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TECHNICAL EFFICIENCY OF PUBLIC CLINICS IN KWAZULU-NATAL PROVINCE OF SOUTH AFRICA
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TECHNICAL EFFICIENCY OF PUBLIC CLINICS IN KWAZULU-NATAL PROVINCE OF SOUTH AFRICA

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ABSTRACT

Background: **In sub-Saharan Africa (SSA) much of the attention of policy makers, health care managers, health systems researchers and donors is focussed almost solely on mobilising additional resources and not on efficiency in their use.**

Objective(s): **To investigate the technical inefficiencies among 155 primary health care clinics in Kwazulu-Natal Province of South Africa; and to draw policy implications.**

Design: **Cross-sectional provincial health clinic survey.**

Setting: **Kwazulu-Natal Provincial Department of Health Clinics survey, 1996.**

Subjects: **The analysis is based on 155 public clinics.**

Interventions: **Non-intervention Data Envelopment Analysis (DEA) study.**

Main outcome measures: **Technical and scale efficiency scores.**

Results: **Forty seven (30%) were found to be technically efficient. Among the 108 (70%) technically inefficient facilities, 16% had an efficiency score of 50% or less. The presence of inefficiencies indicates that a clinic has excess inputs or insufficient outputs compared to those clinics on the efficiency frontier. To achieve technical efficiency, Kwazulu-Natal clinics would, in total have to decrease inputs by 417 nurses and 457 general staff. Alternatively, outputs would have to be increased by 115534 antenatal visits, 1010 births (deliveries), 179075 child care visits, 5702 dental visits, 121658 family planning visits, 36032 psychiatric visits, 56068 sexually transmitted disease visits and 34270 tuberculosis visits.**

Conclusion: **There is need for more detailed studies in a number of the relatively efficient clinics to determine why they are efficient with a view of documenting attributes of 'best practise' that other clinics can emulate. The potential benefit of replicating this kind of study in other provinces, and indeed, other SSA countries cannot be overemphasised.**

Key words: Data Envelopment Analysis, technical efficiency, scale efficiency

INTRODUCTION

"In every developing country decisive steps are needed to correct the pervasive inefficiency of clinical health programmes and facilities and especially of government services". World Bank(1).

As we begin the 21st Century, sub-Saharan Africa (SSA) health care systems are still facing numerous threats, including: increasing demands for quality care; severe budgetary constraints; over-concentration of resources on high-level health facilities that benefit relatively few people(1); skewed distribution of health care resources between geographical regions(2); health inequalities; limited responsiveness to clients rational expectations; unfair financing systems(3,4); and inefficient use of health care resources leading to inflation in costs of service delivery, and hence, undermining health sector reform benefits(5).

In spite of the above threats, we do believe that this century offers opportunities for improving health, reducing health inequalities, enhancing the level and distribution of responsiveness to clients rational expectations, and developing fair systems of financing in SSA. In our opinion, the greatest challenge facing health policy-makers is the extent to which health systems are using the available resources without wastage in achieving the abovementioned health system goals. Our concern with efficient use of resources derives from the immorality of inefficiency. An inefficient health system is unethical because it denies other people an opportunity of improving their health status at no extra cost to the providers.

One of the key challenges facing health systems analysts in this Century is to conduct micro-level efficiency analyses that would enable health policymakers and managers to identify the magnitudes by which some inputs in individual health facilities or programmes could be reduced without a reduction in output(s). So far, the attention of policymakers, health care managers, health systems analysts and donors has been focussed on mobilising additional resources and not on efficiency in their use. This explains the dearth of literature on the subject of health sector micro-level efficiency analyses in SSA.

In 1995/96 financial year, overall South African health budget amounted to 16.1 billion Rands. 68% of the budget was allocated to tertiary, regional, community and specialized (e.g. psychiatric, TB, etc) hospitals; and 19% to primary health care(2). Thus, in general health facilities absorbed over 80% of the total budget. This is why we have chosen to focus on technical efficiency of health facilities. Our first analysis dealt with technical efficiency of public hospitals in Kwazulu/Natal Province(5). This study deals with the same problem, but among primary health care clinics (PHC).

Efficiency of a health facility consists of two strands: technical efficiency (TE) and allocative efficiency (AE)(6). TE reflects the ability of a facility to obtain maximum output(s) from a given set of inputs. Thus, a facility is said to technically inefficient if it is possible to either increase output without increasing any input or decreasing any output. AE reflects the ability of a facility to use inputs in optimal proportions, given their respective prices(7).

The objectives of this study are to: investigate the technical inefficiencies among PHC clinics in Kwazulu-Natal Province of South Africa; and to draw policy implications. The rest of the paper is organised as follows. Section 2 describes the data and DEA conceptual framework. Section 3 presents the empirical results. The last section contains some implications for policy, suggestions for further research and the conclusion.

MATERIALS AND METHODS

Conceptual framework: The two principal methods for estimating the production frontiers are: (a) the *parametric* approach that uses econometric methods(8,9,10); and (b) the *non-parametric* approaches that uses linear programming techniques(6,7), such as, data envelopment analysis (DEA). In this study we used the DEA approach because it: focuses on each clinic in contrast to parametric population or sample averages; produces a single efficiency measure for each clinic in terms of input-output relationships; can simultaneously handle multiple inputs and multiple outputs without the requirement for homogeneous measurement units; can adjust for exogenous variables that are beyond the control of the decision making unit; doesn't require an assumption of a functional form relating inputs to outputs; produces estimates for desired changes in inputs and outputs for getting the inefficient clinics onto the efficient frontier; and focuses on observed best-practice frontiers rather than on central tendency properties of frontiers(11,12).

The following two linear programming problems were estimated using EMS DEA software(13). The first problem (A) is a standard constant returns to scale (CRS) model(11):

$$\text{Max } h_0 = \sum_{r=1}^{t} u_r y_{rj0} \qquad \text{(A)}$$

Subject to:

$$\sum_{r=1}^{m} v_i x_{ij0} = 1,$$

$$\sum_{r=1}^{t} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, \quad j = 1, \ldots, n,$$

$$-u_r \le - \ , r=1,\ldots,t,$$
$$-v_i \le - \ , r=1,\ldots,m.$$

Where:

y_{rj} = the amount of output r produced by clinic j,
x_{ij} = the amount of input i used by clinic j,
u_r = the weight given to output r,
v_i = the weight given to input i,
n = the number of clinics,
t = the number of outputs,
m = the number of inputs,
= a small positive number.

The last constraint means that all clinics (i.e. Decision Making Unit's) are either on or below the frontier.

The second problem (B) is a variable returns to scale model:

$$\textit{Max } h_0 = \sum u_r y_{rj0} + u_0 \qquad \text{(B)}$$

$$\text{s.t.: } \sum v_i x_{ij0} = 1$$

$$\sum u_r y_{rj} - \sum v_i x_{ij} + u_0 \le 0, j = 1, \ldots, N$$

$$u_r, v_i \ge 0$$

From (B) it is possible to derive scale efficiency, that is whether the clinics are operating on an optimal scale of production or not. In this study, following the guidance provided by Coelli (7), scale efficiency score for each individual clinic was obtained by dividing its constant returns to scale efficiency score by the corresponding variable returns to scale efficiency score.

Data: Input and output data was obtained from the Provincial Department of Health, Kwazulu/ Natal, Health Informatics Bulletin(14). The data is for the period between March 1995 to April 1996. The 155 clinics in the province which had inputs and outputs greater than zero were included in the study.

In this study, clinics were assumed to produce mainly eight types of intermediate outputs: antenatal visits, number of births/ deliveries, child health visits, dental care visits, family planning visits, psychiatry visits, sexually transmitted disease visits, and tuberculosis treatment visits. Two inputs were included in the estimation of efficiency scores: number of nurses and number of general staff (including administrative staff, sub-ordinate, and labour provisioning staff). The selection of the above mentioned variables was guided by the availability of data in the Health Informatics Bulletin.

Data Entry and Analysis Procedure:

Step A: The inputs and outputs data were entered on Excel Spreadsheet as follows: names of clinics in column 1; Input1{I}, i.e., number of nurses in column 2; Input2{I}, i.e., number of general staff (including administrative, sub-ordinate, and labour provisioning staff) in column 3; Output1{O}, i.e., antenatal care visits in column 4; Output2{O}, i.e., number of deliveries/births in column 5; Output3{O}, i.e., number of child health care visits in column 6; Output4{O}, i.e., number of dental care visits in column 7; Output5 {O}, i.e., number of family planning visits in column 8; Output6 {O}, i.e., number of psychiatry visits in column 9; Output7 {O}, i.e., number of sexually transmitted diseases-related care visits in column 10; and Output8 {O}, i.e., number of tuberculosis-related visits in column 11.

Step B: Click on Start, Program, and EMS - this will open a window containing five items (FILE, EDIT, DEA, WINDOW and HELP) at the top right-hand corner.

Step C: Click on 'FILE' and then on 'LOAD DATA' - you will be prompted to type 'Filename', e.g. C:\HEC\WHO8.XLS and to indicate 'File Type', e.g. "Excel 5.0 (*.xls)" or "Text (*.txt)".

Step D: At the EMS menu click on "OPEN". If data retrieval process has been successful, Input Output Data C:\HEC\WHO8.XLS will appear at the bottom left-hand corner of the window.

Step E: Click on 'DEA' and then on 'Run Model'. This will lead you to a window titled 'E Run Model Window'. At the menu, click on 'Model'. The programme would take you to a window containing 'Structure' with a choice between 'Convex' and 'non-convex' models; 'Returns to Scale', i.e. 'Constant', 'variable', non-increasing', or 'non-decreasing'; distance - 'Radial' or 'additive'; and orientation - 'input' or 'output'. Once you have made your choices, click on the 'Start' icon for the model to run. The EMS in a few seconds will produce a sheet containing results, which includes DMU name, efficiency score, DEA weights/multipliers, peers/benchmarks, slacks per input, and slacks per output.

Step F: Note that in an input oriented DEA model, excess input equals radial reduction plus slacks. Firstly, add individual variable's slacks across all the DMUs or clinics. If you are using Excel software simply go at the bottom of the column containing slacks for a specific input and click on the summation sign (Σ). Of course, if there are some empty cells, having clicked on Σ in the menu, one will need to manually specify the range [e.g. =sum(P2:P156)]. Secondly, since the technical efficiency score indicates how the DMUs or clinics can reduce their inputs, the radial reduction (RR) is defined as: specific input's absolute quantity (Q) minus efficiency score (TE) times specific input's absolute quantity (Q), i.e. RR=[Q - (TE x Q)].

Step G: Scale efficiency score = CRS Score ÷ VRS Score. Thus, to obtain scale efficiency score, you will need to run the EMS model twice, i.e. using CRS and VRS model specifications.

After the technical efficiency estimations, the following null hypothesis, 'H0: vectors of variable means are equal for the two groups (efficient and inefficient) of clinics', was tested using 2-group Hotelling's T-squared generalised means test. The tests were conducted using STATA(15) software.

RESULTS

The means and standard deviations of input and output variables, for both efficient and inefficient clinics, are presented in Table 1. The 2-group Hotelling's T-squared generalized means test yielded a T-squared of 39.39 which was greater than F(10,144) test statistic of 3.707 at 0.0002% level. This result indicates that the means for efficient and inefficient groups are significantly different at the 0.0002% level.

Table 1

Means and Standard Deviations for various variables

Variable	Efficient Clinics (n=47)		Inefficient Clinics (108)	
	Mean	Standard Deviation	Mean	Standard Deviation
Number of nursing Staff	11.43	19.24	7.57	9.08
Number of general Staff (including administrative, general and labour provisioning staff)	10.92	14.53	8.67	8.90
Number of antenatal visits	4,788.23	6,380.23	2,124.66	1,869.87
Number of births	199.09	489.17	63.19	81.85
Number of child Health	5,900.79	6,127.09	3,510.95	2,486.2
Number of dental care visits	999.28	3,171.88	57.21	229.56
Number of family planning visits	4,704.38	15,261.75	1,927.71	2,260.74
Number of psychiatry visits	472.09	668.29	330.23	449.09
Number sexually transmitted diseases visits	1,672.64	3,106.04	681.01	750.23
Number of tuberculosis visits	1,536.62	4,594.29	350.17	962.34

Table 2 summarises the distribution of clinics by their technical and scale efficiency scores. Forty seven (30%) of the clinics were technically efficient since their efficiency scores were equal to one. 25 (16%) of these facilities manifested 100% scale efficiency. Among the 108 (70%) technically inefficient facilities, 16% had an efficiency score of 50% or less. To enhance readers understanding of these results, lets use clinic 1 as an example. We note that the technical efficiency score for Clinic 1 (in Appendix 1) is 60%. This implies that, Clinic 1 should be able to reduce the utilization of all inputs by 40% without reducing any output. Technical efficiency and scale efficiency scores for individual clinics are presented in Appendix 1.

Table 3 shows total output increases and input reductions needed to make inefficient clinics efficient. Output increases and input reductions needed to make each inefficient clinic efficient are presented in Appendices 2 and 3.

Appendices 4 and 5 summarises the linear probability and logistic models results of the regression analyses conducted to determine the causal-effect relationship between technical efficiency score and various explanatory variables. The linear probability model (LPM) results summarised in Appendix 4 should be interpreted as describing the probability that an individual clinic will be efficient, given information about its output and input characteristics. The coefficients of a LPM represents the effect of a unit change in the concerned explanatory variable on the probability of a clinic being found relatively efficient. For instance, the slope coefficient for general staff was -0.097. It means that on average an increase in the total number of general staff by one would lead to a reduction in clinic's probability of being efficient by 9.7%.

Table 2

Distribution of clinics by their technical and scale efficiency scores

Efficiency brackets (%)	No. of clinics in various technical efficiency brackets (%)	No. of clinics in various scale efficiency brackets (%)
1 - 10	1 (0.6)	0 (0.0)
11 - 20	3 (1.9)	5 (3.2)
21 - 30	4 (2.6)	10 (6.5)
31 - 40	8 (5.2)	15 (9.7)
41 - 50	8 (5.2)	26 (16.8)
51 - 60	19 (12.3)	6 (3.9)
61 - 70	31 (20.0)	16 (10.3)
71 - 80	21 (13.5)	19 (12.3)
81 - 90	9 (5.8)	11 (7.1)
91 - 99	4 (2.6)	22 (14.2)
100	47 (30.3)	25 (16.1)
Total	155 (100)	155 (100)

Note: The technical efficiency scores reported in Table 2 are for variable returns to scale (VRS) specification. That specification was chosen because it permits the calculation of TE devoid of these SE effects(7).

Table 3

Total increases in outputs and input reductions needed to make inefficient clinics efficient

Output (number of visits)	Output increases required
Anate-natal care	115,534
Births	1,010
Child care	179,075
Dental care	5,702
Family planning	121,658
Psychiatric care	36,032
Sexually transmitted diseases care	56,068
Tuberculosis care	34,270
Total input reductions needed to make inefficient clinics efficient	
Input (numbers)	Excess number of inputs
Nurses	417
General Staff (including administrative, general and labour provisioning staff)	457

The slope coefficient for a logit model shows the impact of a unit increase in an explanatory variable (holding other factors constant) on the log of odds in favour of a clinic being relatively efficient. For example, in Appendix 4, the coefficient for general staff was -0.143. This means that a unit increase in number of general staff will lead to a decrease of 0.143 in the log of odds of a clinic being relatively efficient.

DISCUSSION

This study used Data Envelopment Analysis (DEA) - a mathematical programming method - to estimate technical efficiency of 155 clinics of Kwazulu/Natal Province in South Africa. Forty seven (30%) of the clinics were found to be technically efficient. However, a significant number of the clinics (70%) were found to have varying degrees of technical inefficiency. The presence of inefficiencies indicates that a clinic has excess inputs or insufficient outputs compared to those clinics operating on the efficiency frontier. To achieve technical efficiency, Kwazulu-Natal clinics would, in total have to reduce inputs by 417 (30.8%) nurses and 457 (31.5%) general staff (including administrative, casual and labour provisioning staff). Alternatively, outputs would have to be increased by 115534 (25.4%) antenatal visits, 1010 (6.2%) births (deliveries),179075 (27.3%) child care visits, 5702 (10.7%) dental visits, 121658 (28.3%) family planning visits, 36032 (62.3%) psychiatric visits, 56068 (36.8%) sexually transmitted disease visits and 34270 (31.1%) tuberculosis visits. The prevalence and magnitudes of technical inefficiencies in the clinics are significantly smaller than those found in the public hospitals of Kwazulu/Natal Province(5).

With regard to excess inputs, the policy-makers have a number of options, that are not necessarily mutually exclusive:

- Transfer the excess nurses to more efficient clinics. It would not be sensible to re-entrench this cadre of staff for three reasons. Firstly, society has invested substantial amount of resources in their training. Two, given the apartheid legacy of over-investment in high-level hospital care at the expense of primary health care, it would not make sense to deplete the PHC resources further. Thirdly, in general PHC facilities offer more cost-effective services than the hospitals. And, thus, as the Work Bank(1) advocates "reforms [should] entail shifting new government spending for health away from specialised personnel, equipment, and facilities at the apex of health systems and down the pyramid toward the broad base of widely accessible care in community facilities and health centres". Thus, it would be counter-intuitive to even contemplate transferring excess technical staff to higher-levels of care. Lastly, past studies have revealed significant technical inefficiencies in the use of the same cadre of staff among the hospitals(5).
- Excess general staff could be sent on early retirement. The accruing savings could be used to improve terms and working conditions for the remaining staff.
- In this century, it would make lots of economic sense to replace jobs-till-old-age-retirement with fixed shorter duration (e.g. 5 years) renewable contracts, so as to give the Department of Health greater degree of flexibility regarding employment of personnel. The renewal of contracts would then be based on objective and transparent performance appraisal and continuing need for the services of specific cadres of staff. For instance, if this kind of human resource contracting system were in place, at the end of the contractual period the excess staff (whose services are not needed in the system) would be paid their pension entitlements without the early retirement premiums.

Alternatively, the Department of Health could embark on campaign to boost demand for antenatal visits, number of births/deliveries, child health visits, dental care visits, family planning visits, psychiatry visits, sexually transmitted disease visits, and tuberculosis treatment visits. However, such a course of action ought to be: (a) for those services with an unmet need; and (b) preceded by demand analyses that would enable the Department of Health to identify variables that could be changed using policy instruments to induce demand for selected services.

Limitations of the study:

a. The study did not include health care inputs such as pharmaceuticals, non-pharmaceutical supplies, buildings, etc. in the analysis.

b. The study focussed only on technical efficiency and not allocative efficiency. Thus, the scores do not capture total efficiencies or inefficiencies.

c. Since the data used is for only one year, the study does not calculate total factor productivity change and technological change.

d. The study used proxy outcome measures. One of the intrinsic goals of health systems is to improve beneficiaries health status, and thus, the ultimate outcome of health care system ought to be its effect on life expectancy and health-related quality of life of all those who come into contact with it. Therefore, ideally, we should have used indices that combine the two dimensions of health into a unitary measure. The readers can refer to Kirigia(16) for details relating to the application of quality-adjusted-life year (QALY) index in Africa; and to Murray(17) for the disability-adjusted life year (DALY) index. We opted for proxy health outcome measures because of dearth of facility-level information needed to calculate QALYs or DALYs for individual clinics.

Suggestions for further research:
There is need for health systems researchers to conduct:

- Detailed investigative studies in a sample of the relatively efficient health facilities to document key attributes of the "best practise". Such "best practices"could then be emulated by the inefficient clinics.
- efficiency studies in all other South African provinces and other SSA countries. Those future studies should, whenever feasible, include a more exhaustive list of inputs (for example, capital, pharmaceutical and non-pharmaceutical supplies) than those considered in the present study.
- cost and allocative efficiency studies whenever data on prices of inputs is available.
- studies to calculate indices of total factor productivity change, technological change, technical efficiency change and scale efficiency change(5), in countries where panel data (on more than one year) is available, using the Malmquist DEA approach.

CONCLUSION

DEA not only helps health care policy-makers and managers to answer the question 'How well are the clinics doing?' but also 'How much and in what areas could they improve?' It suggests performance targets. In addition, it identifies the clinics which are performing best and their operating practices can then be examined to establish a guide to "best practice" for others to emulate. The potential benefit of replicating this kind of study in other provinces, and indeed, other countries in SSA cannot be over-emphasised.

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Appendix 1

Efficiency score and scale efficiency score

Name of Clinic	Technical Efficiency score	Scale Efficiency Score
Hlokozi	0.60	0.43
Mabaleni	1.00	0.60
Madlala	1.00	0.37
Morrison's Post	1.00	0.94
Ndelu	1.00	0.41
Ntimbankulu	0.58	0.35
Nyangwini	1.00	0.86
Pungashe	0.72	1.00
St. Faiths	0.65	0.92
Umzinto CHC	1.00	0.77
Bomela	0.50	0.70
Gamalakhe	0.31	0.99
Gcilima	1.00	0.99
Izingolweni	0.95	0.77
Ludimala	0.70	0.41
Ntabeni	1.00	1.00
Pisgah	0.58	0.49
Caluza	0.40	0.99
Gcumisa	1.00	1.00
Mpophomeni	0.50	0.91
Mpumalanga	1.00	1.00
Mpumuza	1.00	1.00
Msunduzi	1.00	0.90
Ndaleni	0.82	0.70
Taylors Halt	0.71	0.83
Mobile	1.00	1.00
Imbalenhle	1.00	0.44
Richmond	0.66	0.98
Underberg	0.28	0.74
Ehlanzeni	0.35	0.39
Cwaka	1.00	0.68
Ethembeni	0.52	0.50
Gunjana	1.00	0.40
Mazebeko	0.72	0.27
Ngubevu	0.70	0.17
Nocomboshe	0.69	0.21
Brunville	0.41	0.90
Driefontein	0.57	0.73
Ekuvukeni	1.00	1.00
Ezakheni No. 2	1.00	0.65
Limehill	0.77	0.55
Rockcliff	0.79	0.72
Mobile 1	0.61	0.91
Amazizini	0.52	0.89
Dukuza	0.55	0.77
Injisuthi	0.39	0.78
Ncibindane	0.52	0.72
Ntabamhlophe	0.57	0.98
Oliviershoek	0.96	0.98
Wembesi	0.36	0.98
Dengeni	0.53	0.17
Ekubungazeleni	0.62	0.72
Hlengimpilo	0.62	0.13
Mahashini	0.62	0.48
Maphophoma	0.66	0.65
Ngqeku	0.52	0.21
Njoko	0.72	0.62
Usuthu	0.74	0.49
Mobile 1	1.00	1.00
Dlebe	0.74	0.47
Ezimfabeni	0.75	0.42
Altona	0.62	0.53
Friesgewaagt	0.63	0.80
Hartland	0.84	0.62
Kwashoba	0.54	0.65
Ncotshana	0.68	0.85
Tobolsk	0.73	0.30
Kwamame	0.66	0.64
Lomo	0.79	0.46
Mabedlana	0.78	0.43
Makhosini	0.61	0.28
Mpungamhlophe	0.88	0.70
Ncemane	0.68	0.39
Nhlungwane	0.55	0.21
St. Francis	0.17	0.63
Ulundi A	0.36	0.80
Zilulwane	0.65	0.47
Jozini	1.00	1.00
Madonela	1.00	0.47
Makhathini	0.63	0.47
Mhlekazi	0.58	0.49
Ophansi	0.81	0.62
Kwamsane	1.00	1.00
Mpukunyoni	1.00	0.95
Phelindaba	0.71	0.56
Zamazama	0.91	0.71
Emanyiseni	0.89	0.44
Gwaliweni	0.70	0.47
Ndumu	0.64	0.90
Shemula	0.68	0.40
Mbazwana	0.70	0.54
Ntshongwe	0.85	0.44
Commercial City FP	1.00	1.00
Inanda FP	0.09	0.38
Goodwins	1.00	1.00
Kwamashu	1.00	0.91
Lindelani	0.28	0.75
Molweni	0.52	0.39
Ndwedwe	0.30	1.00
Ntuzuma	1.00	0.87
Qadi	0.75	0.93
Rydalvale	1.00	1.00
Phoenix CHC	1.00	0.75
Baniyena	1.00	0.38
D State	0.62	0.98
Dudulu	1.00	1.00
Ekuphileni	1.00	1.00
Imfume	0.68	0.62
Jolivet	0.62	0.40
Kwamakhutha	0.87	0.92
Kwadengezi	0.33	0.76
Magabheni	0.50	0.46
Mntungwane	0.44	0.32
Nkwali	0.62	0.41
Odidini	0.75	0.97
Osizweni	0.41	0.83
Umbumbulu	1.00	1.00
Umlazi "V"	0.74	0.99
Umzomuhle	0.63	0.35
Zwlibomvu	0.55	0.31

Isandlwana	1.00	0.52
Mangeni	1.00	0.43
Masotsheni	0.61	0.99
Mondlo 1	0.90	0.99
Mondlo 2	0.79	0.47
Ntababomvu	1.00	0.43
Ntinini	1.00	1.00
Naasfarm	0.86	0.78
Osizweni 1	1.00	0.80
Thembalihle	0.45	0.98
Madadeni 1	0.40	1.00
Madadeni 5	0.47	1.00
Dkodweni	0.52	0.28
Ndulinde	1.00	0.71
Mobile	1.00	0.35
Manyane	1.00	0.26
Mfongosi	1.00	0.27
Mntungweni	1.00	0.44
Mobile	0.29	0.95
Gezinsila	0.70	0.12
Ngudwini	0.70	0.25
Ntumeni	0.70	0.19
Osungulweni	0.73	0.31
Melmoth	0.99	1.00
Dondotha	0.18	0.66
Ndlangubo	0.72	0.68
Ndundulu	1.00	1.00
Ngwelezane	0.80	0.77
Nomponjwana	1.00	1.00
Nseleni	0.11	0.84
Ntambanana	0.80	0.86
Ntuze	0.52	1.00
Halambu	1.00	1.00
Vumanhlamvu	0.60	0.69
Mthandeni	1.00	0.46

Appendix 2

Input reductions needed to make inefficient clinics efficient

Name of clinic	Excess number of nurses	Excess number of general staff
Hlokozi	1.62	2.83
Mabaleni	0.00	0.13
Madlala	0.00	0.53
Morrison's Post	0.00	0.00
Ndelu	0.00	0.00
Ntimbankulu	1.67	2.93
Nyangwini	0.00	0.00
Pungashe	1.69	2.39
St. Faiths	1.41	2.47
Umzinto CHC	0.00	0.00
Bomela	2.52	4.03
Gamalakhe	7.55	21.43
Gcilima	0.00	0.00
Izingolweni	0.66	1.28
Ludimala	0.89	2.08
Ntabeni	0.00	0.00
Pisgah	1.67	2.93
Caluza	8.44	5.43
Gcumisa	0.00	0.00
Mpophomeni	4.00	2.50
Mpumalanga	0.00	0.00
Mpumuza	0.00	0.00
Msunduzi	0.00	0.00
Ndaleni	0.71	0.36
Taylors Halt	1.43	1.15
Mobile	0.00	0.00
Imbalenhle	0.00	0.00
Richmond	5.17	7.38
Underberg	8.58	6.44
Ehlanzeni	3.89	9.72
Cwaka	0.00	0.00
Ethembeni	2.38	3.34
Gunjana	0.00	0.01
Mazebeko	0.85	1.99
Ngubevu	0.92	2.14
Nocomboshe	0.93	2.17
Brunville	6.50	8.87
Driefontein	2.55	2.13
Ekuvukeni	0.00	0.00
Ezakheni No. 2	0.00	0.00
Limehill	0.91	0.91
Rockcliff	0.83	1.04
Mobile 1	3.16	0.79
Amazizini	3.38	2.41
Dukuza	2.27	3.18
Injisuthi	4.87	4.87
Ncibindane	2.42	3.87
Ntabamhlophe	3.00	4.71
Oliviershoek	0.18	0.47
Wembesi	5.74	8.29
Dengeni	2.36	2.83
Ekubungazeleni	1.92	2.30
Hlengimpilo	1.54	2.31
Mahashini	1.53	2.29
Maphophoma	1.38	2.06
Ngqeku	2.38	2.86
Njoko	1.14	1.71
Usuthu	0.77	1.54
Mobile 1	0.00	0.00
Dlebe	0.77	1.53
Ezimfabeni	0.76	1.53
Altona	1.50	2.25
Friesgewaagt	1.48	2.22
Hartland	0.47	0.94
Kwashoba	2.28	2.74
Ncotshana	1.62	1.95
Tobolsk	0.80	1.60
Kwamame	1.70	2.04
Lomo	0.64	1.29
Mabedlana	0.67	1.33
Makhosini	1.97	2.36
Mpungamhlophe	0.47	0.71
Ncemane	1.29	1.94
Nhlungwane	2.23	2.67
St. Francis	66.58	66.58
Ulundi A	6.99	5.09
Zilulwane	1.39	2.09
Jozini	0.00	0.00
Madonela	0.00	0.00
Makhathini	1.48	2.58
Mhlekazi	2.12	2.96
Ophansi	0.56	1.32
Kwamsane	0.00	0.00
Mpukunyoni	0.00	0.00

Phelindaba	1.16	2.03
Zamazama	0.36	0.64
Emanyiseni	0.32	0.53
Gwaliweni	1.19	1.79
Ndumu	2.49	2.49
Shemula	1.29	1.93
Mbazwana	1.21	1.81
Ntshongwe	0.45	1.04
Commercial City FP	0.00	0.00
Inanda FP	40.01	20.01
Goodwins	0.00	0.00
Kwamashu	0.00	0.00
Lindelani	8.63	6.48
Molweni	2.38	2.85
Ndwedwe	9.81	7.01
Ntuzuma	0.00	0.00
Qadi	6.44	2.52
Rydalvale	0.00	0.00
Phoenix CHC	0.00	0.00
Baniyena	0.00	0.00
D State	3.77	3.39
Dudulu	0.00	0.00
Ekuphileni	0.00	0.00
Imfume	1.29	1.61
Jolivet	1.53	2.30
Kwamakhutha	1.69	1.04
Kwadengezi	8.05	5.37
Magabheni	2.53	4.04
Mntungwane	4.47	1.68
Nkwali	1.88	1.13
Odidini	2.70	1.47
Osizweni	5.89	4.72
Umbumbulu	0.00	0.00
Umlazi "V"	3.32	2.04
Umzomuhle	1.47	2.20
Zwlibomvu	2.27	2.73
Isandlwana	0.00	0.00
Mangeni	0.00	0.00
Masotsheni	3.10	3.48
Mondlo 1	0.50	0.80
Mondlo 2	0.64	1.27
Ntababomvu	0.00	0.00
Ntinini	0.00	0.00
Naasfarm	1.81	1.39
Osizweni 1	0.00	0.00
Thembalihle	7.72	4.96
Madadeni 1	8.34	5.96
Madadeni 5	7.48	5.35
Dkodweni	2.38	3.33
Ndulinde	0.00	0.00
Mobile	0.00	0.01
Manyane	0.00	0.35
Mfongosi	0.00	0.40
Mntungweni	0.00	0.02
Mobile	9.99	5.71
Gezinsila	0.91	2.11
Ngudwini	0.89	2.08
Ntumeni	0.89	2.08
Osungulweni	0.81	1.88
Melmoth	0.02	0.05
Dondotha	14.02	23.10
Ndlangubo	0.83	1.94
Ndundulu	0.00	0.00
Ngwelezane	0.59	1.38
Nomponjwana	0.00	0.00
Nseleni	28.43	44.43
Ntambanana	0.61	1.43
Ntuze	4.29	3.81
Halambu	0.00	0.00
Vumanhlamvu	2.83	1.61
Mthandeni	0.00	0.46

Appendix 3

Increases in outputs needed to make inefficient clinics efficient

Name of clinic	Ante	Births	Child	Dental	FP	Mental	STD	TB
Hlokozi	1,423	-	401	-	-	130	434	11
Mabaleni	419	4	494	2	0	207	309	64
Madlala	1,242	34	313	5	401	166	211	63
Morrison's Post	-	-	-	-	-	-	-	-
Ndelu	-	-	-	-	-	-	-	-
Ntimbankulu	724	-	1,431	1	240	95	463	-
Nyangwini	-	-	-	-	-	-	-	-
Pungashe	3,710	86	-	-	1,345	-	312	1,183
St. Faiths	76	34	-	-	453	-	446	1,515
Umzinto CHC	-	-	-	-	-	-	-	-
Bomela	441	3	-	-	980	14	-	-
Gamalakhe	2,212	-	-	19	-	-	-	-
Gcilima	-	-	-	-	-	-	-	-
Izingolweni	3,202	58	-	-	3,974	-	1,142	7,912
Ludimala	288	3	1,588	1	420	-	-	-
Ntabeni	-	-	-	-	-	-	-	-
Pisgah	855	6	-	-	963	4	304	-
Caluza	-	107	-	150	5,415	-	-	291
Gcumisa	-	-	-	-	-	-	-	-
Mpophomeni	-	22	-	7	2,268	99	-	-
Mpumalanga	-	-	-	-	-	-	-	-
Mpumuza	-	-	-	-	-	-	-	-
Msunduzi	-	-	-	-	-	-	-	-
Ndaleni	967	9	-	2	1,528	114	578	39
Taylors Halt	343	9	424	12	721	-	823	1,639
Mobile	-	-	-	-	-	-	-	-
Imbalenhle	-	-	-	-	-	-	-	-
Richmond	1,210	96	-	-	3,423	1,564	2,383	2,089
Underberg	-	18	-	4	2,040	538	1,018	82
Ehlanzeni	1,323	-	826	0	706	345	77	25
Cwaka	-	-	-	-	-	-	-	-
Ethembeni	326	-	213	-	1,357	425	414	-
Gunjana	641	8	1,267	0	916	247	161	22
Mazebeko	584	-	1,772	-	1,258	305	274	-
Ngubevu	863	-	1,867	0	772	144	209	-
Nocomboshe	421	-	1,391	0	649	191	165	-
Brunville	962	-	7,477	24	-	738	2,498	239
Driefontein	1,125	-	2,107	15	463	85	619	-
Ekuvukeni	-	-	-	-	-	-	-	-
Ezakheni No. 2	-	-	-	-	-	-	-	-
Limehill	681	-	1,783	6	281	276	885	-
Rockcliff	1,417	-	2,483	7	563	164	666	-
Mobile 1	297	0	-	0	1,212	75	-	-
Amazizini	697	-	508	12	-	-	363	74
Dukuza	1,114	-	168	-	406	103	184	67
Injisuthi	443	-	1,841	11	79	170	139	127
Ncibindane	317	-	-	-	-	241	425	34
Ntabamhlophe	2,700	-	3,905	32	-	559	300	307
Oliviershoek	5,072	-	4,527	-	-	292	807	608
Wembesi	653	55	-	8	-	358	-	60
Dengeni	1,352	-	1,905	2	1,577	409	895	36
Ekubungazeleni	-	-	3,178	7	194	500	271	145
Hlengimpilo	1,170	-	2,033	1	1,304	327	650	34
Mahashini	279	-	-	-	1,161	112	367	10
Maphophoma	-	-	-	2	884	176	465	72
Ngqeku	1,249	3	1,548	2	1,360	315	851	38
Njoko	475	-	1,507	10	-	477	581	95
Usuthu	7	2		1	853	46	215	32

Mobile 1	-	-	-	-	-	-	-	-
Dlebe	666	-	215	-	257	36	276	14
Ezimfabeni	750	-	-	1	744	164	239	12
Altona	-	1	-	-	-	249	133	18
Friesgewaagt	278	21	420	-	685	-	97	-
Hartland	-	49	2,024	-	262	264	-	61
Kwashoba	-	33	127	-	1,494	496	-	56
Ncotshana	-	46	2,197	9	1,209	91	-	-
Tobolsk	590	2	874	-	642	216	27	19
Kwamame	-	14	-	-	301	416	460	265
Lomo	647	-	-	-	1,341	347	568	48
Mabedlana	1,088	-	582	-	1,047	258	389	42
Makhosini	1,426	-	2,140	-	1,654	466	838	118
Mpungamhlophe	1,287	-	-	-	1,008	350	403	386
Ncemane	1,342	-	1,039	-	1,527	472	834	73
Nhlungwane	1,628	-	2,330	-	1,196	471	901	66
St. Francis	8,380	-	6,304	1,910	3,866	-	1,695	4,393
Ulundi A	708	-	1,357	-	1,990	395	-	102
Zilulwane	1,242	-	99	3	1,416	422	747	64
Jozini	-	-	-	-	-	-	-	-
Madonela	-	-	-	-	-	-	-	-
Makhathini	804	-	1,412	-	829	582	192	-
Mhlekazi	1,906	-	2,823	1	851	614	550	49
Ophansi	677	-	235	-	955	612	-	49
Kwamsane	-	-	-	-	-	-	-	-
Mpukunyoni	-	-	-	-	-	-	-	-
Phelindaba	828	-	2,558	-	893	664	144	82
Zamazama	2,191	-	2,780	-	959	748	421	209
Emanyiseni	415	-	1,634	-	994	403	400	61
Gwaliweni	2,623	-	3,464	1	1,292	523	903	34
Ndumu	3,441	-	6,493	-	1,179	858	417	303
Shemula	1,353	-	1,783	7	1,436	549	722	45
Mbazwana	953	-	1,947	-	896	558	165	109
Ntshongwe	336	-	1,594	-	1,004	524	136	189
Commercial City FP	-	-	-	-	-	-	-	-
Inanda FP	1,941	11	3,094	3	-	520	2,683	54
Goodwins	-	-	-	-	-	-	-	-
Kwamashu	-	-	-	-	-	-	-	-
Lindelani	-	7	-	2	-	526	320	66
Molweni	1,101	3	520	-	145	410	655	22
Ndwedwe	2,871	-	4,659	74	-	532	477	197
Ntuzuma	-	-	-	-	-	-	-	-
Qadi	3,191	-	5,720	30	-	713	917	218
Rydalvale	-	-	-	-	-	-	-	-
Phoenix CHC	-	-	-	-	-	-	-	-
Baniyena	-	-	-	-	-	-	-	-
D State	-	87	3,678	67	29	-	420	-
Dudulu	-	-	-	-	-	-	-	-
Ekuphileni	-	-	-	-	-	-	-	-
Imfume	192	8	-	2	-	62	649	-
Jolivet	381	-	1,084	-	765	77	559	-
Kwamakhutha	-	-	2,879	372	-	-	1,965	1,329
Kwadengezi	359	-	-	3	-	123	2,163	66
Magabheni	602	-	2,115	1	256	237	530	-
Mntungwane	752	-	2,320	4	917	263	464	-
Nkwali	662	10	1,741	2	638	243	1,159	-
Odidini	1,314	-	1,188	77	4,254	1,070	-	-
Osizweni	-	13	1,122	-	-	-	1,069	861
Umbumbulu	-	-	-	-	-	-	-	-
Umlazi "V"	-	-	7,500	222	179	-	727	2,468
Umzomuhle	663	1	1,727	-	488	370	425	-
Zwlibomvu	869	-	1,347	0	1,471	452	958	50
Isandlwana	96	6	1,588	1	948	277	92	44
Mangeni	-	-	-	-	-	-	-	-

Masotsheni	1,548	-	3,583	33	-	192	228	-
Mondlo 1	472	-	2,733	3	-	148	97	-
Mondlo 2	380	-	813	-	532	355	38	52
Ntababomvu	546	37	1,167	2	119	100	15	79
Ntinini	-	-	-	-	-	-	-	-
Naasfarm	2,772	-	4,985	2,065	3,977	-	-	1,990
Osizweni 1	-	-	-	-	-	-	-	-
Thembalihle	106	-	-	-	3,167	58	-	522
Madadeni 1	1,520	-	3,964	268	6,238	301	-	519
Madadeni5	371	-	937	127	10,930	-	-	1,187
Dkodweni	1,326	-	1,860	2	1,593	566	850	-
Ndulinde	-	-	-	-	-	-	-	-
Mobile	149	2	1,043	3	343	38	155	25
Manyane	361	19	1,623	0	365	112	219	87
Mfongosi	566	9	1,235	7	760	190	252	59
Mntungweni	432	10	153	1	518	149	114	25
Mobile	710	-	3,167	2	1,048	436	-	51
Gezinsila	1,119	-	1,850	-	848	225	192	7
Ngudwini	589	-	1,369	-	641	270	44	5
Ntumeni	681	-	1,631	-	804	271	148	11
Osungulweni	1,646	-	2,336	1	1,425	529	465	39
Melmoth	16	-	-	-	-	401	-	-
Dondotha	2,788	-	4,271	13	1,310	772	847	-
Ndlangubo	162	27	-	-	555	254	91	-
Ndundulu	-	-	-	-	-	-	-	-
Ngwelezane	213	-	-	-	1,135	671	469	-
Nomponjwana	-	-	-	-	-	-	-	-
Nseleni	2,944	-	1,646	-	228	868	690	9
Ntambanana	-	-	179	-	401	419	399	-
Ntuze	1,609	-	-	13	-	600	225	-
Halambu	-	-	-	-	-	-	-	-
Vumanhlamvu	-	14	930	17	2,517	398	1,553	350
Mthandeni	677	20	1,928	8	23	74	185	100

Appendix 4

Linear probability regression model results

Explanatory variable	Coefficients	Z	P>|z|
Number of nursing Staff	-0.121	-3.099*	0.002
Number of general Staff (including administrative, general and labour provisioning staff)	-0.097	-1.467	0.142
Antenatal care visits	0.00009	1.146	0.252
Number of births	0.004	2.370*	0.018
Child health care visits	0.00009	1.540	0.123
Dental care visits	0.0009	2.057*	0.040
Family planning visits	0.00001	0.469	0.639
Psychiatry care visits	-0.0002	-0.462	0.644
Sexually transmitted diseases care visits	0.0002	1.691	0.091
Tuberculosis care visits	0.0001	1.685	0.092
Constant	-0.288	-0.727	0.467
Number of observations	155		
$Chi^2(10)$	44.48		
Prob > Chi^2	0.000		
Pseudo R^2	0.2339		

* Statistically significant at 95% level.

Appendix 5

Logistic regression model results

Explanatory variable	Coefficients	Odds Ratio	Z	P>lz
Number of nursing staff	-0.249	0.779	-2.802*	0.005
Number of general staff (including administrative, general and labour provisioning staff)	-0.143	0.867	-1.210	0.226
Antenatal care visits	0.0002	1.000	1.268	0.205
Number of births	0.005	1.005	1.697	0.090
Child health visits	0.0002	1.000	1.776	0.076
Dental care visits	0.002	1.002	2.368*	0.018
Family Planning visits	0.00002	1.000	0.405	0.686
Psychiatry care visits	-0.0002	1.000	-0.266	0.790
Sexually transmitted diseases care visits	0.0003	1.000	1.923	0.054
Tuberculosis care visits	0.0002	1.000	1.606	0.108
Constant	-0.505		-0.749	0.454
Number of observations	155			
$Chi^2(10)$	45.20			
Prob > Chi^2	0.000			
Pseudo R^2	0.2376			
Log Likelihood Ratio	-72.504			

* Statistically significant at 95% level.