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ASSESSMENT OF TECHNICAL AND SCALE EFFICIENCY OF PUBLIC CLINICS IN ESWATINI

SUBMITTED BY

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ABSTRACT

Developing countries, while working to achieve the WHO universal health coverage goal, have to constantly strike a balance, when allocating their already limited resources, between health and other sectors of their economies (agriculture, education, infrastructure, housing, security, defence etc..). As a result, there is always a limit on how much funding developing countries local governments are able to allocate to their health sector. Limited heath sector funding in the presence of significant health care needs may in turn have a negative impact on health systems outcomes. In addition to government health financing constraints, health systems outcomes in developing countries may also be jeopardized by the prevalence of inefficiencies within local health care delivery systems, especially within public health facilities. This study investigates the level of technical and scale efficiency of a nationally representative sample of 65 randomly selected public clinics in Eswatini using Data Envelopment Analysis.

The DEA estimates indicate that 42 clinics (64.7%) were technically inefficient, with an average technical efficiency score of 80.4% (STD= 18.8%). Fifty-one (78.4%) clinics were scale inefficient with an average scale efficiency score of 90.4% (STD = 6.6%). The most prevalent scale inefficiency among public clinics was increasing return to scale with 92.2% (47/51) of scale inefficient clinics operating under increasing return to scale. All 42 inefficient clinics could have delivered the same level of output with 5,701,449.4, US $ less in government funding, 115.3 less clinical staff, 138.8 less support staff and 119.8 less consultation rooms

The results reveal inefficiencies within the Health system in Eswatini. It seems possible to save significant amount of money if measures were put in place to mitigate resource wastages. Hence, policy interventions that help not only optimize inputs but also allow outputs expansion through improving the demand for health care would contribute to improving technical and scale efficiency of public clinics in the Kingdom of Eswatini.

DECLARATION

I, KIKANDA KINDANDI, do hereby declare that the work on which this dissertation/thesis is based on is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Signed by candidate

KIKANDA KINDANDI

28 January 2020

Date

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PART A: RESEARCH PROTOCOL

1. Introduction

1.1 Background

“With the push for universal coverage across the developing world and the existence of uncertainties regarding future global investments in health, the question of efficiency in health service delivery has become increasingly important “(Achoki et al, 2017, p. 8). According to the World Health Organization (WHO), health care organizations, like any other organization producing goods and services, follow economic rules. And economic rules provide that the scarce resources allocated to health care should be used efficiently (Sheikhzadeh et al., 2012).

Although the key priority of healthcare organizations is to provide quality services, there remains a need to understand how they are using scarce resources for health to produce health services in a way that optimizes the return on investment for health.

In Africa, while countries are striving to improve health coverage and to expand access to health services of acceptable quality, many health systems are still faced with severe limitations in resource availability (Malawi MOH, 2008).

In addition to the scarcity of resources, there is also evidence that African countries health systems are not always managed efficiently. Investigations conducted in sub-Saharan Africa have demonstrated inefficiencies in health sector resources allocation and utilization (Kirigia et al., 2000; Zere et al., 2001; Zere at al., 2006). They have identified wastages of human and financial resources that could have been assigned to improving access and quality of care (Kirigia et al., 2000; Zere et al., 2000; Zere et al, 2006).

It should be noted that in sub-Saharan Africa a sizable amount of resources is allocated to hospitals.Hospitals allocation represents the largest portion of total health expenditures and is estimated at 45–69% of government health sector expenditures. This justifies why technical efficiency of hospitals should be followed very closely (Zere et al, 2006).

In South Africa, technical of public sector hospitals range between 34-38%" (Zere et al, 2001). In addition, the resouces that have been wasted could have served to build 50 new clinics if used efficiently. This suggests that there is still enough resources from within the health system that can be mobilize provided efficiency is improved (Zere et al, 2001).

1.2 Justification

During the past 10 years, Eswatini government has made substantial efforts to increase its spending on health. Government expenditures on health as a proportion of total government expenditures represented more than half of total health expenditure and increased from 6.5% in 2002 to 12.2% in 2012 and to 13% in 2013 (MOH, 2014). This accounts for 8.1% of the country's GDP and represents a significant portion of the state budget. These resources constitute an important investment in the health sector that should produce a significant return.

The National Health Sector Strategic Plan highlighted that inefficiencies in the way resources for health are being managed in Eswatini should be corrected, stating further that this situation compromises the provision and quality of health care (MOH, 2014).

Knowing that government expenditure on health care facilities makes up most of the public expenditures on health, a study on the efficiency of public health facilities in Eswatini will be useful as it will provide insights on the health system performance in relation to efficiency. Besides, it will serve the purpose of guiding any effort to correct inefficiencies by providing evidence-based resource reallocation strategies that will create more value for the money spent in the health sector.

This paper will constitute, to the best of our knowledge, the first attempt to measure the efficiency of health facilities in Eswatini. It will therefore serve as a baseline for future efficiency studies and future assessments of progress towards universal health coverage in The Kingdom of Eswatini.

1.3 Objectives

The study will pursue the following objectives:

- To assess the relative technical efficiency of public clinics in Eswatini.
- To assess the relative scale efficiency of public clinics in Eswatini.

2: Methods

2.1 Study design

This study adopts a quantitative methodology using cross-sectional data from the Eswatini Health Management Information System Unit, Health Planning Unit and regional implementing partners ' databases.

2.2 Study population, sampling and sample size calculation

Eswatini has a total of 165 public clinics. However, this study will only focus on a representative sample of 85 public clinics in Eswatini that offer TB treatment initiation, antenatal care (ANC), child immunization and basic curative care. Public clinics which do not offer any of these services will be excluded from the study.

Using an expected clinics technical efficiency prevalence of 30%, a precision of 5% at the 95% confidence level with a finite population size of 85 clinics, we calculated the required sample size as 68 using an EpiTools online sample size calculator, accessed at http://epitools.ausvet.com.au.

To ensure that eligible clinics are fairly distributed across the country we determined the proportion of the sample size to be selected from each of the 4 regions.

Table 1: Distribution of sampled clinics per region

	Total number of clinics	Proportion	Sampled clinics
Shiselweni	22	26%	18
Hhohho	21	25%	17
Manzini	11	13%	9
Lubombo	31	36%	24
Total	85	100%	68

This resulted in each of the 4 regions Shiselweni, Hhohho, Manzini, and Lubombo contributing respectively to the sample size with 18, 17, 9 and 24 clinics. The calculated number of clinics was then randomly selected from each region.

2.3 Efficiency measurement

2.3.1 Measuring technical efficiency

2.3.1.1 Inputs and outputs selection

Table 2 below summarizes all inputs and outputs to be part of the DEA model and a justification for their selection.

Table 2: DEA model inputs and outputs and justification for selection

	Indicator	Justification for selection
Inputs	Number of clinical staff (Nurses)	Based on literature (e.g. Jehu-Appiah et al, 2014)
	Number of support staff (HTS counselors, expert clients, mother to mothers, cough officers, active case finders and phlebotomists)	Based on literature (e.g. Jehu-Appiah et al, 2014)
	Number of consultation rooms used	Based on literature (e.g. Alhassan et al, 2015)

	Funding from the central government in US $	Based on literature (e.g. Jehu-Appiah et al, 2014)
Outputs	Outpatient visits	Based on the literature. Besides, it is a relevant output in the context of a clinic. (e.g. Jehu- Appiah et al, 2014)
	Antenatal care visits	Based on the literature. Besides, it is a relevant output in the context of a clinic. (e.g. Jehu- Appiah et al, 2014)
	Child immunizations conducted	Based on the literature. Besides, it is a relevant output in the context of a clinic.
	Number of patients initiated on TB treatment	Relevant output in the context of Eswatini clinics.

Past studies, availability of data in the ministry of health databases and relevance to the scope of practice and operations in a clinic setting were all criteria that guided the selection of inputs and outputs for this study.

2.4 Data sources

Data on the number of different clinical and support staff working in selected clinics will be obtained from the Ministry of health planning unit and from the 4 regional MOH implementing partners' database (EGPAF, URC, ICAP and MSF) for the year 2018.

The total financial transfer from the central government for the financial year 2017/18, will be obtained from the ministry of health general accountant office. Since public clinics recurrent expenses are reported as a regional aggregate, we will compute facility-specific recurrent expenses as weighted averages of the regional health budget, using as the weight for each facility the ratio of the sum of all facility outputs over the sum of all regional outputs.

As for outputs, the number of outpatient visits, the number of antenatal care visits, the number of child immunizations conducted, the number of people tested for HIV, the number of patients initiated on antiretroviral therapy and the number of patients

initiated on TB treatment will be collected from the Ministry of Health HMIS (health management information system) unit database for the year 2017. It is worth mentioning that at the time of data collection output data for the year 2018 were not yet available. This is the reason 2017 HMIS data was used. Staffing in 2018 was fairly similar to 2017 since the last major staff deployment conducted in public health facilities by the ministry of health happened in 2016.

2.5 Data analysis

2.5.1 Technical efficiency

Data envelopment analysis (DEA) will be used to measure the efficiency of public clinics in Eswatini.

Since the mid-1980s, DEA has grown to become a popular tool for measuring the productive performance of health care services (Hollingsworth et al, 1998). “DEA is a deterministic non-parametric mathematical model which uses linear programming to construct a piece-wise linear segmented efficiency frontier based on best practice. This methodology enables one to measure the level of efficiency of non-frontier units and to identify benchmarks against which inefficient units can be compared” (Cook and Seiford, 2008, p. 1).

According to Charnes et al (1978), technical efficiency can be described bt the formula below:

Efficiency = $\frac{Weighted\ sum\ of\ outputs}{Weighted\ sum\ of\ inputs}$

If there are n hospitals, each with m inputs and s outputs, the relative efficiency score of a given hospital is obtained by solving the linear programming model below:

Max $h_{0=}\ \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_{ix_{io}}}$

Subject to

$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1;\ \ j = 1, \dots, n$

$u_r \geq 0, r = 1, \dots, s$ and $v_i \geq 0, i = 1, \dots, m$

Where:

- Ho: represent the efficiency score of hospital 0.
- y_{rj} : represents the amount of output r produced by hospital j.
- x_{ij} : represents the amounts of input *I* consumed by the hospital j.
- u_r = the weight given to output r
- v_i = the weight given to input i
- n = the number of hospitals
- s = the number of outputs
- m = the number of inputs

Hospitals with a score of 1 are the most efficient when compared to others. Those with a score below 1 are inefficient. DEA also guides on how a hospital should adjust its inputs and outputs to reach a score similar to the most efficient.

To compute technical efficiency, we will use a user-written DEA program in Stata 14 developed by Ji & Lee (2010). A step by step description of technical efficiency analysis using DEA in STATA 14 is presented below:

1. A dataset made of an excel data file will be created. This excel file will contain sampled DMUs with their respective input and output variables.
2. Data will be imported to Stata 14 from Excel using the import command of Stata.
3. To access the user-written DEA software in the internet we will use the "findit DEA" command in Stata.
4. The DEA package identified will then be installed.
5. To solve the DEA model created and compute technical efficiency we will use the command dea ivars = ovars where ivars means input variables and ovars output variables.
6. The report file with the results of the solved dea model will then be analyzed (Ji & Lee, 2017).

In the DEA analysis, output orientation will be assumed since public clinics have usually better control over the volume of their outputs through community health promotion and demand creation activities but have little control over the volume of their resources as these resources are allocated from the central purse.

The DEA analysis will be done assuming a variable return to scale (VRS) to allow both technical and scale efficiency to be computed.

2.5.2 Sensitivity analysis

The jackknife test will be used to test the robustness of DEA technical efficiency results (Zere et al., 2006). To determine the presence of extreme outliers which could impact on the efficiency scores, we will run several DEA analyses that will drop out each efficient clinic one at a time. The similarity between scores from the model before removing any efficient unit and the scores from models after removing each efficient unit will be tested using the Spearman rank correlation coefficients. A Spearman coefficient of 0 indicates no correlation meaning that the unit has an influence on the ranking. A coefficient of 1 or -1 indicates correlation which means the outlier has no influence on the ranking. This process is called jackknifing and serves to test the robustness of the DEA results in regard to outlier clinics (Sebastian & Lemma, 2010).

2.6 Ethical considerations

This study will rely on secondary data from the Eswatini Health Information Management System, Health planning unit and regional partners' database and will not enroll human participants. Therefore, no ethical issue is anticipated. However, we will seek ethical clearance from the University of Cape Town Human Research Ethics Committee and from Eswatini National Health Research Review Board.

2.7 Dissemination of findings

This thesis will be accessible publicly via the UCT library to allow the dissemination of findings. Besides, the research findings will be published in academic and peer-reviewed journals.

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PART B: LITERATURE REVIEW

1. THEORETICAL REVIEW

1.1. The concepts of productivity, effectiveness and efficiency

1.1.1. Productivity

“Productivity is simply defined as the ratio of outputs (goods and services) to inputs (resources, such as labor and capital)” (Heizer & Render, 2011, p. 44). As explained by Hollingsworth *et al* (1999), calculating the productivity ratio is simple in the case of a single-input, single-output firm. However, for the more realistic case of a multiple-input, multiple-output firm, calculating the productivity ratio is significantly more difficult and less objective. This is because the inputs and outputs cannot be simply summed; they must be aggregated into a single index representing total output and a single index representing total input.

A further challenge in defining and measuring productivity arises when considering the service industry where the end product can hardly be defined (Heizer & Render, 2011). Economic statistics are not yet able to measure the quality of services or customer satisfaction (Heizer & Render, 2011). “Productivity measurement requires specific inputs and outputs but a free economy is producing worth, what people want, which includes convenience, speed, and safety. Traditional measures of outputs may be a very poor measure of these other measures of worth” (Heizer & Render, 2011, p.45).

In the health sector, hospitals are multiple-input, multiple-output firms. Inputs would include, *inter alia*, the number of doctors, nurses, beds, pharmaceuticals, equipment and facilities. Outputs would include, *inter alia*, the number of treated patients, inpatient days, outpatient cases and surgical procedures. When compared with the manufacturing industry, outputs in a service industry, such as the hospital industry, are more difficult to define (Sherman & Zhu, 2006). For example, there are few objective ways of determining the quality of service in a hospital, such as whether a patient requires one more day of hospitalisation. This aspect of the service industry, particularly the hospital industry, introduces additional complications when dealing with matters of efficiency (Linden, 2013). Therefore, quality measurement problems

should be envisaged when considering measures of productivity such as “patients seen per labour-hour” or “patients seen per doctor”.

1.1.2. Effectiveness

“Effectiveness is the measure of the appropriateness of goals that an organization has selected to pursue and of the degree to which the organization achieves those goals” (Jones & George, 2009, p. 6). For Sherman and Zhu (2006) it is just to do “the right job”. Though effectiveness productivity and efficiency can be addressed separately, they seem to be very close concepts since productivity and efficiency may be seen as part of effectiveness. A profit objective that is within the scope of organizational effectiveness will require efficiency for it to be achieved (Sherman and Zhu, 2006). Sometimes, pursuing effectiveness may limit the extent to which efficiency can be improved. This is when effectiveness has incorporated quality objectives which may be compromised if efficiency were to be prioritized at the cost of quality. This quality-cost trade-off is particularly sensitive in service organizations (Sherman & Zhu, 2006), including the health care industry.

1.1.3. Efficiency

“Efficiency is a measure of how well or how productively resources are used to achieve goals. Efficient is achieved when the amount of input resources or the amount of time needed to produce a given output of goods or services is minimized” (Jones & George, 2009, p. 6).

The concept of efficiency is also closely related to the concept of productivity. While productivity can simply be seen as the ratio of output to input, efficiency emphasizes the fact that output should be produced in an economic way considering the scarcity of resources. Hollingsworth et al (1999) and Nguyen & Coelli (2009) interpret efficiency as the best possible use of economic resources in the production process. Therefore, improving efficiency may be about either increasing output for a given input or decreasing input for a given output (Walford & Grant, 1998).

Efficiency is sometimes used interchangeably with productivity. However, Shermann & Zhu (2006) argue that efficiency appears to be a loaded concept in the sense that carries a value judgement on how a manager performance may be seen while

productivity, less used as a value judgement to describe a manager performance, seems to convey a less sensitive meaning. Both efficiency and productivity should be considered as a component of organizational effectiveness because they contribute towards the extent to which the organization achieves its goals.

It is worth nothing that efficiency is used to measure productivity change over time. The standard approach for measurement of productivity change over time is the “DEA –based Malmquist Productivity index” which, using panel data, measures productivity change by computing a total factor productivity index and then decomposes it into an efficiency change index and technological change index (Camanho, 2007; Tlotlego, 2010). In the presence of an observed change in productivity, for instance, productivity growth over a period of time, this methodology is very useful to analyze the specific contribution of each constituent source of productivity growth, improvement in technical efficiency and technological innovations.

Efficiency within a health care context is difficult to define because not only health care organisations are complex (Sherman and Zhu, 2006) but also because it is usually not easy to decide on what is an input and what is an output for a health facility (Cook and Zhu, 2007).

With the health care sector absorbing an important portion of national expenditures, pursuing efficiency remains imperative for managers. However, the measurement and analysis of efficiency are complex tasks, mostly because of the multiple outputs of health care organisations and many gaps in data quality and availability (Jacobs et al, 2006).

1.2. Efficiency typology

Different aspects of efficiency include technical, scale, allocative, price, cost, economic and X-efficiencies (Appiah-Kubi, 2007; Hollingsworth et al.,1999; Nguyen & Coelli, 2009; Shermann & Zhu, 2006).

1.2.1. Technical efficiency

Being technically efficient refers to being able to produce the maximum output from a given set of input. It therefore equals operating on the production frontier (Farrell, 1957).

1.2.2. Scale efficiency

Scale efficiency measures the optimal activity volume level or optimal size of opeartions. (Shermann & Zhu, 2006). Any modification of the optimum size such a producing beyond or below the optimal level increases costs and makes the organization inefficient because of the inadequate volume of production (Shermann & Zhu, 2006).

1.2.3. Price efficiency

Refers to efficiency achieved through purchasing the inputs at the lowest price without compromising quality. It is worth noting that efficiency can be improved by seeking lower cost good quality inputs (Shermann & Zhu, 2006).

1.2.4. Allocative efficiency

Allocative efficiency is achieved when the optimal mix of inputs is used to produce goods or services (Shermann & Zhu, 2006). It occurs when the input mix is the one that minimizes cost given the price of inputs or alternatively when the output mix is that which maximizes revenue given output prices (Hollingsworth et al.,1999). A firm is allocatively efficient when, given a set of required outputs and prevailing input prices, the firm adopts the input mix that minimises its production costs (Linna, 1998; Coelli *et al*, 2005). Alternatively, a firm is allocatively efficient when it produces the mix of outputs that maximises its revenue, given a set of inputs and prevailing output prices. Allocative efficiency thus refers to the use of inputs, or production of outputs, in optimal proportions. Price information must be available in order to calculate allocative efficiency. Furthermore, a behavioural assumption is needed, such as profit maximisation or cost minimisation (Nguyen & Coelli, 2009).

Allocative efficiency raises the classic economic question of capital versus labour (Linden, 2013; Sherman & Zhu, 2006). According to Shermann & Zhu (2006) allocative

efficiency relates to capital labor trade-offs such as banks using automatic teller machines and internet banking rather than tellers. For Linden (2013), in a hospital context, there may be a trade-off between the number of nursing staff and medical monitoring equipment. The trade-off will depend on the relative prices of the resources but could also be influenced by the efficacy and quality of the care provided by each of the alternatives.

Shermann and Zhu (2006, p. 5) further argue that “allocative efficiency also relates to the question of whether the mix of capital equipment or the mix of labour is optimal. For example, in a hospital, there may be alternate staffing patterns which use more nursing service and fewer housekeeping services and vice versa. The optimal mix is constrained by quality standards and the relative cost of these alternative inputs”.

1.2.5. Productive efficiency

Productive efficiency, also named **cost efficiency,** refers to the attempt to produce at the least possible cost. To achieve productive or cost efficiency the firm must combine factors of production to produce a given output at the lowest possible cost and this happens when the firm minimizes cost by a given output (Appiah-Kubi, 2007). The firm can also choose to maximize output by attempting to get the most output per dollar spent on inputs (Appiah-Kubi, 2007).

1.2.6. X-efficiency

“The basic X-efficiency hypothesis is that neither individuals, nor firms, nor industries are so productive as they can be” (Leibenstein, 1975, p. 582). Even when inputs are allocated to the “right” decision units, it should not be presumed that they will decide to use these inputs in a way that maximize effectiveness. The difference between the level of effectiveness when all inputs are fully utilized and the actual effectiveness is referred to as X-inefficiency (Leibenstein, 1975).

1.3. Measuring efficiency

From the time organizations started working to improve their productivity, measuring efficiency has gained geat interest (Cook and Seiford, 2008). Farrell (1957, p. 11) stated that “the problem of measuring the productive efficiency of an industry is

important to both the economic theorist and the economic policymaker. If the theoretical arguments as to the relative efficiency of different economic systems are to be subjected to empirical testing, it is essential to be able to make some actual measurements of efficiency. Equally, if economic planning is to concern itself with particular industries, it is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources" (Farrell, 1957, p. 11).

Several approaches have been used to measure productivity in service organizations. "They include standard cost systems, comparative efficiency analysis, ratio analysis, profit and return on investments measures, zero-base budgeting, program budgeting, best practice analysis or reviews, data envelopment analysis, peer review, management review, management audit, operational reviews, comprehensive audit, activity analysis, activity-based management functional cost analysis, process analysis, staffing models and balanced scorecards" (Shermann & Zhu, 2006, p. 25).

In reviewing these options to select the most appropriate to use, the questions for managers to consider are: "Which combination of these techniques is most appropriate? Are there important productivity issues addressed with this combination of techniques? Are there service productivity issues missed by these techniques requiring new methods to be developed?" (Shermann & Zhu, 2006. P. 25).

1.4. Measuring efficiency in the health sector

1.4.1. Introduction

Measuring efficiency in healthcare is not an easy task. This is because the production process in health care is complex and health care ideal output "improved health status" is difficult to measure (Zere et al, 2006).

Health services delivery can be considered as a production process where health facilities transform factors of production into health services output or health care. Factors of production in the health sector are labor (doctors, nurses, paramedics, managers, support staff and all unskilled workers), materials (pharmaceuticals, non-pharmaceutical supplies and any other goods that health facilities use to produce

health care) and capital (buildings, medical equipment, vehicles and beds) (Osei et al, 2005).

To measure hospitals performance we may either use ratios that assess capacity utilization or frontier techniques founded in the micro-economic theory of production (Zere et al, 2006)

1.4.2. Ratio measures

The concept of productivity may be understood as a ratio of inputs to outputs. And if an efficiency standard is available, an efficiency ratio will be determined by computing the ratio of standard to actual inputs used. An efficiency ratio value of 1 or 100% will then indicate maximum efficiency. (Shermann & Zhu, 2006). Cost per transaction, cost per unit of output, amounts of resources per unit of output, are all examples of ratios that may be computed. It also happens that many different ratios are needed to measure different aspects of operations. "Ratios are generally used to compare various dimensions of performance among comparable units and within a single unit over time periods" (Shermann & Zhu, 2006, p. 49). This means that a set of ratios for a firm can be compared with other similar firms to compare their performance. Alternatively, ratios can be compared within a single firm over different time periods (Sherman & Zhu, 2006). Commonly used ratios in health care include bed occupancy rate, turnover ratio, turnover interval and the average length of stay.

In health care, ratio analysis has been used to identify situations where the ratio of input and output is exceptionally high or low. Here are examples where extreme values are indications of inefficiencies: a high cost per admission or a low ratio of meals served per dietary employee hour worked (Rosko, 1990). These abnormal relationships can be identified, for example, as large deviations from the mean. Management can then focus their attention on correcting these abnormal relationships (Linden, 2013).

Given that ratio analysis works well in the single input, single output situations, health care organizations using ratios to analyse their efficiencies must usually consider a large set of ratios which practically becomes very complicated (Rosko, 1990). It

becomes even more challenging when multiple input and outputs are involved as it is usually the case in the health sector (Rosko, 1990).

Ratio analysis cannot easily be extended to the multiple-input and multiple-output case. Multiple-inputs and multiple-outputs are sometimes aggregated using weights, which can be subjective and arbitrary. Coelli *et al* (2005) argue that using ratio analysis for multiple-inputs and multiple-outputs may not be useful and may, in fact, be misleading.

Another problem with ratio analysis is that it does not provide an objective way of identifying inefficient firm, such as a specific threshold to be used to segregate efficiency firms from inefficient ones (Rosko, 1990). Arbitrary cut-off points are often used, such as one standard deviation above the mean (Sherman & Zhu, 2006). “For example, should a hospital be classified as inefficient if its case-mix adjusted cost per case is one standard error or one-half standard error beyond the mean?” (Rosko, 1990, p. 316). This involves an element of judgement and reduces the credibility of the method, as there is no way to ensure that firms operating below the cut-off point are in fact efficient.

Furthermore, ratio analysis requires homogeneous measurement units for the aggregation of inputs and outputs (Zere *et al*, 2001,). Nevertheless, ratio analysis may complement other efficiency measures, such as Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA). In particular, ratio analysis can provide an intuitive screening of other methods findings.

1.4.3. Frontier based measures

Measuring efficiency requires the identification of the production or the cost frontier which is made of all the most efficient firms, the best performers. Then all remaining firms will be analysed comparing them to the best performers (Hollingsworth et al, 1999).

Therefore, if we can identify production functions that represent total economic efficiency based on what is recognised as ideal production methods we may come up with a standard yardstick that could help evaluate the efficiency of actual organisations

and industries. It will then be possible to compare the actual efficiency of organisations against the ideal benchmark. (Worthington, 2004).

Frontier methods of efficiency measurement differ in both the way they build the production frontier and the way they analyze and interpret any deviation from the production frontier. Methods used to form the frontier are either parametric when they use econometric regression techniques (e.g. stochastic frontier analysis) or non-parametric when they use linear programming techniques (e.g. data envelopment analysis) (Zere et al., 2006).

Parametric methods impose a specific form to the production function while non-parametric methods do not. They use econometric techniques such as linear and quadratic regression to construct a smooth parametric frontier and give a parametric structure to the production function and to the distribution of efficiency (Hollingsworth et al, 1998). They have the limitation of possibly imposing an inappropriate form to the production function (Hollingsworth et al, 1998).

In the way they analyze any deviation from the production function, frontier methods may be either deterministic or stochastic. “For deterministic methods, any deviation from the frontier is a result of inefficiency while for stochastic methods it may be due to random error” (Hollingsworth et al, 1998).

Multiple regression techniques can be used to build cost or production function for multiple input/multiple output processes. However, they present two limitations in the way they identify inefficiencies. First, the use ordinary least-square techniques (OLS) to build the production function results in estimates of average relationships that are not necessarily efficient relationships, because there is a loss of information that happens when average relationships are used. Second, when using OLS, resulting in average relationships do not directly help identify inefficient firms. An arbitrarily determined distance from the mean or median is then needed for that purpose (Rosko, 1990).

Data envelopment analysis and stochastic frontiers are the two principal techniques used in health care organizations efficiency analysis (Alhassan et al, 2015).

1.4.3.1. Stochastic frontier analysis

Stochastic frontier analysis (SFA) is a technique that uses econometric modelling to specify the production frontier (Linden, 2013).

Within the SFA model, both the production frontier form and the random error distribution must be specified *a priori*. The production frontier takes the form of a function that specifies the relationship between inputs and outputs as independent and dependent variables. Functional forms that are commonly taken are the Cobb-Douglas, normalised quadratic and translog functional forms (Linden, 2013). Once the functional form has been selected, it has to be parameterised using econometric techniques such as corrected ordinary least squares, feasible generalised least squares, and maximum likelihood (Nguyen & Coelli, 2009). Each technique requires various modelling decisions, which involve a judgement (Smith & Street, 2005). Note that the functional form is fitted to the adjusted input-output combinations so that all combinations lie on or below the fitted production frontier (Linden, 2013).

SFA assumes that any deviation away from the imposed production function is not entirely explained by inefficiencies as DEA does. SFA decomposes the deviation measured by the error term in two parts, one representing inefficiency and the other randomness or statistical noise (Worthington, 2004). “The random error term is generally thought to encompass all events outside the control of the organization, including both uncontrollable factors directly concerned with the ‘actual’ production function such as differences in operating environments and econometric errors such as misspecification of the production function and measurement error” (Worthington, 2004, p. 4).

The SFA random noise (error) distribution is commonly assumed, *a priori*, to follow a “half-normal, truncated normal, exponential or gamma distribution” (Nguyen & Coelli, 2009). As with the production frontier functional form, it is not possible to test whether the random noise distribution has been appropriately specified (Jacobs, 2001). It is likely that selecting a different error distribution, or a different functional form will result in different efficiency scores (Coelli *et al*, 2005). The *a priori* specification of error distribution and a functional form are both strong assumptions which make SFA vulnerable to model misspecification (O’Neill *et al*, 2008). Furthermore, the

inappropriate specification of a functional form or an error distribution may confound inefficiency with model misspecification (Lovell, 1996). This detracts from the advantage of SFA being able to establish the difference between random noise and inefficiency (Lovell, 1996). DEA, in contrast, does not require these *a priori* assumptions (Linden, 2013).

The stochastic nature of the SFA model provides a basis for statistical inference, such as hypothesis testing on the efficiency scores (Nguyen & Coelli, 2009). As with DEA, SFA allows the calculation of technical efficiency, allocative efficiency, cost efficiency and scale efficiency (Coelli *et al*, 2005).

Rezaei et al. (2016, p. 2026) argue that "SFA has several advantages over DEA. In the DEA approach, the efficiency of hospitals is measured relative to the observed best practice among all the hospitals, and it does not provide any statistical test to confirm the results. However, in the SFA technique, the efficiencies of the hospitals are estimated and ranked based on the production (cost) function".

However, when compared to DEA, SFA presents some limitations when used to assess hospital efficiency. First, SFA is unable to pick the origin of the inefficiency rendering it less relevant for management willing to make appropriate adjustments. Secondly, SFA can not include multiple inputs and outputs simultaneously. Though it is possible to run several multivariate models explaining one output at a time, it still remains difficult to combine the residuals from the different models (O'Neil, 2007).

DEA and SFA can be used as complementary techniques, as well as a useful check on different efficiency measures (Jacobs, 2001). However, both techniques are fairly complicated and possibly resource intensive. Coelli *et al* (2005) explain that the context of any investigation should guide the selection of an efficiency measure.

Some studies have resorted to SFA to measure health care efficiency in the developed and developing world. These include Zere et al. (2000) in South Africa; Rosko (2001) in the US; Sajadi et al. (2009) in Iran, Goudarzi et al. (2013) in Iran and (Rezaei et al., 2016) in Kurdistan.

1.4.3.2. Data envelopment analysis (DEA)

1.4.3.2.1. Definition

“DEA is a non-parametric statistical test that has been used as a method to estimate technical efficiency” (Alhassan et al, 2015, p. 3). “It was first introduced by Charnes et al in 1978 for measuring the efficiency of organizations such as hospitals and schools that lack the profit maximization motive” (Zere et al, 2006, p. 3). The original idea behind DEA was to compare a group of comparable production units and identify those exhibiting best practice which would then form an efficient frontier. The efficiency level of inefficient units can also be determined which will then be compared to the identified benchmarks (Cook and Seiford, 2008).

1.4.3.2.2. DEA conceptual framework

DEA uses linear programming to compute efficiency. “It sketches a production possibilities frontier (data envelop or efficiency frontier) using combinations of inputs and outputs from best-performing health facilities” (Osei et al., 2005, p. 3). Technical efficiency of health facilities can be defined as:

$$\textit{Technical efficiency score} = \frac{Weighted\ sum\ of\ outputs}{Weighted\ sum\ of\ inputs}\ .$$

Technically efficient hospitals will have a score of 1 and inefficient hospitals efficiency scores of less than 1 (Zere et al., 2006). Technical inefficiency is represented by the distance between the facility and the frontier. “Technically inefficient health facilities use more weighed inputs per weighted output or produce less weighted outputs per weighted input compared to those health facilities on the best practice frontier” (Osei et al., 2005, p. 4).

DEA determines the efficiency of a hospital in comparison to a group's observed best practice. This implies that the benchmark for comparison of an individual hospital is determined by the group of hospitals in the study and not an efficiency value of a hospital outside of the group” (Zere et al, 2006).

“The basic DEA model helps to find answers to questions such as:

- Which district hospitals are the most efficient?

- If all district hospitals are to perform according to best practice (i.e. the efficient peer hospitals), by how much could inputs/resources be reduced to produce the current output levels; or alternatively, by how much could outputs be increased with the current input levels?
- How many resources can be potentially saved if all district hospitals are operating at an optimal scale?
- Which of the efficient district hospitals can serve as role models for the inefficient ones? " (Zere et al, 2006, p. 4).

To answer these questions, DEA will:

1. Compare units with respect to inputs used to produce output. Identify the most efficient units and the inefficient ones in which real efficiency improvements are possible. This makes DEA a very powerful benchmarking tool" (Shermann & Zhu, 2008).
2. Calculate the amount and type of cost and resource savings that can be achieved by making each inefficient unit as efficient as the best performers (Shermann & Zhu, 2008)
3. Identify specific changes in the inefficient units which management can implement to achieve potential savings. These changes would cause inefficient units' performance to approach the best performers. DEA will also estimate the amount of additional output an inefficient unit can produce with the same level of resources (Shermann & Zhu, 2008).
4. Inform managers about better-managed efficient which units which can be used to help transfer system and managerial expertise to the inefficient ones. (Shermann & Zhu, 2008)

These four types of DEA information are vital for managers. They identify relationships that other methods can not identify. As a result, they help managers improve operations better that they could have achieved using other techniques" (Shermann & Zhu, 2008).

1.4.3.2.3. DEA assumptions on returns to scale

DEA models are constructed under two main assumptions, constant return to scale (CRS) and variable return to scale (VRS).

Returns to scale refers to the changes in output after all inputs have been changed by the same proportion. If the output increases by the same proportional change as all inputs change, we say that there are constant returns to scale (CRS). If the output increases less than proportionally with the increase in inputs, we say that there are decreasing returns to scale. If output increases by more than the proportional change of all inputs, we then say that there are increasing returns to scale (IRS) (Osei et al, 2005).

In their original DEA paper (Charnes et al, 1978) assumed a CRS. Banker, Charnes and Cooper (1984) worked further to design a more flexible variable returns to scale (VRS) model for situations where not all DMUs can be considered to be operating at an optimal scale. As in the other sector of the economy, imperfect competition, financial constraints, and barriers to entry, mergers and exits may often result in health care organisations operating at an inefficient scale. The important decision on the choice of CRS or VRS will therefore depend on the analyst's understanding of the market constraints facing health care organizations If CRS is used to compute efficiency while hospitals are operating at a sub-optimal scale, scale efficiency effects will confound technical efficiency estimates. (Jacobs et al, 2006).

Scale inefficiency is computed by running on the same data both the CRS and VRS DEA models. Any difference in measured efficiency represent then the contribution of scale inefficiency" (Jacobs et al, 2006).

A VRS model allows inefficient units to be benchmarked against units of comparable size, while a CRS model benchmarks inefficient units against units operating at the optimal size (Coelli *et al*, 2005). "CRS is appropriate when all firms are operating at an optimal size, and an assumption of VRS is appropriate when all firms are not operating at optimal size" (Coelli *et al*, 2005, p. 172). Using a CRS specification when all units are not operating at optimal scale may cause a unit to be inappropriately benchmarked against units that are operating at a different size. This may result in the effects of

technical and scale inefficiency being confounded (Coelli *et al*, 2005). Using a VRS specification will avoid this problem (Linden, 2013).

When health facilities exhibit CRS they can be considered as operating at their most productive scale size. Facilities displaying DRS should scale down both outputs and inputs to become scale efficient. And facilities exhibiting IRS should expand both inputs and outputs to become scale efficient" (Osei et al., 2005).

1.4.3.2.4. Model orientation

The DEA model can be specified as an input-oriented or output-oriented model. An input-oriented model identifies efficiency improvements that can be achieved by reducing input usage for a given level of output; while an output-oriented model identifies efficiency improvements to be achieved by increasing output production for a given level of input. (Linden, 2013).

Both models will locate the same facilities at the frontier (Coelli et al, 2005). In fact, under CRS the two models will produce an equivalent result but under VRS, the efficiency scores of inefficient facilities may be different between the two models (Nguyen & Coelli, 2009).

The selection of model orientation will depend on the dynamics of the industry being modelled (Linden, 2013). In the healthcare industry, input orientation is considered for facilities that have little control over the volume of their outputs but has greater more over the use of their resources. Output orientation is chosen for facilities with little control over the volume of their inputs but moreover the volume of their outputs. In practice, management may wish to reduce inputs while simultaneously increasing outputs. However, the main consideration when selecting a model orientation for a DEA study should be whether management has more control over the inputs or more control over the outputs used in the production process (Coelli *et al*, 2005).

Within the context of public clinics, it may be argued that facility managers have little control over the resources provided to them hence cannot influence the amounts of inputs that are used to provide services to patients. But they generally have some control over the demand for healthcare services through health promotion activities within the facility catchment area. This will naturally lead to the selection of an output-

orientated DEA model for a study of public clinics efficiency. For these reasons, an output-orientated DEA model was selected for this paper on public clinics efficiency analysis.

1.4.3.2.5. DEA strengths

The ability to accommodate multiple inputs and outputs makes DEA a very valuable tool for evaluating many service organizations (Shermann & Zhu, 2006). This makes DEA particularly relevant to efficiency analysis of health facilities since they combine multiple inputs to produce many outputs. Besides, DEA does not need a functional relationship between inputs to outputs as it would be the case for regression methods. Inputs and outputs can be of very different units and no information on prices is required (Zere et al ,2006). “Furthermore, it provides specific input and output targets that would make an inefficient hospital relatively efficient. It also identifies efficient peers for those hospitals that are not efficient. This helps the inefficient hospitals to emulate the functional organization of their peers so as to improve their efficiency” (Zere et al, 2006, p. 6). Finally, Akazili et al. (2008) argued that DEA is not crippled by issues related to multicollinearity and heteroscedasticity as seen in SFA.

However, it should be noted that using DEA to obtain efficiency measures is limited as it only measures relative efficiency. Even the most efficient DMU may be inefficient, resulting in a poor “reliability yardstick”. Using a broad sample may address this problem because it increases the chances that the most efficient units in the sample are not just the best of a bad lot (Rosko, 1990).

1.4.3.2.6. DEA weaknesses

However, DEA presents some limitations. Results are sensitive to measurement erros and outliers can significantly affect the efficiency of other units. (Zere et al, 2006).

Besides, any deviation form the frontier is attributed to inefficiency yet some may just result from statistical noise (epidemics or measurement erros) (Osei et el., 2005).

Another limitation is that DEA measures an organization efficiency in relation to best practice within the sample. Comparing that organization efficiency with other similar organizations but not part of the sample is not acceptable (Zere et al, 2006).

Finally, the non-parametric nature of DEA does not allow statistical tests of hypothesis to be conducted on the estimates of the inefficiency and on the parameters of the production frontier (Osei et al., 2005).

1.4.3.2.7. Sensitivity analysis

DEA can be very sensitive to errors in the data. It is vital that all relevant inputs and outputs are considered in the model. This is very crucial given that misspecification may lead to erroneous conclusions (Shermann & Zhu, 2006).

Several approaches are available to perform sensitivity analysis on DEA results and verify that data misspecifications did not lead to misleading results (Shermann & Zhu, 2006).

One sensitivity analysis used to determine the robustness of the DEA results is the Jackknife analysis

In the jackniffe analysis, new models are built by omitting from the initial sample one efficient unit at a time and DEA results ranking obtained for each of the new models. The similarity of the efficiency scores ranking between the initial model and the new models based on samples obtained by omitting on efficient unit at a time is then tested using the Spearman rank correlation coefficient. A coefficient of 1 immplies that efficiency scores are robust and not sensitive to outliers. (Zere et al, 2006).

1.4.4. Selecting a measurement technique

Ratio analysis as highlighted before fails to adequately capture the multiple-inputs, multiple-outputs nature of the hospital production function. This makes it less appropriate to be used to measure efficiency in the context of public clinics in Eswatini.

SFA on the other hand will require a priori assumptions regarding the functional form of the production frontier and the random error distribution. In Eswatini there is no evidence of any previous research conducted that can be used to inform any a priori assumptions relating to the hospital production function.

These are reasons why DEA stands as the most appropriate efficiency measurement technique in the Eswatini context since it is a multiple-inputs, multiple outputs efficiency measurement technique and it does not require the existence of an absolute efficiency standard or any a priori assumptions regarding the functional form of the production frontier.

1.4.5. Inputs and outputs in the health sector

Selecting the inputs and the outputs, measured in a reasonably accurate manner to include in the model is the most critical step in the DEA process since misinterpretation can destroy the value of the analysis (Shermann & Zhu, 2006). It should be noted that "as the number of outputs and inputs increase, the power of DEA decrease to some degree. And similarly, as the number of service units decreases, the power of DEA to identify inefficiency also decreases" (Shermann & Zhu, 2006, p. 129). "While more service units make the result more distinctive in locating inefficiencies, DEA has been effective in-service unit sets as low as seven and applications in government and financial services has proven to be valuable with fewer than 40 units" (Shermann & Zhu, 2006).

The goal of the health system in general is improved health status. However, the concept of health status as a health system output is not easy to measure. This is the reason why hospital output is measured by a range of intermediate health services that are provided with the ultimate goal of improving health status (Zere et al., 2006).

Hospital output may fall into four broad categories (Butler, 1995): "inpatient treatment", "outpatient treatment", "teaching" and "research". However, using inpatient days or outpatient visits as outputs fall short of grasping the different types of cases managed by the facility (Buttler, 1995). Through the use of diagnosis-related groups (DRGs) this issue may be covered. However, lack of data limits the use of diagnosis-related groups in most developing countries (Butler, 1995).

In developing countries, analyzing facilities of the same level should be enough to accommodate the type of cases managed and other determinants of quality of services offered such as staffing, equipment and technology (Zere et al, 2006).

The different categories of Inputs used in hospital production are labor, capital and supplies. Labor input can be broken down into several professional groups such as doctors, nurses, managers, administrative and support staff. In most studies, the number of beds is used as a proxy for capital (Zere et al, 2006).

1.4.6. Measuring the efficiency of health care organizations in Africa

Several studies have been conducted to measure hospital efficiency in Africa using DEA. Some of the most recent studies were conducted in Ethiopia (Murad et al, 2017), in Zambia (Achoki et al, 2016), in Uganda (Mujasi et al, 2016), in Ghana (Alhassan et al, 2015 and Jehu-Appiah et al, 2014) and in Eritrea (Kirigia et al, 2013). They used different type of inputs and outputs to measure efficiency and have revealed average efficiency scores ranging from 61.5% to 93%. They were all aiming to guide the design of interventions to reduce wastages and they demonstrated the usefulness of DEA for policy advice.

2. Empirical review

2.1. Reviewed studies from developing countries

A total of 28 studies from developing countries, from 1996 to 2017 were reviewed. Google Scholar and Pubmed databases were used to identify relevant studies. Search terms such as hospital efficiency, data envelopment analysis were used. We also used snowballing to include additional studies from the reference lists of previously identified papers. Five studies were from Ghana, 3 from Zambia, 3 from South Africa, 2 from Sierra Leone, 2 from Kenya and one from each of the following countries: Botswana, Namibia, Ethiopia, Eritrea, Guatemala, India, Uganda, Burkina Faso, Angola, Benin, Nigeria, Iran and Seychelles.

2.2. Summary of studies from developing countries

2.2.1 Study design: All 28 studies reviewed were cross-sectional studies.

2.2.2 Study sample: Of the 28 studies reviewed 46% (13/28) were nationally representative, and the remaining 54% (15/28) were of varying sample sizes, some representative of a specific province or district but not nationally representative. 50% (14/28) of studies focused on hospitals efficiency, 25% (7/28) on health centres, 11% (3/28) on clinics, 7% (2/28) on both health centres and clinics, 3% (1/28) on both hospitals and health centres. One study (3%) used states as decision-making-units and another one (3%) used districts.

2.2.3 Type of efficiency analysis: of all studies reviewed, 78% (22/28) analysed both technical and scale efficiencies, 14% (4/28) analysed technical efficiency, 3% (1/28) analysed both technical and allocative efficiencies, 3% (1/28) technical, allocative and cost efficiencies and 3% (1/28) technical, scale, allocative and cost efficiencies.

2.2.4 Inputs indicators: With respect to inputs indicators, all studies used a combination of the following inputs: clinical staff, support staff, beds, wards, recurrent expenditures, number of health centres 1000 population, personnel cost, facility area in m^2, equipment depreciation, vaccine cost, maintenance cost, food ration cost, location, state, ownership, doctor hours and nurse hours.

2.2.5 Output indicators: All 28 studies used a combination of the following outputs: Outpatients visits, ANC visits, deliveries, family planning visits, children immunized, Inpatients discharge, lab tests, dental care visits, Psychiatric care visits, STI visits, TB treatment visits, number of surgical operations, infant survival rate, health education session, paediatric ward admissions, maternity ward admissions, vector control activities, health education sessions, and number emergency patients.

2.2.6 Summary of findings

The proportion of technical inefficient facilities ranged from 25% to 89% across all reviewed studies and average technical efficiency scores ranged from 43% (Jehu-Appiah et al, 2014) to 97% (Kirigia & Asbu, 2013) across all reviewed studies.

The proportion of scale inefficient facilities varied from 30% (Marschal et al, 2009) to 97% (Zere et al, 2001) and average scale efficiency scores ranged from 51% (Kirigia et al, 2010) to 97% (Marschal et al, 2009).

Of 18 studies where the form of scale inefficiency was identified, DRS was prevalent at 61% (11/18) against 39% for IRS.

2.2.7 Summary of policy recommendations

In order to improve health care facilities efficiency, studies reviewed have formulated recommendations that fall into two broad strategies namely strategies aiming at reducing inputs and those aiming at increasing outputs.

To reduce inputs studies reviewed have recommended:

1. Resource reallocation between urban-based facilities found to be inefficient and efficient rural-based facilities (Alhassan et al, 2015, Jehu-Appiah et al, 2014).
2. Policies to attract and retain qualified health professionals in remote areas reduce redundancies in inefficient (Alhassan et al, 2015).
3. Transferring excess clinical staff (doctors and nurses) to efficient facilities or lower level facilities such as health centres, clinics or health posts (Alhassan et al, 2015, Osei et al, 2005, Zere et al, 2006, Kirigia et al, 2001, Sheikzadeh et al, 2012, Tigga and Mishra, 2015)

4. To offer non-clinical staff either early retirement or transfer to under-staffed primary health care facilities. (Akazili et al, 2008, Osei et al, 2005, Zere et al, 2006, Kirigia et al, 2001, Sheilzadeh et al, 2012).

5. To avail beds and cots to private providers at a cost. Alternatively to transfer them to efficient facilities or sell them. (Akazili et al, 2008, Zere et al, 2006, Sheikzadeh et al, 2012).

To improve outputs studies recommended:

1. To improve staff attitude, responsiveness and perceived quality of care (Jehu-Appiah et al, 2014, Kirigia et al, 2008).

2. To intensify health promotion activities (Alhassan et al, 2015, Osei et al, 2005, Kirigia et al, 2010).

3. To embark on outreach campaigns to help increase output activities and reduce redundancies (Alhassan et al, 2015, Osei et al, 2005, Kirigia et al, 2002).

4. To improve access to health services by reducing or removing financial barriers such as official and unofficial user fees. (Kirigia et al, 2007, Kirigia et al, 2008).

5. To implement a universal coverage policy up to the community level to reduce financial barriers to health care access and increase demand for health services (Osei et al, 2005, Kirigia et al, 2011, Jehu-Appiah et al, 2014).

Besides, studies have also recommended

1. To introduce fixed shorter duration (5 years) renewable contracts, so as to give the Ministries of Health greater degree of flexibility regarding employment of personnel with the renewal of contracts based on objective and transparent performance appraisal and the continuing need for the services of specific cadres of staff (Kirigia et al, 2001)

2. To institute joint peer review activities to allow best practices in efficient facilities to be benchmarked by peers (Alhassan et al, 2015).

3. To institutionalize routine technical efficiency assessments in existing Ministries of health reporting, monitoring and evaluation activities (Masiye et al, 2006, Tlotlego et al, 2008, Murad et al, 2017, Hermandez & San Sebastian, 2013).

4. “In countries with health national insurance schemes, there is a need to be generating mean efficiency for each hospital to help these national insurance schemes identify best performers and introduce elements of yardstick competition into the purchasing arrangements” (Jehu-Appiah, 2014, p. 11).

5. “To conduct more research on ownership, organizational decision-making and market-level dynamics to help better understand the institutional context in which ownership matters for provider performance. This will help identify institutional reforms that could improve performance, based on best practice” (Jehu-Appiah, 2014, p. 11).

Table 3: Summary of reviewed papers from developing countries

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Akazili et al. (2008)	Cross sectional, Ghana N= 89 health centres	"To determine the degree of efficiency of health centers and recommend performance targets for the inefficient facilities"	Technical and scale efficiency study	"Number of non-clinical staff including laborers Number of clinical staff Number of beds and cots Expenditure (in local currency call cedi) on drugs and supplies. The inter-bank exchange rate of the cedi to the dollar was ¢8,500 to 1 US$ at the time of the study.	1. General outpatient visits 2. Number of antenatal care visits 3. Number of deliveries 4. Number of children immunized 4. Number of family planning visits	Data envelopment analysis	1) 65% of health centres were technically inefficient 2) Average technical efficiency for inefficient health centres was 57% with a standard deviation of 19% 3) 79% of Halth centres were scale inefficient 4) Average scale efficiency score for inefficient health centres was 86% with a standard deviation of 14% 5) Average technical efficiency scores were highest amongst health centres in the coastal belt, followed by the northern belt and then by the middle belt which recorded the lowest average efficiency scores. 6) The prevalent scale inefficiency was increasing returns to scale.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Alhassan et al. (2015)	Cross sectional, Ghana, N= 64 private and public clinics and health centres accredited by the National Health Insurance Authority"	"To explore efficiency levels of NHIS-accredited private and public health facilities" "To ascertain factors that account for differences in efficiency" "To determine the association between quality care and efficiency levels"	Technical efficiency study	1. Number of clinical staff 2. Number of support staff 3. Number of observation beds 4. Number of detention wards	1. Number of deliveries 2. Number of outpatients visits 3. Number of antenatal and postnatal visits 4. Number of family planning (FP), reproductive health and child health visits	Data envelopment analysis Tobit regression Spearman rank correlation analysis	1) 69% of facilities were technically inefficient 2) Average technical efficiency score was 65% 3) Higher efficiency scores associated with Mission/NGO facilities located in Western Region ($p < 0.05$) compared to those in GAR. 4) Higher efficiency scores associated with public/government facilities located in Western Region ($p < 0.05$) compared to those in Great Accra Region. 5) There is no significant association between technical efficiency and quality care proxies

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Zere et al. (2006)	Cross sectional covering 4 financial years (1997/1998, 1998/1999, 1999/2000, and 2000/2001), Namibia N= 30 district hospitals	"To quantify the level of technical inefficiency in the countries"	Technical and scale efficiency study	1. Recurrent expenditures 2. Beds 3. Nursing staff	1. Outpatient visits 2. Inpatient days	Data envelopment analysis Hospital capacity utilization ratios	1) The mean occupancy rates for all the 4 financial years ranged between 55 and 67, and were much less than the conventionally accepted levels of 80–85% occupancy rate. 2) Average technical efficiency scores for all 4 financial years ranged from 62.7% to 74.3%. 3) Average scale efficiency scores for all 4 financial years ranged from 73.2% to 83.7%. 4) The prevalent scale efficiency was increasing returns to scale.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Kirigia et al. (2013)	Cross sectional, Eritrea N=20 secondary public community hospitals	"To estimate the relative technical and scale efficiency of pubic secondary level community hospitals in Eritrea" "To estimate using Tobit regression analysis the impact of institutional and contextual/environmental variables on hospital inefficiencies"	Technical and scale efficiency study	1. Number of physicians 2. Number of nurses and midwives 3. Number of laboratory technicians 4. Number of operational beds and cots	1. Number of outpatient department visits 2. Number of inpatient department discharges	Data envelopment analysis Tobit regression analysis	1) Average CRS technical efficiency score was 90.3%. 2) Average VRS technical efficiency score was 96.9% and 68% hospitals were variable returns to scale technically efficient 3) Average scale efficiency scores was 93.3% and 42% hospitals were scale efficient. 4) With the same resources, inefficient hospitals could have increased their outpatient visits by 5.05% and hospital discharges by 3.42%. 5) outpatient visit as a proportion of inpatients was negatively correlated with hospital inefficiency and this was statistically significant at 5% level of significance. 5) Average length of stay was positively correlated with hospital efficiency at 5% level of significance.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Murad et al. (2017)	Cross sectional, Ethiopia N= 12 hospitals	"To examine the technical efficiency, total factor productivity and determinants of technical inefficiency of hospitals".	Technical and scale efficiency and Malmquist total factor productivity study	1. Total health staff 2. Cost of drug supply 3. Total beds	1. Outpatient department visits 2. Inpatients days 3. Number of surgery	1. Data envelopment analysis 2. DEA-based Malmquist productivity index 3. Tobit regression analysis	1) 50%, 42%, 25% 25% 33% and 25% of hospitals were technically inefficient between 2007/08 and 2012/13 and the average VRS TE scores of hospitals stood at 91, 89, 91, 83, 86 and 93% respectively. 2) 75%, 75%, 58%, 58% and 67% were scale inefficient between 2007/08 and 2012/13.and the average scale efficiency score was 93%, 86%, 89%,91%, 91%, 87% in the respective years between 2007/08 and 2012/13. 3) On average, Malmquist Total Factor Productivity (MTFP) of the hospitals decreased by 3.6% over the panel period. 4) Teaching status of the hospital is positively related to inefficiency score at 5% level of significance. 5) The proportion of medical doctor to the total staff is negatively related with inefficiency score at 1% level of significance. 6) The proportion of inpatients treated by a medical doctor is negatively related to inefficiency score and statistically significant at 1% level of significance.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Jehu-Appiah et al. (2014)	Cross sectional, Ghana N= 128 hospitals comprising 73 government hospitals, 42 mission hospitals, 7 quasi-government hospitals and 6 private hospitals	"To estimate the relative technical and scale efficiency of government, mission, private and quasi-government district hospitals in Ghana in 2005". . "To use Tobit regression analysis to estimate the impact of ownership on hospital efficiency".	Technical and scale efficiency study	1. Beds 2. Clinical staff 3. Non-clinical staff 4. Expenditure	1. Number of deliveries 2. Number of outpatients visits 3. Number on Inpatient days 4. Number of laboratory tests	Data envelopment analysis (VRS) Tobit regression	1)76% of facilities were technically inefficient 2) Quai-government hospitals had the highest mean efficiency score (83.9%), followed by public hospitals (70.4%), mission hospitals (68.6%), and private hospitals (55.8%). 3) 75% of hospitals are scale inefficient and increasing returns to scale was the predominant form of inefficiency except for private hospitals that showed predominantly decreasing returns to scale. 4) Quasi-government ownership is positively associated with hospital efficiency while private ownership negatively affects hospital efficiency. 5) 75% of hospitals were scale inefficient 6) Increasing return to scale at 52% was the most prevalent form of scale inefficiency.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Osei et al. (2005)	Cross sectional, Ghana N= 17 Hospitals and 17 Health centres	"To estimate the relative technical efficiency and scale efficiency of a sample of public hospitals and health centres in Ghana".	Technical and scale efficiency study	Hospitals: 1. Doctors/dentists 2. Technical staff (including nurses) 3. Subordinate staff 4. Beds Health centres: 1. Medical assistants/nurses/other technical staff 2. Subordinate staff	Hospitals: 1. Number of deliveries 2. Number of maternal and child health care visits 3. Inpatient discharges Health centres: 1. Number of deliveries 2. Number of maternal and child health care visits 3. Fully immunized children 4. OPD curative visits	Data envelopment analysis (VRS)	1) 47% of hospitals were technically inefficient with average technical efficiency score at 61% 2) 18% of health centres were technically inefficient with an average TE score of 49%. 3) 59 % of hospitals were scale inefficient with average SE score of 81%. 4) 47% of Health centres were scale inefficient with an average SE score of 84%. 5) The most prevalent scale inefficiency was IRS (80%) among hospitals and DRS (78%) among health centres

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Hermandez and San Sebastian (2014)	Cross sectional, Guatemala N= 34 health posts	"To assess the efficiency and change in the productivity of health posts over two years (2008 and 2009) in a rural department of Guatemala"	Technical and scale efficiency study	1. Number of health care workers	1. Number of new patients attended 2. Number of children less than two years old in growth monitoring 3. Number of prenatal follow-up visits 4. Number of family planning (FP) users 5. Number of children receiving a dose of the DPT vaccine	Data envelopment analysis Malmquist productivity index Sensitivity analysis using jackknife technique and Spearman rank correlation coefficients	1) 70% and 76% of health posts were technically inefficient in 2008 and 2009 and technical efficiency means scores were 78% in 2008 and 75% in 2009. 2) 44% of health posts were scale inefficient in 2008 and 65% in 2009. Average scale efficiency scores were 94% in 2008 and 70% 3)The most prevalent scale inefficiency is diminishing returns to scale (DRS). 3) Overall productivity increased by 4% through 49% of health posts experienced a decline in productivity.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Tigga and Mishra (2015)	Cross sectional, India N= 27 states	"To assess and compare the health system across states in India"	Technical efficiency study	1. Health workers per 1,000 population (doctors, nurses and paramedical staff) 2. Health centres per 1,000 population (Primary health centres, Communiy health centres and sub centres)	1. Infant survival rate 2. Percentage of institutional deliveries	Data envelopment analysis	1) 78% of states were technically inefficient 2) Average technical efficiency score was 84%.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Kirigia et al. (2004)	Cross sectional, Kenya N= 32 Primary health centres	"To determine the degree of technical efficiency of individual primary health care facilities in Kenya".	Technical and scale efficiency study	1. Clinical officers + Nurses 2. Physiotherapist + Occupational Therapist + Public health officer + Dental technologist 3. Laboratory technician + Laboratory technologist 4. Administrative staff 5. Nonwage expenditures 6. Number of beds	1. Diarrhoeal + Malaria + STI + Urinary tract infections + Intestinal worms + Respiratory disease visits 2. Antenatal + Family planning visits 3. Immunizations 4. Other general outpatients visits	Data envelopment analysis	1) 56% of health centres were technically inefficient 2) Average technical efficiency for inefficient health centres was 65% with a standard deviation of 22% 3) 41% of health centres were scale inefficient 4) Average scale efficiency score for inefficient health centres was 70% with a standard deviation of 19%

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Renner et al. (2005)	Cross sectional, Sierra Leone N= 37 health centres	"To measure the technical efficiency (TE) and scale efficiency (SE) of a sample of public peripheral health units (PHUs) in Sierra Leone".	Technical and scale efficiency study	1. Technical staff 2. Subordinate staff	1. Antenatal plus postnatal care visits. 2. Number of deliveries 3. Nutrition/growth monitoring visits 4. Family planning visits 5. Number of children under the age of 5 years and pregnant women fully immunized 6. Health education sessions	Data envelopment analysis	1) 59% of health units were technically efficient 2) Average technical efficiency for the inefficient health unit was 63% with a standard deviation of 18% 3) 65% of Health centres were scale efficient 4) Average scale efficiency score for inefficient health centres was 72% with a standard deviation of 17% 6) The prevalent scale efficiency was decreasing returns to scale (57%).

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Mujasi et al. (2016)	Cross sectional, Uganda N= 18 (14 public sector referral hospitals and 4 large private not for profit hospitals)	"To explore the technical efficiency of hospitals in Uganda during the 2012/2013 financial year"	Technical and scale efficiency study	1. Total number of medical staff 2. Hospital beds	1. Outpatient department visits 2. Inpatients days	Data envelopment analysis Tobit regression analysis	1) 53% of hospitals were technically inefficient 2) Overall average technical efficiency for inefficient health centres was 91% with a standard deviation of 12.6% 3) 82% of Hospitals were scale inefficient 4) Average scale efficiency score for was 87.1% with a standard deviation of 14.9% 5) The prevalent scale efficiency was decreasing returns to scale (59%). 6) Tobit regression indicates that significant factors in explaining hospital efficiency are: hospital size ($p < 0.01$); bed occupancy rate ($p < 0.01$) and outpatient visits as a proportion on inpatient days ($p < 0.05$).

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Achoki et al. (2017)	Cross sectional, Zambia N= 72 districts	"To investigate technical and scale efficiency in the delivery of maternal and child health services in the country"	Technical and scale efficiency study	1. Number of non clinical staff including laborers 2. Number of clinical staff 3. Number of beds and cots 4. Expenditure (in local currency call cedi) on drugs and supplies. The inter-bank exchange rate of the cedi to the dollar was ¢8,500 to 1 US$ at the time of the study.	1. General outpatient visits 2. Number of antenatal care visits 3. Number of deliveries 4. Number of children immunized 4. Number of family planning visits	Data envelopment analysis	1) 65% of health centres were technically inefficient 2) Average technical efficiency for inefficient health centres was 57% with a standard deviation of 19% 3) 79% of Health centres were scale efficient 4) Average scale efficiency score for inefficient health centres was 86% with a standard deviation of 14% 5) Average technical efficiency scores were highest amongst health centres in the coastal belt, followed by the northern belt and then by the middle belt which recorded the lowest average efficiency scores. 6) The prevalent scale efficiency was increasing returns to scale.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
kirigia et al. (2001)	Cross sectional, South Africa N= 155 public clinics	"To investigate the technical inefficiencies among 155 primary health care clinics in KwaZulu-Natal Province of South Africa"	Technical and scale efficiency study	1. Number of nurses 2. Number of general staff	1. Antenatal care visits 2. Number of births/deliveries 3. Child health visits 4. Dental care visits 5. Family planning visits 6. Psychiatry visits 7. Sexually transmitted disease visits 8. Tuberculosis treatment visits	Data envelopment analysis	1) 70% of public clinics were technically inefficient 2) 84% of public clinics were scale inefficient

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Akazili et al. (2008)	Cross sectional, Ghana N= 113 Health centres	"To calculate technical efficiency and allocative efficiency of a sample of health centres in Ghana".	Technical and allocative efficiency study	1. Beds 2. Number of staff 3. Supplies and recurrent expenditures	1. ANC visits 2. Outpatients visits 3. Deliveries 4. Children immunized 5. Family planning visits	Data envelopment analysis (VRS) Logistic regression analysis	1) 78% of health centres were technically inefficient 2) 88% health centres were allocatively inefficient 3) Newer health centres and those which receive incentives were more likely to be technically efficient compared to older health centres and those who did receive incentives.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Marschall et al. (2009)	Cross sectional, Burkina Faso N= 20 health centres	"To evaluate the relative technical and scale efficiency of health centres in rural Burkina Faso" "To investigate the reasons for inefficient performance"	Technical and scale efficiency study	1. Personnel costs (US $) 2. Area (m2) 3. Equipment depreciation (US $) 4. Vaccine (US $)	1. General consultations 2. Deliveries 3. Other care 4. Vaccination	Data envelopment analysis Tobit regression analysis	1) 30% of health centres were technically inefficient and average technical efficiency score was 91%. 2) 30% of facilities were scale inefficient and average scale efficiency score was 97%. 3) More favorable location leads to better performance

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Kirigia & Asbu (2013)	Cross sectional, Eritrea N= 19 community clincs	"To estimate the relative technical and scale efficiency of public secondary level community hospitals in Eritrea". "To estimate using the impact of institutional and contextual/environmental variables on hospital inefficiencies"	Technical and scale efficiency study	1. Number of physicians (Doctors) 2. Number of nurses and midwives 3. Number of laboratory technicians 4. Number of operational beds and cots	1. Number of outpatients department visits 2. Number of inpatients department discharges	Data envelopment analysis Tobit regression analysis	1) 68% of clinics were technically inefficient 2) 58% of clinics were scale inefficient 3) Average VRS technical efficiency score was 96.9%. 4) Average scale efficiency score was 93.3%. 5) Decreasing return to scale was the most prevalent form of scale inefficiency 6) The coefficient for OPDIPD (outpatient visits as a proportion of inpatient days) had a negative sign and was statistically significant at 5% level of significance. 7) the coefficient for ALOS (average length of stay) had a positive sign and was statistically significant at 5% level of significance.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Kirigia et al (2008)	Cross sectional covering 2000 to 2002, Angola, N= 28 public municipal hospitals	"To assess the technical efficiency of public municipal hospitals in Angola" "To assess changes in productivity over time with a view to analyzing changes in efficiency and technology".	Technical and scale efficiency and Malmquist total factor productivity study	1. Doctors + Nurses 2. Drugs and other supplies 3. Beds	1. Outpatients + Antenatal visits 2. Inpatients admissions	Data envelopment analysis DEA-based Malmquist productivity index	1) 61%, 57%, and 64% of hospitals were technically inefficient in 2000, 2001 and 2002. 2) 79%, 82% and 71% of hospitals were scale inefficient in 2000, 2001 and 2002. 3) Average technical efficiency scores were 66.2%, 65.8% and 67.5% in 2000, 20001 and 2002. 4) Average scale efficiency scores were 83%, 81% and 89% in 2000, 2001 and 2002.. 5) On average, Malmquist Total Factor Productivity (MTFP) increased by 4.5% over the period 2000-2002

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Kirigia et al. (2010)	Cross sectional covering the period of 5 years from 2003 to 2007, Benin N= 23 zonal hospitals	"To measure the technical and scale efficiency of hospitals in Benin"	Technical and scale efficiency study	1. Number of doctors 2. Number of other staff 3. Non-salary running costs 4. Number of beds	1. Number of outpatients visits 3. Number of admissions	Data envelopment analysis	1) 87%, 87%, 61%, 52% and 35% of facilities were technically inefficient in 2003, 2004, 2005, 2006 and 2007. 2) 91%, 91%, 91%, 87% and 74% of facilities were scale inefficient in 2003, 2004, 2005, 2006 and 2007. 3) Average technical efficiency score was 63%, 64%, 64%, 78%, 78% and 86% in 2003, 2004, 2005, 2006 and 2007. 4) Average scale efficiency score was 51%, 46%, 52%, 59% and 77% in 2003, 2004, 2005, 2006 and 2007. 5) The most prevalent form of scale inefficiency was increasing return to scale from 2003 to 2007.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Tlotlego et al, 2008	Cross sectional covering 3 years from 2006 to 2008, Botswana N= 21 non-teaching hospitals	"To quantify the technical and scale efficiency of hospitals in Botswana" "To evaluate changes in productivity over a three year period in order to analyze changes in efficiency and technology use"	Technical and scale efficiency and Malmquist total factor productivity study	1. Clinical staff 2. Beds	1. Outpatients visits 2. Inpatient days	Data envelopment analysis Malmquist productivity index	1) 76.2%, 76.2%, and 62% of hospitals were technically inefficient in 2006, 2007 and 2008. 2) 90%, 86%, and 86% of hospitals were scale inefficient in 2006, 2007 and 2008. 3) Average VRS technical efficiency scores were 70.4 %, 74.2% and 76.3% in 2006, 2007 and 2008. 4) DRS in 2006, IRS and DRS in 2007 and DRS in 2008 were the most prevalent form of scale inefficiency. 5) On average, Malmquist Total Factor Productivity (MTFP) of the hospitals decreased by 1.5% over the period 2006-2008

Author (year	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Kirigia et al. (2002)	Cross sectional, Kenya N= 54 public hospital	"To measure relative technical efficiencies of 54 public hospitals in Kenya using Data Envelopment Analysis (DEA) technique"	Technical efficiency study	1. Doctors/pharmacists/dentists 2. Clinical officers 3. Nurses 4. Administrative staff 5. Technicians & technologists 6. Other technical staff 7. Subordinate staff 8. Drugs (in Ksh) 9. Non-pharmaceutical supplies (in Ksh) 10. Maintenance (in Ksh) 11. Food-rations (in Ksh) 12. Beds	1. OPD casual visits 2. Special care visits 3. MCH–FP visits 4. Dental care visits 5. Inpatient department general admissions 6. Paediatrics ward admissions 7. Maternity ward admissions	Data envelopment analysis	1) 26% of facilities were technically inefficient 2) Average technical efficiency score was 84%

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Ichoku et al. (2011)	Cross sectional, Nigeria N= 200 hospitals	"To analyze the relative technical efficiency of hospitals in the southeast of Nigeria"	Technical and scale efficiency study	1. Beds 2. Doctors 3. Pharmacists 4. Nurses 5. Other staff 6. Drug 7. Power 8. Equipment 9. Location 10. State 11. Ownership	1. Outpatients visits 2. Inpatients admissions 3. Lab tests conducted	Data envelopment analysis	1) 58% of hospitals were technically inefficient 2) 64% of hospitals were scale inefficient 3) Average VRS technically efficiency was 72%. 4) Average scale efficiency score was 82.7%. 5) 47% of hospitals were operating under decreasing returns to scale.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Anaytical methods	Results
Kirigia et al(2007)	Cross sectional covering 4 years from 2001 to 2004, Seychelles N= 17 public health centres	"To measure the technical and scale efficiency of health centres" "To evaluate changes in productivity" "To highlight possible policy implications of the results for policymakers"	Technical and scale efficiency and Malmquist total factor productivity study	1. Total number of doctors hours 2. Total number of nurses hours	1. Number of patients dressed 2. Domiciliary cases treated 3. PFMAPIS (Pap smear visits+Family planning visits+MCH visits+ANC visits+PNC visits+children immunized+children participating in school health program)	Data envelopment analysis The DEA-based Malmquist productivity index	1) 41%, 53%, 47% and 41% of health centres were technically inefficient in 2001, 2002, 2003 and 2004. 2) Average VRS technical efficiency scores were 93%, 92%, 92% and 96% in 2001, 2002 2003 and 2004. 3) 70.5%, 64.7%, 58.8% and 58.8% of health centres were scale inefficient in 2001, 2002, 2003 and 2004. 4) Average scale efficiency scores were 90%, 93%, 92% and 95% in 2001, 2002, 2003 and 2004. 5) On average, Malmquist Total Factor Productivity (MTFP) of the hospitals Increased by 2.4% over the period 2001-2004. 6) Decreasing return to scale was the most prevalent form of scale of inefficiency.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Kirigia et al. (2011)	Cross sectional, Sierra Leone N= 32 Maternal and child health posts, 22 Community health centres and 21 community health posts.	"To estimate the technical efficiency of samples of community health centres (CHCs), community health posts (CHPs) and maternal and child health posts (MCHPs) in Kailahun and Kenema districts of Sierra Leone". "To explore strategies for increasing technical efficiency of these institutions".	Technical and scale efficiency study	1. Number of community health officers+MCN Aids+Sate enrolled community health nurses 2. Number of support staff	1. Number of outpatient, maternal, child health and family planning visits, plus immunization visits (OMFE) 2. Number of vector control activities 3. Number of health education sessions.	Data envelopment analysis	1) 77.8% of the MCHPs, 59.1% of the CHCs and 66.7% of the CHPs were variable returns to scale technically inefficient 2) 53% of the MCHPs, 68% of the CHCs and 38% of the CHPs were scale inefficient 3) Average variable returns to scale technical efficiency was 68.2% (SD = 27.2) among the MCHPs, 69.2% (SD = 33.2) among the CHCs and 59% (SD = 34.7) among the CHPs. 4) Average SE scores were 52.8% (SD = 50.6) among MCHPs, 88.8% (SD = 13.5) among CHCs, and 95.5% (SD = 9.4) among CHPs. 5) DRS was the most prevalent form of scale inefficiency

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Kirigia et al. (2000)	Cross sectional, South Africa N= 55 Kwazulu-Natal public hospitals.	"To find out what proportion of hospitals are operating efficiently and for those inefficient hospitals what inputs and outputs contribute most to inefficiency".	Technical and scale efficiency study	1. Number of medical doctors 2. Number of nurses 3. Number of paramedics 4. Number of technicians 5. Number of administrative staff 6. Number of general staff 7. Number of labour provisioning staff 8. Other types of staff 9. Number of beds	1. Inpatients day 2. Outpatients visits 3. Number of surgical operations	Data envelopment analysis	1) 40% of hospitals were technically inefficient 2) 58% were scale inefficient 3) Average technical efficiency was 90.6% 4) Average scale efficiency rate was 95%.

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Masiye et al. (2007)	Cross sectional, Zambia N= 30 hopitals.	"To estimates the technical efficiency of a sample of hospitals in Zambia".	Technical and scale efficiency study	1. Number of medical doctors 2. Number of nursing and other clinical staff 3. Number of non-clinical staff 4. Total non-labor cost	1. Inpatients day 2. Outpatients visits 3. Number of deliveries 4. Number of lab tests, Xrays and theater operations performed	Data envelopment analysis	1) 60% of hospitals were technically inefficient 2) 87% were scale inefficient 3) Average technical efficiency was 67% 4) Average scale efficiency rate was 80%. 5) 43% of hospitals were operating under DRS while 43% were operating under IRS

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Masiye et al. (2006)	Cross sectional, Zambia N= 40 health centres	"To estimates the degree of technical, allocative and cost efficiency of private and public health centres in Zambia". "To identify the relative inefficiencies in the use of various inputs among individual health centers".	Technical, allocative and cost efficiency study	1. Number of clinical officers 2. Number of nurses 3. Number of support staff	1. Number of outpatient health care visits)	Data envelopment analysis	1) 71% of privately owned health centres were technically inefficient 2) 96% of government owned health centres were technically inefficient 3) 77% of privately owned health centres were allocatively inefficient 4) 96% of government owned health centres were allocatively inefficient 5) 77% of privately owned health centres were cost inefficient 6) 96% of government owned health centres were cost inefficient .

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Zere et al. (2001)	Cross sectional, South Africa N= 86 hospitals classified into three levels: 55 Community hospitals with emergency services only (level I), 19 community hospitals with outpatients services (level II) and 12 non-academic secondary and tertiary hospitals (level III)	"To examine the technical efficiency and productivity of South African public hospitals (Eastern, Northern and Western Cape provinces)"	Technical and scale efficiency study	1. Number of beds 2. Recurrent expenditures	1. Inpatients day 2. Outpatients visits	Data envelopment analysis Tobit regression analysis Malmquist productivity index for Western Cape province only)	1) 89%, 84% and 83% of level I, II, and III hospitals were technically inefficient 2) 93%, 97% and 98% of level I, II, and III hospitals were scale inefficient 2) Average CRS technical efficiency was 74%, 68% and 70% for level I, II and III hospitals. 3) Average VRS technical efficiency was 82.8%, 82.5% and 82% for level I, II and III hospitals. 4) Average scale efficiency rate was 90%, 82.5% and 84.5% for level I, II and III hospitals with decreasing return to scale dominating II and III hospitals 5) Low occupancy rates as well as a high the proportion of inpatient days to outpatient days had a negative impact on efficiency 6) Total factor productivity had decreased by 12.1% over time for the period 1992/93 and 1997/98 as a result of both a decline in efficiency and technical regress. 7) IRS is most prevalent in level I hospitals and DRS in level II and III

Author (year)	Type, location, sample size	Objectives of the study	Type of efficiency study	Inputs indicators	Outputs indicators	Analytical methods	Results
Sheikzadeh et al. (2012)	Cross sectional, Iran N= 11 private and public hospitals	"To present a model of efficiency for selected public and private hospitals of East Azerbaijani Province of Iran by making use of Data Envelopment Analysis"	Technical, scale, allocative and cost efficiency study	1. Number of specialist physicians 2. Number of general physicians+nurses+residents+member of a medical team having a bachelor degree or above. 3. Number of medical team member having 14 years diploma or lower+number of non-medical and support staff 4. Number of active beds	1. Number of outpatient health care visits 2. Number of emergency patients 3. Number of inpatients X average daily inpatients' residing	Data envelopment analysis	1) 55% of hospitals were technically inefficient and average technical efficiency score was 79% 2) 55% of hospitals were scale inefficient and average scale efficiency score was 87% 3) 82% of hospitals were allocatively inefficient and average allocative efficiency score was 76% 4) 82% of hospitals were cost inefficient and average cost efficiency score was 61%. 5) The most prevalent scale inefficicency (55%) was increasing return to scale .

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PART C: JOURNAL MANUSCRIPT

1. Abstract

Developing countries, while working to achieve the WHO universal health coverage goal, have to constantly strike a balance, when allocating their already limited resources, between health and other sectors of their economies (agriculture, education, infrastructure, housing, security, defense etc..). As a result, there is always a limit on how much funding developing countries local governments can allocate to their health sector. Limited health sector funding in the presence of significant health care needs may in turn have a negative impact on health systems outcomes. In addition to government health financing constraints, health systems outcomes in developing countries may also be jeopardized by the prevalence of inefficiencies within local health care delivery systems, especially within public health facilities. This study investigates the level of technical and scale efficiency of a nationally representative sample of 65 randomly selected public clinics in Eswatini using Data Envelopment Analysis.

The DEA estimates indicate that 42 clinics (64.7%) were technically inefficient, with an average technical efficiency score of 80.4% (STD= 18.8%). Fifty-one (78.4%) clinics were scale inefficient with an average scale efficiency score of 90.4% (STD = 6.6%). The most prevalent scale inefficiency among public clinics was increasing return to scale with 92.2% (47/51) of scale inefficient clinics operating under increasing return to scale. All 42 inefficient clinics could have delivered the same level of output with 5,701,449.4, US $ less in government funding, 115.3 less clinical staff, 138.8 less support staff and 119.8 fewer consultation rooms.

The results reveal inefficiencies within the Health system in Eswatini. It seems possible to save a significant amount of money if measures were put in place to mitigate resource wastages. Hence, policy interventions that help not only optimise inputs but also allow outputs expansion through improving the demand for health care services would contribute to the improvement of the technical and scale efficiency of public clinics in the Kingdom of Eswatini.

2. Background

“With the push for universal coverage across the developing world and the existence of uncertainties regarding future global investments in health, the question of efficiency in health service delivery has become increasingly important” (Achoki et al, 2017, p. 8). According to the World Health Organization (WHO), health care organizations, like any other organization producing goods and services, follow economic rules. And economic rules provide that the scarce resources allocated to health care should be used efficiently (Sheikhzadeh et al., 2012).

Although the key priority of healthcare organizations is to provide quality services, there remains a need to understand how they are using scarce resources for health to produce health services in a way that optimizes the return on investment for health.

In Africa, while countries are striving to improve health coverage and to expand access to health services of acceptable quality, many health systems are still faced with severe limitations in resource availability (Malawi MOH, 2008).

In addition to the scarcity of resources, there is also evidence that African countries health systems are not always managed efficiently. Investigations conducted in sub-Saharan Africa have demonstrated inefficiencies in health sector resources allocation and utilization (Kirigia et al., 2000; Zere et al., 2001; Zere at al., 2006). They have identified wastages of human and financial resources that could have been assigned to improving access and quality of care (Kirigia et al., 2000; Zere et al., 2000; Zere et al, 2006).

It should be noted that in sub-Saharan Africa a sizable amount of resources is allocated to hospitals.Hospitals allocation represents the largest portion of total health expenditures and is estimated at 45–69% of government health sector expenditures. This justifies why technical efficiency of hospitals should be followed very closely (Zere et al, 2006).

“In South Africa, studies conducted on technical efficiency technical of public sector hospitals show that technical inefficiency levels range between 34-38%” (Zere et al, 2001, p. 2). In addition, the resources that have been wasted were could have served to build 50 new clinics if used efficiently. This suggests that there are still enough

resources from within the health system that can be mobilize provided efficiency is improved (Zere et al, 2001).

Eswatini is a landlocked country situated in Southern Africa between Mozambique and South Africa; covering an area of 17,364 km2. The country has a predominantly rural population (78.9%) and is divided in 4 administrative regions which are Hhohho, Manzini, Lubombo and Shiselweni (MOH, 2015). The population was estimated at 1.093 238 million by the 2017 national population and household census (MOH, 2017). Fifty-three per cent of the population is female and almost half (48%) of the households are headed by women. Eswatini has a young population, with 44% of its citizens being under 15 years and 4% aged 65 years or older (MOH, 2015).

The economy of Eswatini is fairly diversified with agriculture, forestry and mining accounting for about 9% of GDP: Manufacturing (textiles and sugar-related processing) representing 41% of GDP and services - with government services in the lead – constituting 46% of GDP. While the country experienced high economic growth levels of 9% on average in the late 1980s, real GDP growth since 2001 has averaged 2.8%, nearly 2 percentage points lower than the average growth in other Southern African Customs Union (SACU) member countries. The World Bank classifies the country has a lower middle-income country with a GDP per capita of about US 3,000 despite the majority of people (63%) in the country living below the poverty line and about 29% living below the extreme poverty line (MOH, 2017). There is no doubt that economic achievements are being curtailed by the effects of the dual epidemic of HIV and TB (MOH, 2015).

Eswatini through the Ministry of Health is aiming at providing universal health coverage as defined in the Essential Health Care Package (EHCP) to all its citizen (MOH, 2017). The National health system is made up of 9 hospitals, 6 public health units, 5 health centers, 215 clinics, 47 specialized clinics and 6 private hospitals. However, human resources constraints continue to be a challenge, negatively affecting the safety, quality, and coverage of health services to the public (MOH, 2014).

Eswatini's health service delivery system is structured around a five-tier system of service provision, comprising: the community level (with Rural Health Motivators, Faith-based Health care Providers, Volunteers and Traditional Practitioners), clinics,

public health units, health centres, regional referral hospitals, and three national referral hospitals (MOH, 2017). Health services are delivered through a decentralized system in the four regions of Hhohho, Manzini, Lubombo and Shiselweni. The central level performs executive and administrative functions andprovides strategic guidance on the delivery of health care services at all levels of care based on the Essential Health Care Package (EHCP). At the regional level, each region is headed by a Regional Health Administrator and supported by the Regional Health Management Teams (RHMTs). About 85% of the country's population lives within a radius of 8km from a health facility (MOH, 2014).

During the past 10 years, Eswatini government has made substantial efforts to increase its spending on health. Government expenditures on health as a proportion of total government expenditures represented more than half of total health expenditure and increased from 6.5% in 2002 to 12.2% in 2012 and to 13% in 2013 (MOH, 2014). This accounts for 8.1% of the country's GDP and represents a significant portion of the state budget. These resources constitute an important investment in the health sector that should produce a significant return.

The National Health Sector Strategic Plan highlighted that inefficiencies needed to be addressed in the way resources for health are being managed are in Eswatni, stating further that this situation compromises the provision and quality of health care (MOH, 2014).

Knowing that government expenditure on health care facilities makes up most of the public expenditures on health, a study on the efficiency of public health facilities in Eswatini will be useful as it will provide insights on the health system performance in relation to efficiency. Besides, it will serve the purpose of guiding any effort to correct inefficiencies by providing evidence-based resource reallocation strategies that will create more value for the money spent in the health sector.

3. Methods

3.1 Study design

This study adopted a quantitative methodology using cross-sectional data from the Eswatini Health Management Information System Unit, Health Planning Unit and PEPFAR regional implementing partners' databases.

3.2 Study population, sampling and sample size calculation

This study focused on a representative sample of public clinics in Eswatini that offer TB initiation, antenatal care (ANC), child immunisation and basic curative care. Public clinics which do not provide any of these services were excluded from the study. Using an expected clinics technical efficiency prevalence of 30%, a precision of 5% at the 95% confidence level with a finite population size of 86 clinics, the required sample size was computed to be 68 using an EpiTools online sample size calculator. To ensure a fair distribution of eligible clinics across the country, we determined the proportion of the sample size to be selected from each of the four regions to be equal to each region's contribution to the total population. This resulted in each of the four regions, namely Shiselweni, Hhohho, Manzini, and Lubombo contributing to the sample size with 17, 16, 9 and 29 clinics, respectively. The calculated number of clinics was then randomly selected from each region. From the initial sample of 68 public clinics, complete data were only available for 65 facilities. Three clinics with missing data were therefore excluded from the study.

3.3 Technical efficiency measurement

3.3.1 Inputs and outputs selection

The following considerations guided the choice of inputs and outputs: past studies that included similar inputs and outputs, availability of data in the ministry of health databases and relevance of these inputs and outputs to the scope of practice and operations in a public clinic setting. Four inputs were considered: Number of clinical staff (Nurses), number of support staff (HTS counsellors, expert clients, mother to mothers, cough officers, active case finders and phlebotomists) number of consultation rooms used and central government funding in US$. Four outputs were

considered: Number of outpatient visits, number of antenatal care visits, number of child immunisation conducted and the number of patients initiated on TB treatment.

3.3.2 Data sources

Data on the number of different clinical and support staff working in selected clinics were obtained from the Ministry of Health Planning Unit and the four regional Ministry of Health implementing partners' database (EGPAF, URC, ICAP and MSF) for the financial year 2018. The total financial transfer from the central government for the financial year 2017, was sourced from the Ministry of Health's general accountant office. Since public clinics recurrent expenses are reported as a regional aggregate, we computed facility-specific recurrent expenses as the weighted averages of the regional health budget, using as the weight for each facility, the ratio of the sum of all facility outputs over the sum of all regional outputs. Outputs comprise the number of outpatient visits, the number of antenatal care visits, the number of child immunisations conducted, the number of people tested for HIV, the number of people initiated on antiretroviral therapy (ART) and the number of people initiated on TB treatment. These were collected from the Ministry of Health's HMIS (health management information system) unit database for the financial year 2017. It is worth mentioning that at the time of data collection, output data for the financial year 2018 were not yet available. This is the reason for using the 2017 HMIS data. Staffing in 2018 was somewhat similar to 2017 since the last major staff deployment conducted in public health facilities by the Ministry of Health was in 2016.

3.3.3 Data analysis

Data envelopment analysis (DEA) was used to measure the relative efficiency of public clinics in Eswatini.

Since the mid-1980s, DEA has grown to become increasingly popular as a tool for measuring the productive performance of health care services (Hollingsworth et al, 1998). "DEA is a deterministic non-parametric mathematical model which uses linear programming to construct a piece-wise linear segmented efficiency frontier based on best practice. This methodology enables one to measure the level of efficiency of non-

frontier units and to identify benchmarks against which inefficient units can be compared" (Cook and Seiford, 2008, p. 1).

According to Charnes et al (1978), technical efficiency can be expressed using the formula below:

Efficiency = $\frac{Weighted\ sum\ of\ outputs}{Weighted\ sum\ of\ inputs}$

If we have *n* hospitals, each with *m* inputs and *s* outputs, the relative efficiency score of a given hospital is obtained by solving the following linear programming model:

Max $h_0 = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}}$

Subject to

$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1;\ \ j = 1, \dots, n$

$u_r \geq 0, r = 1, \dots, s$ and $v_i \geq 0, i = 1, \dots, m$

where:

- h_0 : represents the efficiency score of hospital *0*.
- y_{rj} : represents the amount of output *r* produced by hospital *j*.
- x_{ij} : represents the amounts of input *i* consumed by the hospital *j*.
- u_r = the weight given to output *r*
- v_i = the weight given to input *i*
- *n* = the number of hospitals
- *s* = the number of outputs
- *m* = the number of inputs

DEA will assign an efficiency score of 1.0 to the most efficient hospital relative to the others. Less efficient hospitals are assigned a score between 0 and 1.0. It, therefore, assesses relative efficiency among hospitals and also indicates how a hospital should

adjust inputs and outputs to achieve a performance comparable to that of the best observed.

To compute technical efficiency, we used a user-written DEA program in Stata 14 developed by Ji & Lee (2010). In the DEA analysis, output orientation was assumed since public clinics usually have better control over the volume of their outputs through community health promotion and demand creation activities but have limited control over the volume of their resources as these resources are allocated from the central purse. The DEA analysis was done assuming a variable return to scale (VRS) to allow both technical and scale efficiency to be computed.

3.3.4 Sensitivity analysis

The robustness of DEA estimates will be tested using the jackknife test (Zere et al., 2006). To determine the presence of extreme outliers which could impact on the efficiency scores, we will run several DEA analyses that will drop out each efficient clinic one at a time. The similarity between scores from the model before removing any efficient unit and the scores from models after removing each efficient unit will be tested using the Spearman rank correlation coefficients. A Spearman coefficient of 0 indicates no correlation meaning that the unit has an influence on the ranking. A coefficient of 1 or -1 indicates correlation which means the outlier does not influence the ranking. This process is called jackknifing and serves to test the robustness of the DEA results in regard to outlier clinics (Sebastian & Lemma, 2010).

3.4 Ethical considerations

The study relied on secondary data from the Eswatini Health Information Management System, Health Planning Unit and regional partners' databases and did not enroll any human participants. Therefore, no ethical issue was foreseen. However, ethical clearace was obtained from the University of Cape Town's Human Research Ethics Committee and the Eswatini National Health Research Review Board.

4. Result

4.1. Characteristics of health facilities

Table A1: Characteristics of clinics (n=65)

Facility characteristics	Descriptive statistics	
	Frequency (f)	Percentage (%)
Geographical location		
Hhohho	16	24.6%
Manzini	9	13.8%
Lubombo	22	33.8%
Shiselweni	18	27.6%
Ownership		
Government	49	75.3%
Private not for profit	16	24.7%
Type of facility manager		
Nursing sister	37	56.9%
Senior nurse	28	43.1%
The facility has a client management information system		
Yes	41	63.1%
No	24	36.9%
Facility receives mentorship from regional partner		
Yes	65	100%
No	0	0%

Sixty-five of the 68 clinics in the original sample, participated in the study, representing a 95.5% participation rate. Three facilities (1 in Hhohho and 2 in Lubombo) were excluded because of data quality and data availability issues.

As shown in Table A1, of the 65 clinics, 33.8% (22/65) were from Lubombo region, 24.6% (16/65) from Hhohho region, 27.7% (18/65) from Shiselweni region and 13.8% (9/65) from Manzini region. Seventy-five percent (49/65) are purely government public facilities while the remaining 25% (16/65) is part of the private-public partnership with faith-based and other not-for-profit organisations. Private not for profit facilities share all characteristics of government facilities. They receive their funding from central government and have their staff paid by the Ministry of Health. A nursing sister manages Fifty-seven percent of the facilities while a senior nurse manages the remaining 43%. Sixty-three percent of facilities have a functional client management information system (CMIS) while the remaining 37% are still using paper-based records and registers. All facilities reported receiving mentorship visit from the regional partners which are Elizabeth Glaser Pediatric AIDS Foundation (EGPAF) for Hhohho clinics, International Centre for AIDS care and treatment programs (ICAP) for Manzini clinics and URC for Lubombo clinics. For Shiselweni clinics, mentorship is provided by EGPAF for clinics in the Hlathikhulu and Matsanjeni zones while Medecins Sans Frontieres (MSF) covers Nhlangano zone's clinics.

Table A2: Facilities inputs and outputs by region in 2017

Regions	Government Funding (in US $) *	Number of clinical staff **	Number of lay cadres **	Number of consultation rooms	Number of outpatient visits	Number of antenatal care (ANC) visits	Number of child immunisations	Number of TB treatment initiations
Hhohho	6,562,302.3	96	146	91	90932	5878	53914	188
Manzini	3,227,925.0	49	100	44	44254	2338	20087	179
Lubombo	6,695,908.9	133	137	120	109406	6357	51084	288
Shiselweni	7,915,512.9	85	120	95	73039	2851	26401	197
Total	24,401,649.1	363	503	350	317631	17424	151486	852

*converted in US $ using 2017 average a rate of 1 US $ = 13.3 Emalangeni

** Based on 2018 data

The 65 facilities used a total of 24,401,649.1 US $ as government funding, 363 clinical staff (sisters, midwives, staff nurses, nursing assistants), 503 lay cadres (HTS counsellors, expert clients, mother to mothers, cough officers, active case finders) and 350 consultations rooms. Total output includes 317,631 outpatients visits, 17,424 antenatal care visits, 151,486 child immunisations and 852 TB treatment initiations (Table 2).

4.2 DEA results

4.2.1 Technical efficiency (TE)

4.2.1.1 Average technical efficiency

Table A3: DEA model summarized results

	CRS technical efficiency scores (%)	VRS technical efficiency scores (%)	Scale efficiency scores (%)
Average	75.5%	80.4%	94.0%
Standard deviation	17.4%	18.8%	6.6%
Minimum	40.7%	41.6%	73.6%
Maximum	100%	100%	100%

Table A3 presents the average technical and scale efficiency scores of the 65 clinics. Average technical efficiency for all 65 clinics was 80.4% while average scale efficiency stood at 94.0%. Technical efficiency scores ranged from 41.6% to 100% (Table B1).

About 35.3% (23/65) of clinics were technically efficient, while the remaining 64.7% (42/65) were technically inefficient. Twenty-two percent of clinics (14/65) were scale efficient while the remaining 78% (51/65) were scale inefficient.

Among the 23 technically efficient clinics, 30.4% (7/23) were in Hhohho region, 47.8% (11/23) in Lubombo,13.0% (3/23) in Manzini and 8.7% (2/23) in Shiselweni. Seventy percent of clinics (16/23) are purely government-owned clinics, while 30% (7/23) are private not-for-profit clinics.

Among the 42 inefficient facilities, 35.7% (15/42) had a technical efficiency score between 75 and 99%, 54.8% (23/42) facilities had a score between 50% and 74% and 7.1% (3/42) had a technical score below 50%. The highest efficiency score was 99.7% and the lowest was 41.6%. The inefficient clinics had an average TE score of 70% and a standard deviation of 15.5%. This implies that for them to become efficient, on average, they should reduce their inputs by 30% without reducing outputs.

The technical efficiency score estimates showed that average technical efficiency scores were highest amongst clinics in Manzini (89.6%), followed by Lubombo (87.1%) and Hhohho (86.1%). The lowest average efficiency score (64.8%) was recorded among clinics in Shiselweni (Table B1 in annex). A one-factor analysis of variance showed that differences between these regional averages are statistically significant at 5% level of significance with a p-value estimated as <0.001 (Table B2 in annex).

4.2.1.2 Average inputs and outputs

Table A4: Means and standard deviation (SD) of inputs and outputs of efficient and inefficient clinics

	Efficient clinics (N=23)		**Inefficient clinics (N=42)**			
Input	**Mean**	**SD**	**Mean**	**SD**	**One-factor Anova F_stat**	**p-value**
Input 1: Government funding in US $)	340,868.44	265,178.41	394,325.59	183,030.98	0.92	0.34
Input 2: Number of clinical staff	5.68	2.95	5.60	1.74	0.014	0.544
Input 3: Number of lay cadres	7.31	5.17	7.97	3.25	0.37	0.441
Input 4: Number of consultation rooms	4.69	1.82	5.76	1.45	6.71	0.010
Output						
Output 1: Number of outpatients visits	5109.00	3925.06	4764.86	2007.17	4.21	0.04

Output 2: Number of antenatal care visits	341.60	324.13	227.78	117.63	4.21	0.04
Output 3: Number of child immunizations conducted	2780.17	288746	2084.33	1298.04	1.79	0.18
Output 4: Number initiated on TB treatment	17.82	16.93	10.52	6.84	6.83	0.01

Table A4 shows that efficient facilities used less of all inputs compared to inefficient facilities. A one-factor analysis of variance showed that these differences are statistically significant at the 5% level of significance only for the number of consultation rooms (p-value = 0.01).

With respect to outputs, efficient facilities were able to produce more of all outputs compared to inefficient facilities. Differences in output between efficient and inefficient clinics, for outpatient visits (p-value = 0.04), for antenatal care visits (p-value = 0.04) and TB treatment initiations (p-value = 0.01) were statistically significant at the 5% level of significance (Table A4).

Table A5: Inputs reduction to make inefficient clinics efficient per region

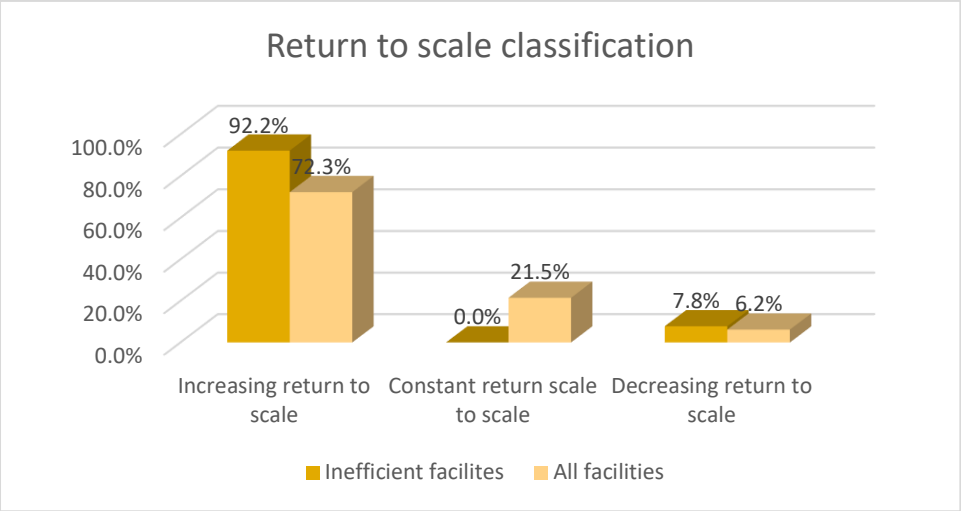
Regions	Government funding in US $	Clinical staff	Support staff	Consultation rooms
Hhohho	891,665.1	26.0	30.5	28.6
Manzini	606,332.5	8.3	25.9	9.9
Lubombo	968,885.2	41.0	25.1	35.0
Shiselweni	3,234,566.6	40.0	57.3	46.3
Total	5,701,449.4	115.3	138.8	119.8

Table A5 presents the input reduction that is needed to make efficient all 42 inefficient clinics per region. This result combines the relative decrease in inputs as guided by the facility's technical efficiency score and the respective inputs slacks. In total, all 42 inefficient clinics could have delivered the same level of output with 5,701,449.4, US$

less in government funding, 115.3 less clinical staff, 138.8 less support staff and 119.8 fewer consultation rooms.

4.2.2. Return to scale classification

Figure 1: Distribution of clinics by the return to scale (RTS) category



The most prevalent scale inefficiency among inefficient facilities is increasing return to scale with 92.2% (47/51) of scale inefficient clinics operating under increasing return to scale (IRS). This represented a prevalence of IRS at 72.3% (47/65) for all surveyed clinics (Figure 1).

4.2.3 Decomposition of CRS technical efficiency

It should be noted that constant return to scale technical efficiency (CRS TE) helps to measure the combined efficiency that is due to both variable returns to scale technical efficiency (VRS TE) and efficiency that is due to facility size and scale efficiency (SE) (Kumar & Gulati, 2008). Table B4 in annex shows that average CRS TE was 75.5%, average VRS TE was 80.4% and average SE was 94.0% showing predominance of inefficiencies due to input utilisation over scale of operations.

4.2.4 Sensitivity analysis

The Jackknife test showed that Spearman rank correlation coefficients for all efficient clinics ranged between 0.92 and 1, indicating that outliers did not influence the overall DEA result. Efficiency scores are, therefore robust (Table B7).

5. Discussion

This study sought to assess the technical and scale efficiency of public clinics in Eswatini. It has been conducted in a context where the government of the Kingdom of Eswatini has indicated in the National Development Strategy that Eswatini should strive to improve the efficiency of civil service, to improve the efficiency of the use of public resources (donor funding and local resources) and to institute tight measures for the control of government expenditures (Ministry of economic planning and development, 1997).

Out of 65 public clinics in the analysis, 35.3% were technically efficient. The remaining 64.7% were technically inefficient, and therefore not using scarce resources optimally. This indicates that though they are all in the same situation regarding limited resources, some clinics are more effective than others in their production process. Our findings are similar to those reported in previous studies from other developing countries. In South Africa, 70% of public clinics were technically inefficient (Kirigia et al, 2001), in Guatemala, 70% and 76% of health posts were technically inefficient in 2008 and 2009, respectively (Hermandez & San Sebastian, 2013). In Eritrea, 68% of clinics were technically inefficient (Kirigia & Asbu, 2013) and in Sierra Leone, 67% of community health posts were technically inefficient (Kirigia et al, 2011).

The average technical efficiency score for all 65 clinics was 80.4%. It means that if these clinics were operating efficiently, they could have produced 19.6% more output using the same levels of input. The average technical efficiency score was within the range of public clinics average technical efficiency scores found in developing

countries, between 59% and 97% (Kirigia et al, 2011; Hermandez & San Sebastian, 2013; Kirigia et al, 2013). However, Eswatini's average technical efficiency score was higher than those from Guatemala and Sierra Leone clinics (Hermandez & San Sebastian, 2013; Kirigia et al, 2011) but lower than the one from Eritrea clinics (Kirigia et al, 2013).

An analysis of average technical efficiency scores across regions reveals some differences. These regional differences were statistically significant at the 5% level of significance. Manzini is the most populated region of Eswatini (MOH, 2017). Thus, clinic attendance is expected to be high among clinics in Manzini. The consequence is that they display better efficiency scores given that "DEA estimates are based on the weighted sum of service output divided by the weighted sum of inputs (resources). Thus, the higher the outputs over inputs, the higher the efficiency score and vice versa" (Alhassan et al, 2017, p. 14).

This study identified that the most prevalent scale inefficiency among facilities is increasing return to scale with 92.4% (49/51) of scale inefficient clinics operating under increasing return to scale. This represented 75.4% (49/65) of all clinics. These facilities need to increase their output to become efficient.

The study showed that average CRS TE was 75.5%, average VRS TE was 85.4% and average SE was 87.3%. This implies that inefficiencies in the health sector are due to both poor managerial input utilisation and failure to operate at the most productive scale. However, SE being greater than VRS TE, inefficiencies are mostly attributable to poor input utilisation. Besides, about 69.2% (36/52) of CRS technically inefficient clinics had a TE score that is lower than their respective SE score which further confirms the greater prevalence of inefficiencies in input utilisation compared to inefficiencies due to inappropriate scale of operations. However, it should be noted that clinic managers do not influence their facilities inputs since all resources (government funding and staff) are decided centrally by the Ministry of Health.

The study further revealed that Eswatini's clinics could have delivered the same level of output with 5,701,449.4 US$ less in government funding, 115.3 less clinical staff, 138.8 less support staff and 119.8 fewer consultation rooms. With a nurse average monthly salary of 1,018 US$ (Salary explorer, 2020), a medical officer average monthly salary of $1,823 (MOH, 2012) and total annual expenditures on antiretroviral drugs at $ 30,086,963 (Pepfar, 2020), the saving on government funding alone represents the annual salary for 467 nurses or 261 medical officers and the total cost for 2 months stock of antiretroviral drugs.

The level of inefficiencies in Eswatini health system is a cause concerning and requires that the country adopts a number of remedial policies. With respect to excess inputs, policymakers have the following options which may not be mutually exclusive:

- Use government funding to improve the quality of services among efficient clinics.
- Re-allocate clinical staff to provide services closer to the patients within their communities by establishing mobile outreach teams.
- Use the re-allocated non-clinical staff to support demand creation activities within the community to address unmet needs. Indeed, with unmet need for family planning at 15.2%, contraceptive prevalence at 66.1%; at least four antenatal care visits by any provider coverage at 76%; births attended by skilled health personnel at 88.3% coverage, full immunisation at the first birthday at 70.7%, measles immunisation coverage among 1-year-olds at 91.4%, uptake of HIV testing in the past 12 months at 66.5% and 55.33 respectively among women aged 15 to 49 years and men aged 15 to 59 years (CSO & UNICEF, 2016), Eswatini has still work to do to bridge the gap for universal health coverage. Besides, demand for family planning satisfied with modern methods, antenatal care coverage, birth attended by skilled personnel and measles immunisation coverage indicators showed a pro-rich distribution highlighting inadequate health coverage affecting the poorest members of the community (CSO & UNICEF, 2016). Hence the need for more investments on health in favour of the poorest especially those staying in remote and rural areas.

Besides, there is a need for public sector reforms that focus on linking health workers contract renewal and remunerations to achieving service delivery targets, including efficiency targets. In the case of Eswatini, reviewing and improving the structure of incentives at all levels to make it reward high performance in the public service is well embedded in the National Development Strategy (Ministry of Economic Planning and Development, 1997). However, implementation is still lagging behind.

The study has also identified efficient clinics located on the frontier which other inefficient clients may benchmark and emulate. There is, therefore, a need to institute joint peer review activities to allow best practices in efficient facilities to be learnt by their peers (Alhassan et al, 2015). There is also a need to institutionalise routine technical efficiency assessments in existing Ministry of Health reporting, monitoring and evaluation activities. On these two aspects, the Regional and National semi-annual data review meetings (ReSAR and NaSAR) may serve as a platform to review efficiency results and share best practices.

This study has limitations. The absence of data on facility recurrent expenses compelled the use of facility weighted averages computed from the overall regional funding allocated by the central government. For clinics that actually used more government funding than their computed weighted averages, we may have overestimated their performance. Conversely, we may have underestimated the performance of clinics that received less in government funding than their computed weighted averages. Thirdly, although this study highlighted differences in efficiency among public clinics, it did not investigate the causes of the variation.

This paper's findings point to the need for future research to more comprehensively investigate technical efficiency in Eswatini, including private-for-profit health facilities. Besides, another area of future research will be to monitor changes in efficiency over time using the Malmquist total factor productivity index. Finally, an investigation of efficient facilities should be conducted to determine further how and why production

processes are operating differently at these sites and identify institutional and environmental factors that may determine efficiency.

5. Conclusion

The study demonstrated that public clinics technical and scale efficiency are suboptimal in Eswatini. About 65% of public clinics were technically inefficient while 81.6% were scale inefficient. The inefficiency levels identified within the health system suggest substantial wastage of resources, which if properly redirected could have contributed to improving the quality of health care in Eswatini. Given the prevalence of increasing return to scale, government policies should focus on strategies that would not only optimise inputs but also allow outputs expansion through improving the demand for health care. Finally, institutionalising routine technical efficiency assessments within existing Ministry of health reporting, monitoring and evaluation activities will ensure that the Ministry of Health can consistently monitor technical efficiency performance in public clinics in the Kingdom of Eswatini.

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Annex

Table B1: Technical efficiency scores per region

	Min	Max	Average	Standard deviation
Hhohho	54.7%	100%	86.1%	16.3%
Manzini	70.3%	100%	89.6%	11.6%
Lubombo	52.0%	100%	87.1%	15.8%
Shiselweni	41.6%	100%	64.8%	19.6%

Table B2: One-factor analysis of variance

Anova: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Hhohho	16	13.78	0.86	0.03		
Lubombo	22	19.17	0.87	0.02		
Manzini	9	8.07	0.90	0.01		
Shiselweni	18	11.657	0.648	0.036		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.67	3	0.22	8.45	8.81E-05	2.76
Within Groups	1.60	61	0.03			
Total	2.27	64				

Table B3: Facilities inputs and outputs

Dmus	Funding in Emalangeni	Clinical staff	Support staff	Consultation rooms	Outpatient visits	ANC visits	Immunizations	TB treatment initiations
Mliba nazarene clinic	433,942.0	5	7	4	5194	387	3147	11
Bhekinkhosi nazarene clinic	283,633.9	3	8	3	4692	173	831	16
Sigombeni Red cross clinic	490,599.3	4	13	6	5064	355	4454	7
Cana clinic	589,017.1	4	10	6	8469	361	3019	13
Mpuluzi clinic	325,046.8	3	6	4	5287	285	2820	16
Luyengo clinic	365,863.9	12	22	4	3297	391	3616	64
Mafutseni nazarene clinic	277,526.2	5	10	5	4829	171	556	33
Mahlangatsha clinic	89,529.4	5	14	5	610	67	1114	12
Mkhulamini clinic	372,766.1	8	10	7	6812	148	530	7
Siphofaneni clinic	193,519.2	7	7	10	2595	194	1489	32
Tsambokhulu clinic	137,304.3	5	8	6	2604	71	379	4
Lubuli clinic	405,267.7	7	8	5	6037	280	2690	19
Ndzevane clinic	460,360.2	8	5	7	7473	345	2424	11
Mpolonjeni clinic	428,346.4	6	13	7	10099	798	7286	39
Manyeveni clinic	321,574.1	4	5	5	4526	230	2394	12
Tikhuba clinic	452,861.8	6	10	7	6042	381	3643	20
Sinceni clinic	463,413.3	5	6	5	7734	303	2278	6
Lomahasha clinic	151,447.8	8	7	8	1707	111	1537	18
Shewula clinic	395,075.5	10	12	8	5042	370	3371	16
New Thulwane clinic	54,463.7	4	4	5	1086	22	100	5
Nkalashane clinic	110,347.7	5	4	4	2764	73	110	3
Gilgal clinic	381,857.5	6	12	6	10559	708	6043	26
Siteki nazarene clinic	517,742.4	13	6	6	4444	892	6160	35
Malindza refugee clinic	459,776.4	2	1	3	6711	305	3208	16

Khuphuka clinic	117,997.3	6	3	4	2285	71	269	3
Sitsatsaveni clinic	140,716.7	3	3	4	2102	82	938	12
Vuvulane clinic	262,126.4	8	8	5	5463	288	84	3
Hlane clinic	255,391.4	5	7	5	4247	195	1246	0
Ekutfokomeni sos clinic	243,268.4	6	1	2	5132	264	20	2
Gucuka clinic	359,739.1	5	3	3	4849	224	2933	6
Nkonjwa clinic	383,311.7	4	4	5	5905	150	2482	0
Nkhaba clinic	422,232.6	8	14	8	5754	335	3614	7
Nyonyane clinic	37,961.7	3	4	5	490	48	327	8
Malandzela clinic	285,300.5	3	6	3	3499	265	2795	2
Ndzingeni clinic	125,278.3	9	9	5	1135	104	1642	0
Horo clinic	456,411.2	6	12	8	7204	312	2972	8
Ntfonjeni clinic	525,725.2	5	7	7	6610	487	4980	13
Siphocosini clinic	535,335.2	6	5	5	8795	279	3226	11
Motshane clinic	985,093.3	9	16	8	14297	878	7456	23
Ezulwini satellite clinic	1,115,850.6	6	8	5	13992	1063	10560	46
Sigangeni clinic	387,358.1	6	7	5	5646	282	2972	8
Ndwabangeni clinic	227,075.0	4	8	5	3488	174	1546	14
Mahwalala red cross clinic	398,620.5	10	7	4	5573	687	2889	18
Bhalekane nazarene clinic	302,563.8	6	14	9	3941	374	2613	30
Herefords clinic	368,964.3	6	8	6	5177	350	2958	0
Hhukwini clinic	349,352.9	4	9	4	4962	214	2858	0
Bulandzeni clinic	39,179.3	5	12	4	369	26	506	0
Nkwene clinic	751,559.8	10	10	6	5523	332	3861	15
Moti clinic	311,482.9	5	6	5	3330	140	556	7
Kaphunga nazarene clinic	184,202.0	4	1	3	2246	20	115	4
Kamfishane clinic	537,313.9	5	6	5	5323	181	1451	2
Nhletsheni clinic	415,207.6	5	7	6	3067	205	2097	7
Mahlandle clinic	657,334.8	4	4	4	6281	200	2015	15

Our Lady of Sorrows clinic	94,456.6	5	4	5	767	20	424	12
Hluti clinic	625,591.8	5	7	6	6964	157	966	13
Mashobeni clinic	141,955.3	2	7	3	1084	35	707	12
Mhlosheni clinic	347,628.3	4	3	8	2771	110	1613	7
Magubheleni clinic	640,497.9	4	11	4	5642	210	2433	8
Gege clinic	372,420.2	3	4	5	4085	124	603	10
Lavumisa clinic	206,445.3	4	0	5	2348	41	278	6
Jci clinic	392,964.4	5	9	9	4425	101	552	10
New haven clinic	169,527.7	5	13	5	1845	182	157	11
Jericho clinic	531,135.2	5	9	6	5017	170	1677	13
Silele clinic	759,823.8	5	9	5	5707	409	3706	16
Ntshanini clinic	775,965.6	5	10	5	6614	214	3190	29
Total	24,401,649.1	**363**	**503**	**350**	**317631**	**17424**	**151486**	**852**

Table B4: DEA model results

Facilities	CRS_TE	VRS_TE	NIRS_TE	SCALE	RTS
Mliba_nazarene_clinic_	0.663697	0.742598	0.7935	0.89375	1
Bhekinkhosi_nazarene_clinic	0.872926	1	1	0.872926	1
Sigombeni_Red_cross_clinic	0.763489	0.814465	1	0.937412	1
Cana_clinic	0.82629	0.898883	1	0.919241	-1
Mpuluzi_clinic	0.835792	0.938658	0.984426	0.890412	1
Luyengo_clinic	1	1	1	1	0
Mafutseni_nazarene_clinic	1	1	1	1	0
Mahlangatsha_clinic	0.939605	0.969793	1	0.968871	1
Mkhulamini_clinic	0.688347	0.703012	1	0.979141	1
Siphofaneni_clinic	1	1	1	1	0
Tsambokhulu_clinic	0.68586	0.737944	1	0.929419	1
Lubuli_clinic	0.718337	0.720947	0.907241	0.99638	1
Ndzevane_clinic	0.785704	0.899462	1	0.873527	-1
Mpolonjeni_clinic	1	1	1	1	0
Manyeveni_clinic	0.697388	0.736579	0.804083	0.946793	1
Tikhuba_clinic	0.618909	0.629465	0.735921	0.98323	1
Sinceni_clinic	0.832215	1	1	0.832215	1
Lomahasha_clinic	0.830892	0.841832	1	0.987005	1
Shewula_clinic	0.515997	0.520447	1	0.99145	1
New_Thulwane_clinic	0.848351	1	1	0.848351	1
Nkalashane_clinic	0.905844	1	1	0.905844	1
Gilgal_clinic	1	1	1	1	0
Siteki_nazarene_clinic	1	1	1	1	0
Malindza_refugee_clinic	1	1	1	1	0
Khuphuka_clinic	0.738795	0.824899	1	0.895619	1
Sitsatsaveni_clinic	0.901616	1	1	0.901616	1
Vuvulane_clinic	0.759673	0.777907	1	0.976559	1
Hlane_clinic	0.62311	0.666505	1	0.934891	1
Ekutfokomeni_sos_clinic	1	1	1	1	0

Gucuka_clinic	0.869434	1	1	0.869434	1
Nkonjwa_clinic	0.806055	0.809581	1	0.995645	1
Nkhaba_clinic	0.524684	0.546809	1	0.959537	1
Nyonyane_clinic	1	1	1	1	0
Malandzela_clinic	0.736445	1	1	0.736445	1
Ndzingeni_clinic	0.770554	0.842914	1	0.914155	1
Horo_clinic	0.638959	0.660451	1	0.967459	1
Ntfonjeni_clinic	0.823863	0.842252	1	0.978167	1
Siphocosini_clinic	0.866136	0.996971	1	0.868768	-1
Motshane_clinic	0.827999	1	1	0.827999	-1
Ezulwini_satellite_clinic	1	1	1	1	0
Sigangeni_clinic	0.665872	0.672287	0.839147	0.990458	1
Ndwabangeni_clinic	0.653181	0.715367	0.874046	0.913072	1
Mahwalala_red_cross_clinic	1	1	1	1	0
Bhalekane_nazarene_clinic	0.8378	0.863186	1	0.97059	1
Herefords_clinic	0.622306	0.636685	1	0.977416	1
Hhukwini_clinic	1	1	1	1	0
Bulandzeni_clinic	0.759276	1	1	0.759276	1
Nkwene_clinic	0.455644	0.457828	1	0.995228	1
Moti_clinic	0.457834	0.467905	0.64583	0.978476	1
Kaphunga_nazarene_clinic	0.69389	0.738287	1	0.939865	1
Kamfishane_clinic	0.524451	0.576482	1	0.909745	1
Nhletsheni_clinic	0.406599	0.416268	0.481239	0.976771	1
Mahlandle_clinic	0.658694	0.678379	1	0.970982	1
Our_Lady_of_Sorrows_clinic	0.752263	0.997256	1	0.754333	1
Hluti_clinic	0.596556	0.680315	1	0.876882	1
Mashobeni_clinic	0.894986	1	1	0.894986	1
Mhlosheni_clinic	0.494652	0.54886	1	0.901236	1
Magubheleni_clinic	0.597893	0.598081	1	0.999687	1
Gege_clinic	0.5967	0.632072	1	0.944038	1
Lavumisa_clinic	1	1	1	1	0
Jci_clinic	0.470356	0.471747	1	0.997052	1

New_haven_clinic	0.605714	0.605714	1	1	0
Jericho_clinic	0.467429	0.491666	0.750088	0.950704	1
Silele_clinic	0.51355	0.513967	1	0.99919	1
Ntshanini_clinic	0.782198	0.782398	1	0.999744	1

Table B5: Inputs and output slacks

dmus	Funding	Clinical staff	Support staff	Consultation rooms	Outpatient visits	ANC visits	Immunizations	TB initiations
Mliba nazarene clinic	990671	.	.	0.0119922	.	.	.	3.25653
Bhekinkhosi nazarene clinic	1252898	.	1.85266	.	.	171.256	2212.97	.
Sigombeni Red cross clinic	830534	.	4.28969	1.39009	1011.52	118.594	.	15.2406
Cana clinic	0	.	3.97003	1.55431	.	167.409	2069.22	9.99625
Mpuluzi clinic	943994	.	0.188905	0.587717	.	76.0353	445.716	.
Luyengo clinic	0	0	0	.	.	.	.	.
Mafutseni nazarene clinic	0	.	.	.	0	0	0	.
Mahlangatsha clinic	37130.5	1.53172	8.49016	.	924.715	64.6918	.	.
Mkhulamini clinic	0	1.61522	.	1.16199	.	295.124	3115.17	8.9428
Siphofaneni clinic	0	.	.	.	0	.	0	.
Tsambokhulu clinic	95114	2.21004	2.94418	2.94798	.	103.603	1111.29	2.41197
Lubuli clinic	35582.9	1.96035	.	.	.	128.398	1081.7	.
Ndzevane clinic	0	4.03485	.	2.61327	.	79.635	1593.23	7.5334
Mpolonjeni clinic	0	.	0	0	.	0	.	.
Manyeveni clinic	257462	0.340681	.	1.16795	.	56.8643	.	.
Tikhuba clinic	0	0.548876	.	0.717732	.	49.2824	313.806	.
Sinceni clinic	1643852	.	.	1.048	.	162.506	1119.13	9.63791
Lomahasha clinic	27975.7	3.43624	.	4.62183	139.413	58.3509	.	.
Shewula clinic	39006.9	2.25519	0.0245266	0.892022	.	7.01955	.	0.969732
New Thulwane clinic	109849	2.45111	1.58696	2.76637	.	56.0033	537.47	.

Nkalashane clinic	138186	3.4294	0.858793	2.4294	.	112.331	1471.86	3.80595
Gilgal clinic	0	.	.	0	.	0	0	.
Siteki nazarene clinic	0	.	0	.	.	.	.	0
Malindza refugee clinic	0	.	.	0	.	0	0	0
Khuphuka clinic	176132	3.57303	.	2.02433	.	80.1886	964.993	2.35763
Sitsatsaveni clinic	323950	.	.	0.530108	.	63.4083	65.9588	.
Vuvulane clinic	84390.8	3.11899	0.0147167	0.785266	.	78.304	3042.52	10.4518
Hlane clinic	195620	0.81645	.	0.949765	.	87.0991	1087.37	10.1031
Ekutfokomeni sos clinic	0	.	.	.	.	0	0	0
Gucuka clinic	869324	2.94815	.	0.464362	.	75.9511	.	8.7609
Nkonjwa clinic	27231	.	.	1.1798	.	174.811	101.574	12.3263
Nkhaba clinic	0	1.09362	0.986333	0.930602	.	75.0791	.	9.94929
Nyonyane clinic	0	.	0	0	0	0	0	.
Malandzela clinic	1609053	0.698326	1.01304	0.314713	375.102	41.1227	.	12.9609
Ndzingeni clinic	120566	6.23404	4.6565	2.63702	1140.95	75.8402	.	8.78918
Horo clinic	0.582573	.	0.268335	1.38799	.	179.414	1322.12	10.5134
Ntfonjeni clinic	208687	0.576541	.	2.45611	.	40.5007	.	10.962
Siphocosini clinic	0.287649	2.32424	.	0.892994	.	244.796	1814.4	12.0463
Motshane clinic	0	0	0	.	.	0	0	0
Ezulwini satellite clinic	0	.	.	.	.	0	0	0
Sigangeni clinic	54948.3	1.12142	.	0.375754	.	60.1519	.	5.36643
Ndwabangeni clinic	198600	.	0.34231	.	.	92.1265	810.277	.
Mahwalala red cross clinic	0	0	.	.	.	.	0	0
Bhalekane nazarene clinic	261892	.	1.90942	4.3351	361.024	.	813.661	.
Herefords clinic	140643	0.654657	.	0.866907	.	.	.	13.2969
Hhukwini clinic	2249604	1.17726	3.34242	1.16517	.	120.172	.	12.389
Bulandzeni clinic	125438	4.58331	11.0972	3.51386	332.358	29.4197	.	2.70848

Nkwene clinic	0	1.87128	.	0.164135	.	75.6586	.	2.44694
Moti clinic	70436.4	.	.	0.577494	.	69.5654	908.693	.
Kaphunga nazarene clinic	129864	0.787536	.	0.831228	.	94.0883	332.263	.
Kamfishane clinic	0	0.547075	.	0.358463	.	146.709	1653.18	12.0252
Nhletsheni clinic	95669.4	0.516407	.	0.697873	.	17.0701	.	3.70235
Mahlandle clinic	0	0.310744	.	0.104219	.	186.966	1852.75	2.6761
Our Lady of Sorrows clinic	369281	1.67581	.	.	94.9765	52.5005	115.908	.
Hluti clinic	0.125284	0.264498	.	0.909444	.	300.769	3382.68	6.34285
Mashobeni clinic	660305	.	3.10758	1.57022	408.917	59.5499	.	.
Mhlosheni clinic	352190	1.04596	.	2.9093	.	54.7005	.	1.25473
Magubheleni clinic	3788.15	.	3.30736	.	.	163.946	1210.88	8.27508
Gege clinic	241785	.	.	1.07359	.	107.563	1490.95	.
Lavumisa clinic	0	.	.	0	.	0	0	0
Jci clinic	13795.2	.	.	1.83171	.	178.911	1873.02	0.697508
New haven clinic	0	0.768188	3.7868	.	409.066	.	1470.38	.
Jericho clinic	0.633775	.	0.224864	0.455695	.	159.43	1338.4	0.293051
Silele clinic	10465.2	.	0.721083	.	.	.	279.23	2.46079
Ntshanini clinic	12079.4	.	1.98804	0.497011	1238.3	346.126	2161.84	.

Table B6: Inputs reduction needed to make inefficient clinics efficient (N=42)

Facilities	Funding	Clinical staff	Support staff	Consultation room
Mliba nazarene clinic	186184.1	1.3	1.8	1.0
Sigombeni Red cross clinic	153469.5	0.7	6.7	2.5
Cana clinic	59559.6	0.4	5.0	2.2
Mpuluzi clinic	90916.0	0.2	0.6	0.8
Mahlangatsha clinic	5496.2	1.7	8.9	0.2
Mkhulamini clinic	110707.1	4.0	3.0	3.2
Tsambokhulu clinic	43132.8	3.5	5.0	4.5
Lubuli clinic	115766.6	3.9	2.2	1.4

Ndzevane clinic	46283.7	4.8	0.5	3.3
Manyeveni clinic	104067.4	1.4	1.3	2.5
Tikhuba clinic	167801.1	2.8	3.7	3.3
Sinceni clinic	26057.6	4.7	1.1	5.9
Lomahasha clinic	192392.5	7.1	5.8	4.7
Shewula clinic	33904.5	4.6	0.5	2.7
Khuphuka clinic	64561.6	4.9	1.8	1.9
Vuvulane clinic	99880.0	2.5	2.3	2.6
Hlane clinic	75037.3	0.8	0.8	2.1
Nkonjwa clinic	191352.0	4.7	7.3	4.6
Nkhaba clinic	28744.6	7.6	6.1	3.4
Ndzingeni clinic	154974.0	2.0	4.3	4.1
Horo clinic	98622.8	1.4	1.1	3.6
Ntfonjeni clinic	1621.6	2.3	0.0	0.9
Siphocosini clinic	131073.7	3.1	2.3	2.0
Sigangeni clinic	79565.4	1.1	2.6	1.4
Ndwabangeni clinic	61086.1	0.8	3.8	5.6
Bhalekane nazarene clinic	144624.9	2.8	2.9	3.0
Herefords clinic	407474.7	7.3	5.4	3.4
Hhukwini clinic	171034.5	2.7	3.2	3.2
Nkwene clinic	57972.3	1.8	0.3	1.6
Moti clinic	227562.1	2.7	2.5	2.5
Kamfishane clinic	249563.1	3.4	4.1	4.2
Nhletsheni clinic	211412.7	1.6	1.3	1.4
Mahlandle clinic	28024.7	1.7	0.0	0.0
Our Lady of Sorrows clinic	199992.3	1.9	2.2	2.8
Hluti clinic	183309.5	2.9	1.4	6.5
Mhlosheni clinic	257713.1	1.6	7.7	1.6
Gege clinic	155203.2	1.1	1.5	2.9
Jci clinic	208621.8	2.6	4.8	6.6
New haven clinic	66842.4	2.7	8.9	2.0
Jericho clinic	269994.1	2.5	4.8	3.5

Silele clinic	370086.3	2.4	5.1	2.4
Ntshanini clinic	169759.9	1.1	4.2	1.6
Total	5,701,449.328	115.28204	138.8484763	119.8448872

Table B7: Sensitivity analysis

Outlier omitted	**Spearman score**	**P-value**	**Outlier omitted**	**Spearman score**	**P-value**
Bhekinkosi	1	0.0000	Gucuka	1	0.0000
Luyengo	0.9502	0.0000	Nyonyane	0.9860	0.0000
Mafutseni	0.9515	0.0000	Malandzela	0.9565	0.0000
Siphofaneni	0.8908	0.0000	Motshane	1	0.0000
Mpolonjeni	0.9935	0.0000	Ezulwini	0.9453	0.0000
New Thulwane	1	0.0000	Mahwalala	0.9155	0.0000
Nkalashane	0.9578	0.0000	Bulandzeni	0.9770	0.0000
Gilgal	0.9866	0.0000	Kaphunga	0.9582	0.0000
Siteki Nazarene	0.9997	0.0000	Mashobeni	0.9578	0.0000
Malindza	0.9997	0.0000	Magubheleni	0.9342	0.0000
Sitsatsaveni	0.9968	0.0000	Lavumisa	0.9205	0.0000
Ekutfokomeni SOS	0.9189	0.0000			

PART D: APPENDICES

Appendix 1: Human Research Ethics Committee Approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6626
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

10 October 2018

HREC REF: 668/2018

A/Prof John Ataguba
Health Economics Division
Public Health & Family Medicine
Room 1.08
Falmouth Building

Dear A/Prof Ataguba

PROJECT TITLE: ASSESSMENT OF TECHNICAL AND SCALE EFFICIENCY OF PUBLIC CLINICS IN SWAZILAND (MPH Candidate - Dr K. Kindandi)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study subject to Swaziland National Health Research Board approval.

Approval is granted for one year until the 30 October 2019.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

The HREC acknowledge that the student, Dr Kikanda Kindandi will also be involved in this study.

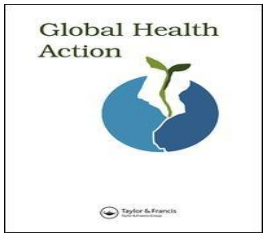
Yours sincerely

Signature Removed

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.

HREC 668/2018

Appendix 2: Global Health Action – Guide for authors



GLOBAL HEALTH ACTION

Aims and scope

Global Health Action is an international peer-reviewed Open Access journal based at the Department of Epidemiology and Global Health at Umeå University in Sweden.

Vision: Our vision is to be a leading journal in the global health field, narrowing health information gaps and contributing to the implementation of policies and actions that lead to improved global health.

Aim: The widening gap between the winners and losers of globalisation presents major public health challenges. To meet these challenges, it is crucial to generate new knowledge and evidence in the field and in settings where the evidence is lacking, as well as to bridge the gaps between existing knowledge and implementation of relevant findings. Thus, the aim of *Global Health Action* is to contribute to fuelling a more concrete, hands-on approach to addressing global health challenges. Manuscripts suggesting strategies for practical interventions and research implementations where none already exist are specifically welcomed. Further, the journal encourages articles from low- and middle-income countries, while also welcoming articles originated from South-South and South-North collaborations. All articles are expected to address a global agenda and include a strong implementation or policy component. Articles reporting research involving primary data collection will normally include researchers and institutions from the countries concerned as authors, and include in-country ethical approval.

Scope: *Global Health Action* publishes Original Research articles, Review articles, Short Communications and Current Debate articles. Special niches within *Global Health Action* include articles on Capacity Building, Study Designs and a Methods Forum, as well as PhD reviews. These are described in our Instructions for Authors. All articles, except editorials and invited commentaries, follow a stringent process of external peer-review. If manuscripts are received that are not up to the standard required for publication in the Journal, but relate to research that has publication potential, authors may be offered mentorship from a senior academic who will work collaboratively to improve the manuscript. In such cases the mentor will be named in the published article as a Contributing Editor.

Instructions for authors

About the journal

Global Health Action is an Open Access, international, peer reviewed journal, publishing high-quality, original research, publishing high-quality, original research. Please see the journal's Aims & Scope for information about its focus and peer-review policy.

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This journal accepts the following article types: Original Articles, Review Articles, Short Communication Articles, Capacity Building Articles, Study Design Articles, Current Debates Articles, Methods Forum Articles, and PhD review with invited commentaries.

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- Reason for waiver application
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GHA Initial screening

GHA editors will screen each submitted manuscript to *Global Health Action*. We are looking for high-quality manuscripts which: (i) present original research results within the field of global health, (ii) are well-motivated, designed appropriately with valid data collection methods, analysed using the state-of-the-art methods, and (iii) contextualise findings within appropriate public health policy context and suggest concrete action for the population, policymakers, and other stakeholders.

Manuscripts may be rejected directly by the Editor or in consultation with external experts, if one or more of the following weaknesses are identified:

1. The manuscript did not pass the originality detection test using iThenticate software. The test will show if the manuscript consists of text published elsewhere without proper citations. The test would also indicate that the paper, in full or part, may have been previously published in a different format (for example as a project report or a conference presentation).
2. The manuscript is out of the scope of global health. For example, the manuscript is too clinical (unless there are clear public health implications), it is focused on animal studies, it is too technical for a general readership, or it has only local significance (unless there is a clearly stated and justifiable proposal for wider implementation).
3. The study lacks scientific originality.
4. There is no clear "evidence-based" rationale for the work. The manuscript does not include references to similar work or the need for work in this area.
5. The authors have not explained the significance/importance or added values of their work. The manuscript does not include a specific research question or a clear statement of intent.
6. The study methods are neither valid nor reliable. The study design does not clearly address the research question. There are flaws in the study design or data collection that cannot be corrected.
7. The study does not use the most recent or best available data, or the authors do not present a justification for using historical material.
8. The study cannot be contextualized within a current public health policy context.
9. The study uses primary data that were collected by local researcher(s) in low- or middle-income countries and are not publicly available, but does not include any local researcher(s) as co-authors.
10. The manuscript is not well structured (as per GHA Author Guidelines). The manuscript has poor English grammar, style, and syntax. The references are not up-to-date or relevant.

For quantitative studies:

1. The study includes a survey with low response rates that are not justified. Other issues arising from bias are not adequately explained or addressed.
2. The study is based on a small selected population. The results allow inference of marginal impact only within this small population.

For qualitative studies:

1. The qualitative design cannot be understood from reading the manuscript.
2. The manuscript lacks analytical rigour that cannot be corrected. There is no section in the manuscript that clearly explains how the study was conducted and how the data were analysed.

GHA Peer-review Processes

When manuscripts have passed through the initial screening, they are subjected to rigorous peer review to ensure that the research published is 'good science'. Manuscripts are sent out for review electronically, and all correspondence takes place via e-mail. Manuscripts are sent to at least two independent reviewers. Fast track peer-review may be provided for topical papers.

Global Health Action has a 'single blind' review process: The peer reviewers identities remain unknown to the authors; however, a reviewer may choose to reveal his/her identity at a later stage. Peer reviewers are asked to give their opinion on issues pertinent to the scientific and formal aspects of a manuscript, and to judge manuscripts on grounds of originality and public health relevance. All relevant information will be forwarded to the author(s).

Peer reviewers can make one of the following recommendations for the editors to consider:

1. Accept manuscript (i.e., no need for any revision)
2. Conditional accept (i.e., can be accepted if the author makes the requested minor editorial revisions)
3. Minor revision (i.e., can be accepted after minor revisions have been made)
4. Major revision (i.e., can be accepted or rejected after major revisions have been made - the manuscript may be sent out for another peer review round)
5. Reject manuscript - unsound (i.e., the manuscript is sub-standard)
6. Reject manuscript - unsuitable (i.e., the manuscript is better suited for another journal)

When asking for revisions, reviewers have two possible goals: to ask authors to tighten their arguments based on existing data, or to identify areas where more data are needed. Formal revision may be required if the language or style is sub-standard. To facilitate rapid publication, authors are given a maximum of two weeks for minor revisions and four weeks for major revisions, with possible extensions of up to 6 weeks, after which time the revised manuscripts will be rejected and can only be re-considered as new submissions.

Manuscript preparation for GHA

Please refer to the information provided below to ensure your manuscript conforms to the requirements before beginning the submission process. Incomplete submissions will not be considered. All authors submitting to medicine, biomedicine, health sciences, allied and public health journals should conform to the Uniform Requirements for Manuscripts Submitted to Biomedical Journals, prepared by the International Committee of Medical Journal Editors (ICMJE). The authors also need to comply with the American Psychological Association's (APA) Ethical Principles of Psychologists and Code of Conduct.

Types of Articles

Editorials and Commentaries - up to 3000 words: Editorials and Commentaries are commissioned and submission is based on invitation.

Original Research articles - up to 4000 words: An Original Research article must follow the following structure: Introduction, Methods, Results, Discussion and Conclusions. *Global Health Action* publishes articles based on quantitative and/or qualitative designs, and authors should follow the relevant reporting guidelines.

Review articles - up to 6000 words: *Global Health Action* welcomes literature reviews as well as systematic reviews. *Global Health Action* considers literature reviews in the form of narrative reviews, syntheses, etc. The systematic review is defined by The Cochrane Collaboration as a review that has a clearly formulated research question, uses explicit systematic methods to identify, select and critically appraise relevant research, and synthesizes data from studies that are included in the review. Statistical methods in the form of a meta-analysis may complement a systematic review. When submitting a systematic review and/or a meta-analysis, authors are encouraged to complete the PRISMA checklist as supporting information.

PhD Reviews - up to 6000 words: Young or emerging researchers who have recently defended their theses on a global health topic are invited to write a summary article based on their thesis. One rationale for this is that PhD theses are often based on a set of articles synthesized into a "cover story" of about 30-50 pages. Some of these syntheses provide excellent reviews of the research area but they seldom reach beyond the host institution or the close collaborators and examiners. Condensing the articles into a PhD Review may also serve as an incentive for the young or emerging researcher to publish his or her first post-doctoral paper as a sole author and thus "kick-start" their research career.

A PhD Review paper should have the same structure as an Original Research article including the Introduction, Methods, Results, Discussion and Conclusions sections. One should be aware of self-plagiarism in writing a PhD review and not copy and paste text from the PhD thesis into the paper. The aim should be to synthesize the thesis, preferably cutting across papers thematically. The author should also provide a link to the full text of the PhD thesis, and secure permission from the University where the thesis was defended, if the thesis is not published in the public domain. In addition, authors are encouraged to submit supplementary files, such as an MS Powerpoint presentation, photos, videos, etc. that are related to the thesis/PhD review to be included as supplementary material. If published, these files will not incur an additional charge.

Methods Forum articles - up to 4000 words: *Global Health Action* invites papers on innovative tools in global health research that are being evaluated or implemented. These tools can be statistical and quantitative but they can also be based on field-oriented surveys and qualitative interviews.

Study Design articles - up to 6000 words: These articles are intended to be methodological papers presenting the design, rationale and aims, as well as hypotheses and background data of, for example, a longitudinal/cohort study or an intervention study. This type of article sets the scene and could be referenced in forthcoming original research papers arising from the studies.

Capacity Building articles - up to 4000 words: Capacity building articles are published to document how research infrastructure, human resources and capacity, and research design/intervention dealing with major public health issues have been developed, particularly in low-and middle-income countries. These articles should reflect how partnerships and collaborations are established and built over time, and how research capacities are being built and sustained in low-and middle-income countries. The contribution of these articles to capacity building should be through scientific discussion of the issues rather than simple reporting of activities.

Current Debates - up to 2000 words: This section aims to create a platform for critical reflection about ongoing global/public health issues and policies.

Short Communications - up to 1500 words: A short communication presents important preliminary observations, results and data from pilot studies, or side issues/secondary findings in a larger study that do not warrant publication as full papers.

Reporting Guidelines

Submitted manuscripts should follow the recommendations stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals prepared by the International Committee of Medical Journal Editors (ICMJE). The submission should also comply to the American Psychological Association's (APA) Ethical Principles of Psychologists and Code of Conduct. In addition, please follow the respective guidelines for different study designs:

- For fields/clinical trials, please follow the CONSORT guidelines
- For observational studies, please follow the STROBE guidelines
- For systematic reviews and meta-analysis, please follow the PRISMA guidelines
- For health economics papers, please follow the CHEERS guidelines
- For diagnostic tests papers, please follow the STARD guidelines
- For original qualitative research papers, please follow the COREQ guidelines
- For synthesis of qualitative research papers, please follow the ENTREQ guidelines
- For health care quality papers, please follow the SQUIRE guidelines

These and other guidelines are collated on the EQUATOR Network website. *Global Health Action* asks its authors to follow these reporting guidelines and to complete the respective checklists before submission. Compliance with appropriate guidelines will be considered in the evaluation of the manuscript and will contribute to the final decision on the manuscript.

Manuscript Guidelines

Manuscript length: *Global Health Action* has no strict upper limit for manuscript lengths but authors are advised to follow the recommendations stated here for different types of articles. The word limits exclude references, tables and figures, though authors should comply with a maximum of six tables and/or figures in their manuscript. Major deviations from the recommended word length must be justified in the covering letter. Over-long manuscripts are likely to be rejected or returned for major revisions.

Manuscript formatting: Manuscripts may be supplied as single or multiple files. These can be Word, rich text format (rtf), open document format (odt), or PDF files. Figures and tables can be placed within the text or submitted as separate documents. Figures should be of sufficient resolution to enable refereeing.
• All manuscripts must contain the essential elements needed to evaluate a manuscript: abstract, author affiliation, figures, tables, funder information, and references. Further details may be requested upon acceptance.
• References should be in NLM style or format. Author name(s), journal or book title, article or chapter title, year of publication, volume and issue (where appropriate) and page numbers are essential. All bibliographic entries must contain a corresponding in-text citation. The addition of DOI (Digital Object Identifier) numbers is recommended but not essential.
• Spelling can be US or UK English so long as usage is consistent.
Note that, regardless of the file format of the original submission, an editable version of the article must be supplied at the revision stage.

Title page: Organize the title page in the following way: 1) title of manuscript, 2) short running title, 3) name of author(s), 4) affiliations for all authors, including name of institution(s) and department(s), 5) email addresses of all authors and 5) name and *full* postal address of the corresponding author who also acts as 'guarantor' for all parts of the manuscript. The corresponding author's institution, postal and email addresses are displayed in the article PDF and the online article. Please note: the submitting author must also enter the names and contact information for all co-authors during the submission process.

The title should be informative and accurate and at the same time trigger the interest of the reader. The short running title will appear as a header in the published the paper. The title page should also include a separate word count of the abstract and manuscript (excluding references, tables and figures). Please include 5-10 keywords that do not replicate words in the title. Since *Global Health Action* does not use double-blind review, the title page is the first page of the manuscript.

Abstract: Articles must include an abstract of 300 words. The abstract should provide sufficient information for a reader to be able to decide whether or not to proceed to the full text, and should not generally consist of sentences cut and pasted from the manuscript.

A structured abstract should follow the structure: Background, Objective, Methods, Results, and Conclusions, and is required for Original Research, Review Articles or PhD Reviews.

An unstructured abstract is required for Editorials, Study Design Articles, Current Debates, Methods Forum Articles, Short Communications, or Capacity Building Articles.

You can opt to include a **video abstract** with your article. Find out how these can help your work reach a wider audience, and what to think about when filming.

Manuscript sections: Original and review articles should follow the layout *: Background, Methods, Results, Discussion, and Conclusion.* Other types of articles may have different structures.

Section headings: Please do not number section headings. Use a maximum of three levels of headings made clear by orthographic indicators, e.g., capitals, italics, bold, etc. Begin each section, including figure and table legends, on separate sheets. Insert running page numbers in the footer.

Units and Equations. Please use SI units (non-italicized). If you are submitting your manuscript as a Word document, please ensure that equations are editable. More information about mathematical symbols and equations.

Tables: Tables should present new information rather than duplicating what is in the text. Readers should be able to interpret the table without reference to the text. Please supply editable files.

Ensure that all the tables have been formatted correctly. Tables should have titles, column/row headings, and footnote if applicable. Ensure that all parts of the tables fit within the page margins. If necessary, split large tables into two or more, but ensure column/row headings are provided on each page. Very large tables may be better presented as on-line supplementary material. Authors are encouraged to use one decimal point for percentages, and three decimal places for p-values (note p=0.000 is not acceptable; instead write p<0.001).

Figures: If the manuscript is accepted for publication, please supply figures/graphics/images in at least 300 dpi files. Figures should be saved as TIFF, PostScript or EPS files. All charts (bar, pie, column, etc.) should be two dimensional, unless three dimensions are required to present the data. On-line versions of papers normally include figures in colour, but remember that some readers may use monochrome printed versions; therefore check that important details do not disappear in monochrome. More information on how to prepare artwork.

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End materials: Please ensure you supply all end matter sections required in the following order: Acknowledgments, Author contributions, Disclosure statement, Ethics and consent, Funding information and Paper context. If one or more of these headings don't apply, please use N/A.

Acknowledgements: All contributors who do not meet the criteria for authorship should be listed in an acknowledgments section. Examples of those who might be acknowledged include a person who provided purely technical help, writing assistance, or a department chairperson who provided only general support. Financial and material support should also be acknowledged.

Authors contribution: *Global Health Action* requests its authors to comply with authorship criteria as defined by the International Committee of Medical Journal Editors (ICMJE) in its requirements for authorship. The contributions of each author should be revealed clearly and will be published in the article.

The International Committee of Medical Journal Editors (ICMJE) recommends that authorship be based on the following 4 criteria:

1. Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND

2. Drafting the work or revising it critically for important intellectual content; AND

3. Final approval of the version to be published; AND

4. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

See here for further information on the authorship criteria.

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Ethics and consent: When reporting experiments on patients or population surveys, please indicate whether the procedures followed were approved by the local ethics committee and/or in accordance with the Helsinki Declaration of 1975, as revised in 2008 (http://www.wma.net/en/30publications/10policies/b3/17c.pdf). All other studies with direct involvement of human beings should also have ethical approvals and clear statements on how the ethical issues have been considered and resolved in the study.

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PART E: POLICY BRIEF

POLICY BRIEF

TECHNICAL AND SCALE EFFICIENCY OF PUBLIC CLINICS IN ESWATINI

31 JANUARY 2020

KEY CONCEPTS

- **Inefficiency refers to wastage of resources or inappropriate use of resources.**
- **Data Envelopment Analysis is a technique that is used to identify hospitals that use resources better than other and to identify those that waste resources.**
- **In sub-Saharan Africa, hospitals absorb the greatest proportion of the total health expenditures, which is estimated at 45–69% of government health sector expenditures .**

As African countries are striving to achieve WHO universal health coverage goal for their population, they are usually confronted with critical resource constraints. Their limited ability to adequately finance their health care needs is further exacerbated by inefficiency in their health care delivery systems, especially within public health facilities. This study is about assessing efficiency in Eswatini's health system in utilizing scarce human and financial resources to meet the health needs of its population.

ABOUT THIS STUDY

A data envelopment analysis (DEA) model was built to analyze the efficiency of a nationally representative sample of 65 public clinics from all four regions of the Kingdom of Eswatini.

The DEA model used as inputs: the number of clinical staff, the number of support staff, the number of facility consultation rooms and central government funding to the health facility.

Selected outputs were the number of outpatient visits, the number of antenatal care visits, the number of children immunized and the number of patients initiated on TB treatment .

Data on inputs and outputs variables were collected from Eswatini Ministry of health Health management information system, health planning unit and regional implementing partners databases.

467 more nurses or 261 more doctors could have been paid for 12 months or 2 months stock of ARVs could have been bought if all 65 clinics were operating efficiently!

KEY FINDINGS

- **A total of 42 out of the 65 hospitals are operating inefficiently because there is substantial wastage of resources.**
- **All 42 inefficient clinics could have delivered the same level of output with 5,701,449.4, US $ less in government funding, 115.3 less clinical staff, 138.8 less support staff and 119.8 less consultation rooms**

POLICY RECOMMENDATIONS

1. Use government funding to improve the quality of services among efficient clinics.
2. Re-allocate clinical staff to provide services closer to the patients within their communities by establishing mobile outreach teams.
3. Use re-allocated non-clinical staff to support demand creation activities within the community to address unmet needs.
4. Institutionalize routine assessments of wastages within Eswatini's health system.

Eswatini Ministry of Health should conduct regular assessments of the level of resource wastage within the health system.

CONCLUSION

Significant amounts of resources could be saved if measures were put in place to mitigate resource wastages. Hence, policy interventions that help not only optimize inputs but also allow outputs expansion through improving the demand for health care would contribute to improving efficiency of public clinics in the Kingdom of Eswatini.

This policy brief is based on an MPH (Health Economics) mini-dissertation by Dr. Kikanda Kindandi submitted to University of Cape Town (UCT) at the Health Economics Unit, Faculty of Health Sciences. The dissertation was supervised by Dr. John E. Ataguba (Health Economics Unit, UCT).

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