 1. Nonparametric Revenue Function Estimates

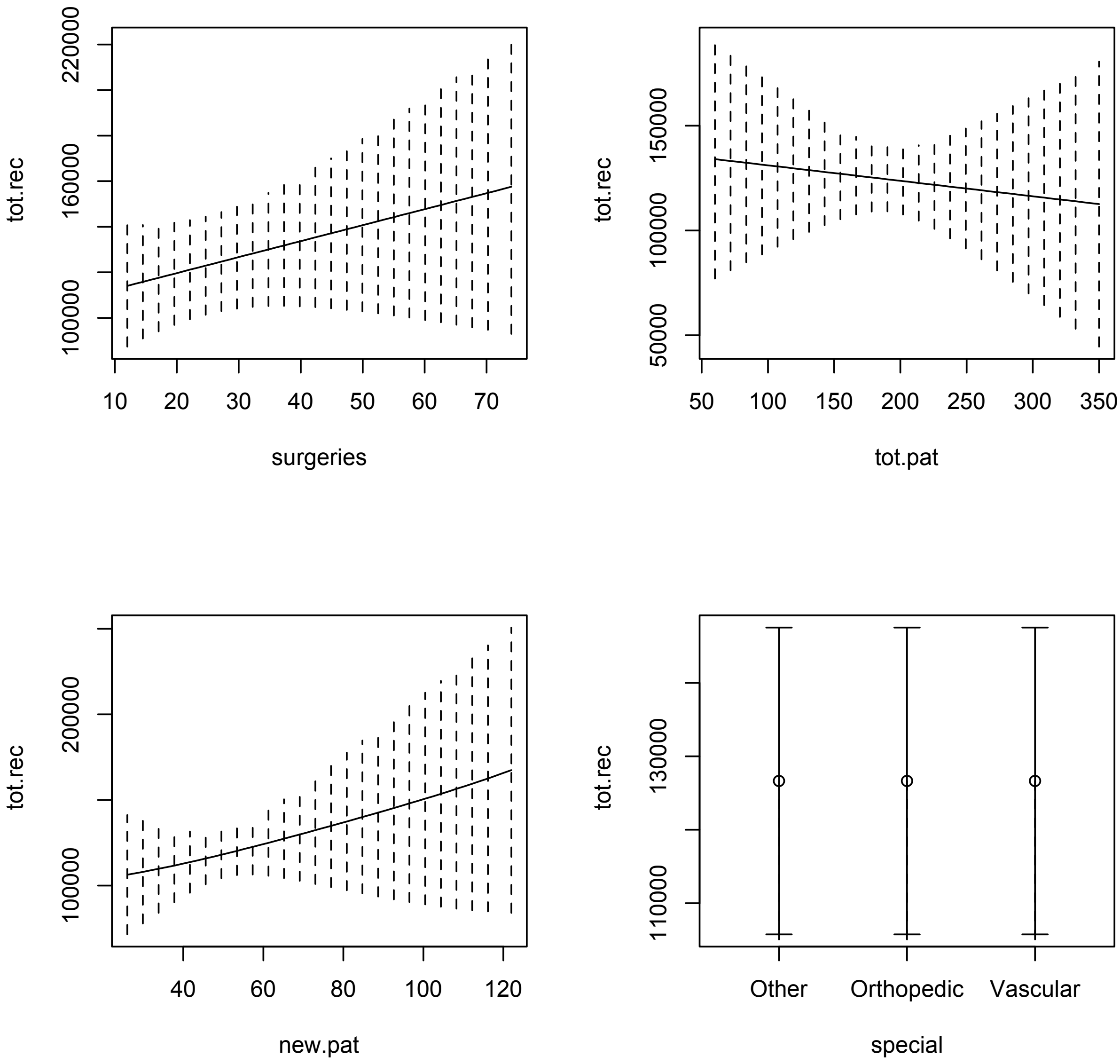

Figure 2. Nonparametric Cost Function Estimates

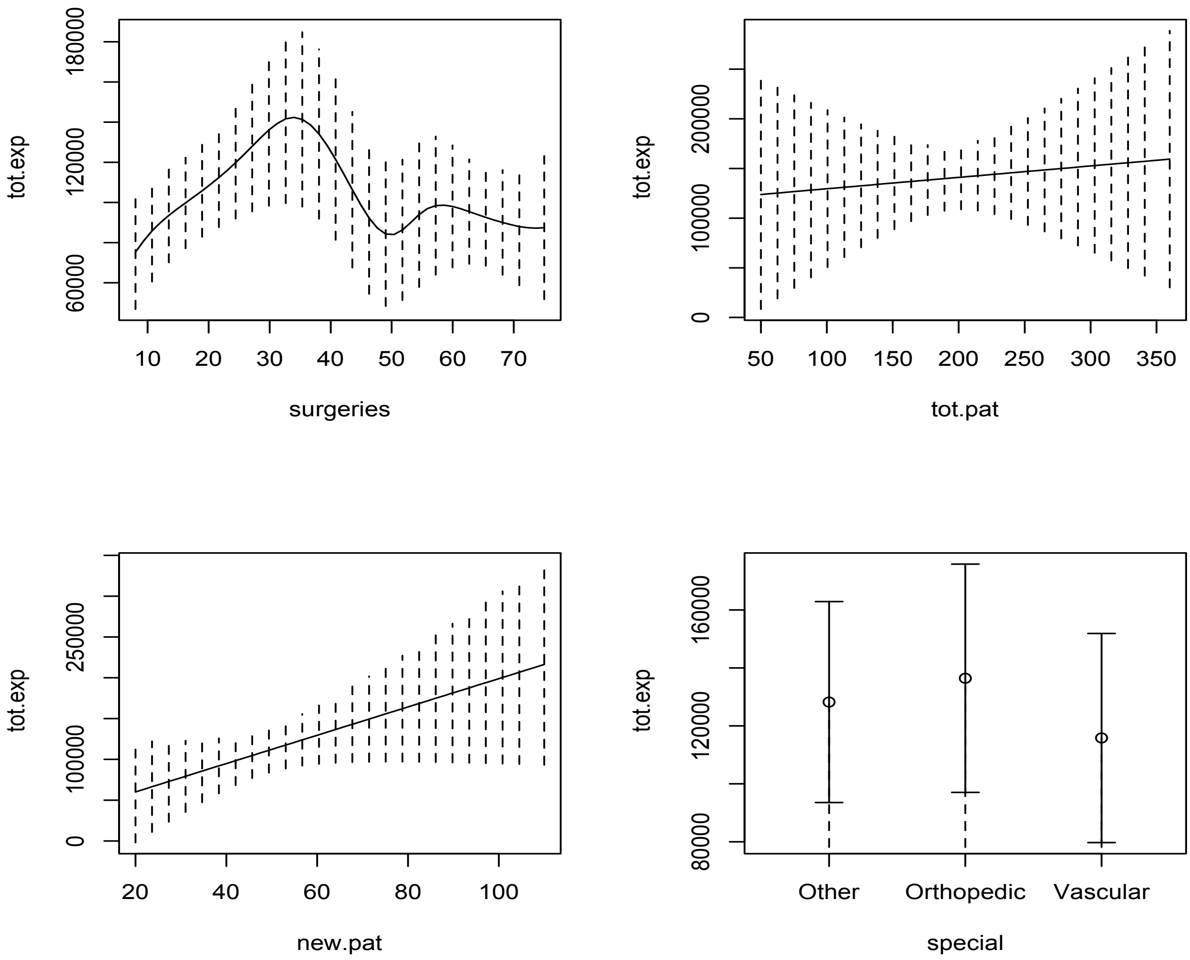

Figure 3. Nonparametric Income/Profit Function Estimates

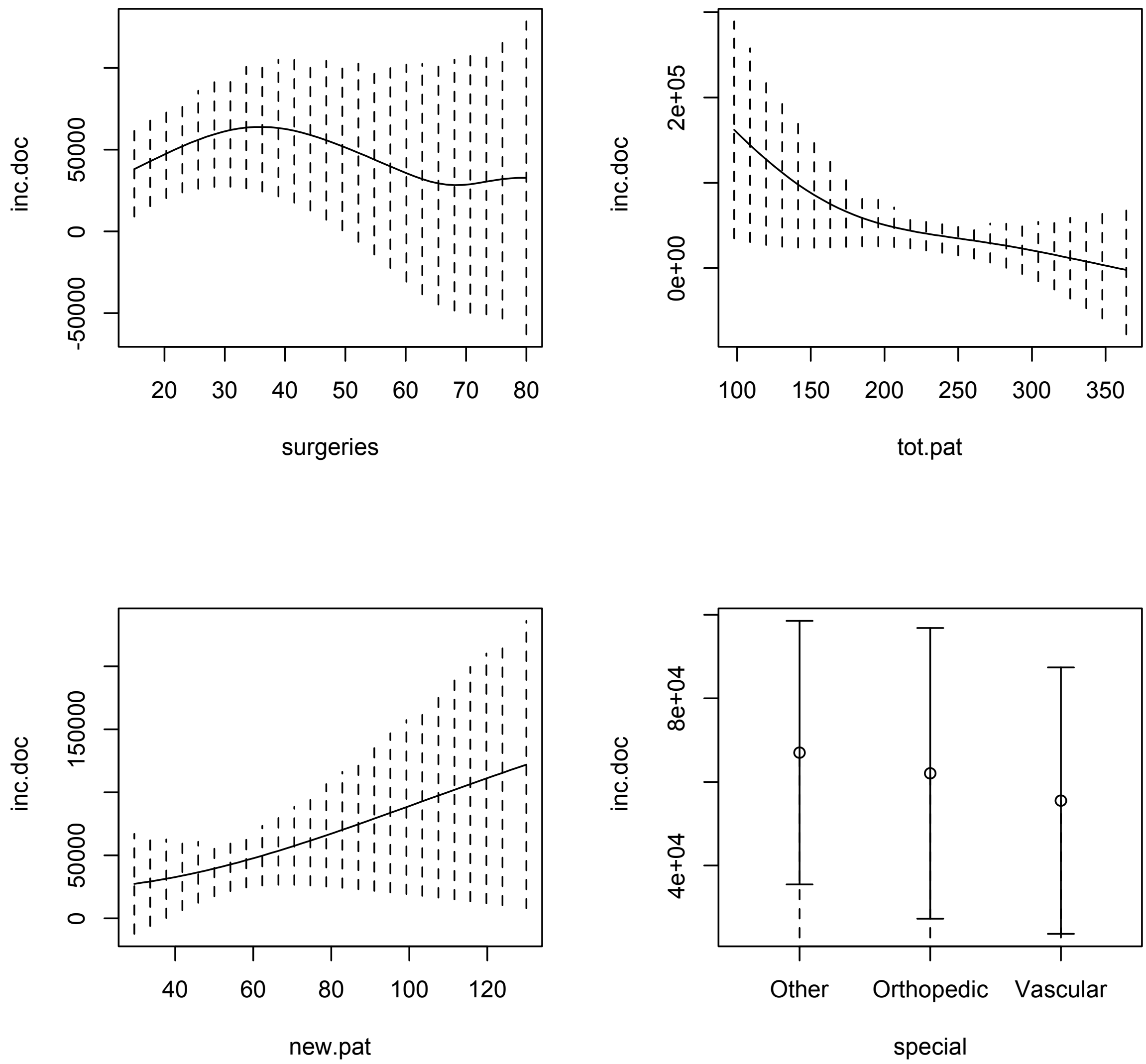

Figure 4: Nonparametric Regression of Experience on Income

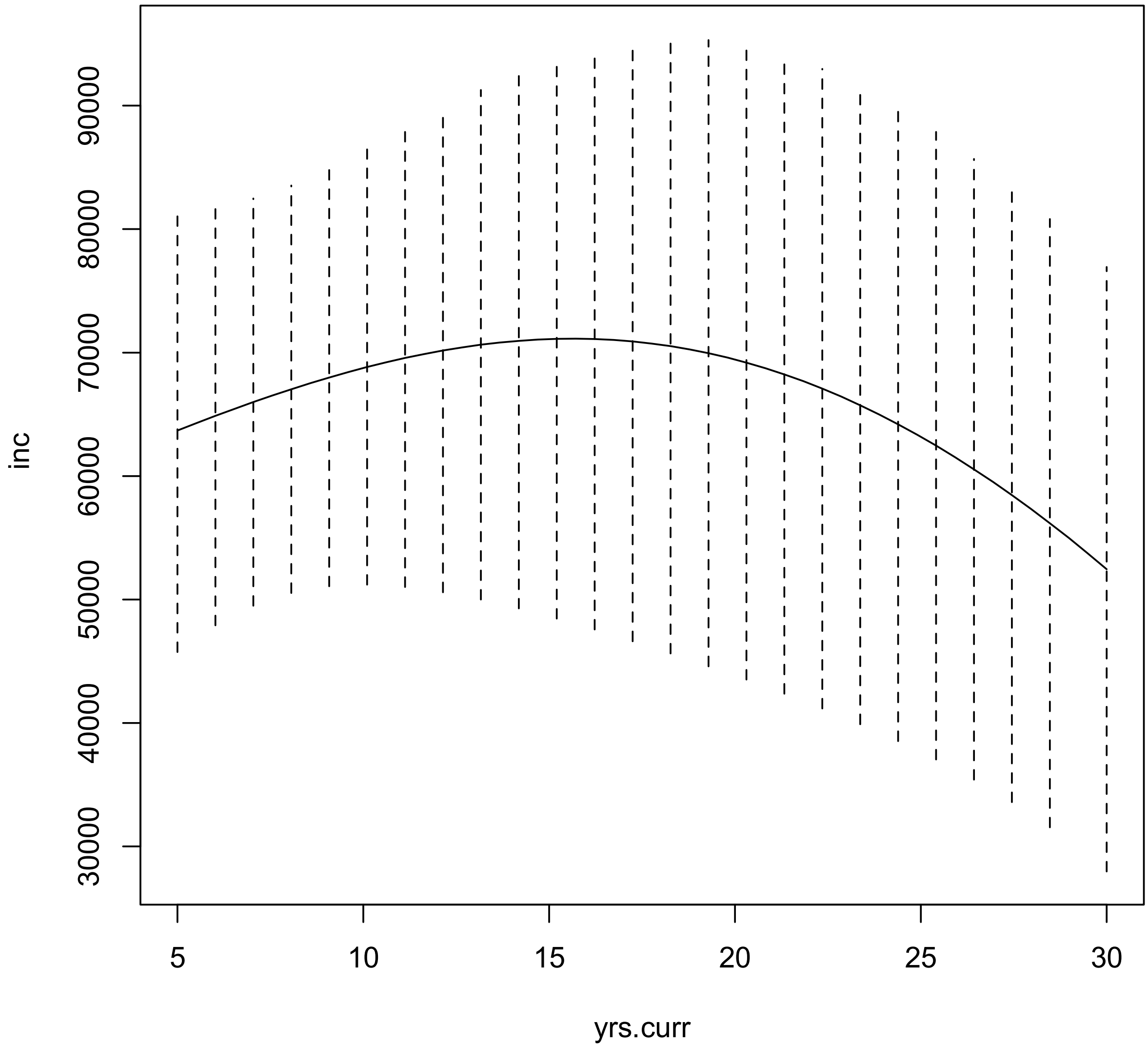

Table 1: Linear Regression of Revenues

Variable	Model 1		Model 2		Model 3		Model 4		Model 5	
Surgeries	515.39		790.85	^	429.30		875.10	*		
	(463.0)		(476.1)		(431.3)		(445.9)			
Total	-4.01		86.63							
Patients	(158.3)		(162.6)							
New	722.24	*	1054.99	**	689.40	*	1246.90	*	818.10	***
Patients	(425.7)		(440.1)		(286.9)		(251.2)		(256.1)	
Orthopedic	67301.97	***								
Surgeons	(24996.8)									
Vascular	48066.57									
Sugeons	(31538.9)									
Other	95650.19	***								
Surgeons	(33591.3)									
Intercept					71253.10	***			78156.00	***
					(21862.7)				(20732.0)	

Source: OLS regression on data collected from Gauteng specialist surgeons.
Standard errors in parentheses.
*** - Significant at 1%, ** - Significant at 5%, * - Significant at 10%, ^ - Significant at 15%.

Table 2: Linear Regression of Costs

Variable	Model 1		Model 2		Model 3	
Surgeries	5274.88	**	5141.67	**	5215.05	**
	(2304.1)		(2214.6)		(2166.1)	
Surgeries	-114.02	**	-111.72	**	-113.36	**
Squared	(49.6)		(47.32)		(46.2)	
Surgeries	0.64	**	0.63	**	0.64	**
Cubed	(0.3)		(0.3)		(0.3)	
Total	5.61		25.22			
Patients	(128.7)		(124.2)			
New	717.89	*	694.71	*	748.92	***
Patients	(375.6)		(369.0)		(252.5)	
Orthopedic	16510.84					
Surgeons	(25937.6)					
Vascular	3552.64					
Sugeons	(310567.0)					
Intercept	-5789.46		5127.46		5387.70	
	(37434.9)		(28215.6)		(27944.2)	

Source: OLS regression on data collected from Gauteng specialists.
Standard errors in parentheses.
*** - Significant at 1%, ** - Significant at 5%, * - Significant at 10%.

Table 3: Linear Regression of Income

Variable	Model 1		Model 2		Model 3		Model 4	
Surgeries	1559.75		1559.75		398.95		544.69	
	(1257.0)		(1257.0)		(419.5)		(464.9)	
Surgeries	-10.48		-10.48					
Squared	(10.69)		(10.69)					
Total	-1127.13	***	-1127.13	***	-1078.97	***	-174.78	
Patients	(366.7)		(366.7)		(363.2)		(229.5)	
Total Pat	2.00	***	2.00	***	1.85	***	0.14	
Squared	(0.7)		(0.7)		(0.7)		(0.4)	
New	712.61	*	712.61	*	798.82	**	880.52	**
Patients	(367.6)		(367.6)		(356.7)		(400.7)	
Orthopedic	-40545.87		92297.50	***	106780.32	***		
Surgeons	(29583.1)		(41957.9)		(39243.5)			
Vascular	-35339.55		97503.83	**	108411.53	**		
Sugeons	(33210.9)		(44105.5)		(42651.0)			
Other			132843.38	***	147379.85	**		
Surgeons			(43825.3)		(41211.9)			
Intercept	132843.38	***						
	(43825.3)							

Source: OLS regression on data collected from Gauteng specialist surgeons.
Standard errors in parentheses.
*** - Significant at 1%, ** - Significant at 5%, * - Significant at 10%.

Table 4: Linear Regression of Income

Variable	Model 1		Model 2		Model 3		Model 4	
Years	4559.84		4559.84		4768.78		9261.92	***
Experience	(3852.9)		(3852.9)		(3773.4)		(1634.5)	
Squared Yrs	-134.16		-134.16		-143.65	^	-245.25	***
Experience	(99.7)		(99.7)		(97.4)		(60.06)	
Orthopedic	-28998.61		37640.69					
Surgeons	(31656.7)		(32427.3)					
Vascular	-32067.01		34572.29					
Sugeons	(36596.2)		(35094.1)					
Other			66639.30	^				
Surgeons			(41373.3)					
Intercept	66639.30	^			40283.45			
	(41373.31)				(30554.2)			

Source: OLS regression on data collected from Gauteng specialist surgeons.
Standard errors in parentheses. *** - Significant at 1%, ^ - Significant at 15%.

Appendix A: Descriptive Statistics

Table A1: Descriptive Statistics

Variable	N	Mean	Std Dev
Total Receipts (tot.rec)	53	135963.4	79871.3
Total Expenses (tot.exp)	61	108932.5	73949.5
Income (inc)	40	64807.3	65568.8
New Patients (new.pat)*	61	68.5	39.6
Total Patients (tot.pat)*	61	197.6	119.4
Surgeries*	62	36.0	26.6

Source: Authors' calculations from survey data
* Sample size, means and standard deviations vary by regression

Appendix B: Survey Instrument

1. Practice Profile

Size of the practice
(Please specify)

Number of doctors in the practice	
Number of nurses employed	
Number of administrative staff i.e. receptionists, typists, etc.	

Services

Which of the following services does your practice supply?

(Please circle the correct answer and specify where needed)

Magazines/newspapers	Yes	No		
-If Yes; How often are they exchanged	Daily	Weekly	Monthly	
How many different magazines/ Newspapers are available	1-4	5-8	9 or more	
Paintings/portraits in waiting area	Yes	No		
-If Yes; Please provide the estimated cost of the paintings/portraits	R__________			
Refreshments to patients in waiting area	Yes	No		
-If Yes; Which of the following	Tea/ coffee	Cold drinks	Biscuits / cake	Vending machine
Please indicate the estimated cost of the furniture in the waiting area	R__________			
Flowers in waiting area	Yes	No		
Patient bathroom facilities	Yes	No		
Disabled facilities	Yes	No		

Patient profile
(Please specify)

Number of new patients per month	
Total number of patients per month	
Average consultation length (minutes)	
Number of surgeries per month	

2. Cost analysis

General (Fixed) expenses (monthly averages)
(Please specify)

Total rent	
Accounting fees	
Total insurance	
Motor vehicle expenses	
Water & electricity	
Telephone and fax	
Printing and stationary	
Flowers and magazines	
Repairs and maintenance	
Marketing	
Subscriptions (medical journals, etc.)	
Outsourced functions (billing, etc.)	
Staff training	
CPD Meetings/seminars	
Other: (Please specify)	1. 2. 3.

Clinical supplies (Monthly averages)

(Please specify)

Equipment/material purchases - Rental - Maintenance - Depreciation	
Medicine and consumables	

Taxes (Monthly averages)

(Please specify)

Payroll	
Other	

Salaries & wages (Monthly averages)

(Please specify)

Total nurses salaries (if more than one)	
Reception staff	
Administrative staff (billing, data capturer)	
Full-time staff	
Part-time staff	
Cleaning staff	

3. Doctor (Personal and professional profile)

(Please complete)

Age	________Years

(Pease circle your gender)

Male	1
Female	2

(Please circle your race)

Black	1
Indian	2
Coloured	3
White	4
Other	5

(Please complete)

Years qualified	_________Years
Years in private practice	_________Years
Years in current practice	_________Years

(Please specify)

Doctor Salary (monthly)	

4. Practice revenue

(Please specify)

Total receipts (monthly)	