# TECHNICAL EFFICIENCY OF PUBLIC HEALTH CENTERS IN THREE WOREDAS OF JIMMA ZONE, SOUTHWEST ETHIOPIA

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A research report submitted to Jimma University College of Health Sciences, Department of Health Economics, Management, and Policy for the Partial Fulfillment for the Requirement for Master of Public Health in Health Services Management (MPH-HSM)

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# Technical efficiency of public health centers in three Woredas of Jimma Zone, Southwest Ethiopia

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## Abstract

***Background:*** in low and middle income countries, which are where the vast majority of African countries are ranked, scarcity of funds for health is an acute problem. Health centers at the center of primary Health Care Unit (PHCU) are a vital part of Ethiopia's public health system. Funds are being generously (75% of the total budget allocated to the health sector) provided for construction and running of health centers by the government, donors and international organizations. Therefore, scarce resources available to the health sector are compelling to question efficiency of health centers. Unless inefficiencies are identified and eliminated, resources will keep on leaking out of the health care system.

***Objectives:*** the objective of the study was to measure the magnitude of individual health center's technical and scale efficiency. And estimate the amount of input reduction and/or output increases needed to make inefficient health centers efficient. Moreover, identifying factors associated to efficiency.

***Methods:*** This study used a two stage data envelopment method, to estimate the technical efficiency and factors associated with efficiency among 16 public health centers found in Kersa, Mana and Seka Chekorsa Woreda s of Jimma zone. Data envelopment analysis was used to estimate technical, scale efficiency of the health centers. Second stage analysis was conducted to identify institutional and environmental factors associated with efficiency using Tobit regression model.

**Results:** Three out of the 16 health centers in the study were found to be technically efficient, with an average score of 77% (standard deviation = 16%). On the other hand, 8 out of 16 health centers were found to be scale efficient, with an average scale efficiency score of 94% (standard deviation = 9%). Catchment population and number of clinical staff were found to be directly associated with efficiency, while the number of nonclinical staff inversely was found to be associated with efficiency.

**Conclusion:** The study has revealed that majority of the health centers are technical inefficient. Only half of the health centers were found to be scale efficient, implying that significant amounts of resources is being wasted. Considering the scarce resource available to the health sector, the findings indicate that performance improvement measures have to be taken to curb leakage of health care resources.

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Abbreviations

AE allocative efficiency
CE cost efficiency
CH health centers
CHC community health center
CHP community health posts
CRS Constant return to scale
DEA Data Envelopment Analysis
DEAP 2.1 DEA Programme, version 2.1
DMU Decision Making Units
DRS Decreasing return to scale
GNP gross national product,
HEP Health Extension package
HP health posts
HSDP IV Health Sector Development Programme IV
IRS Increasing return to scale
MCHP maternal and child health posts
MOH Ministry Of Health (Federal Democratic Republic of Ethiopia)
PHCU Primary Health Care Unit
SD standard deviation
SE scale efficiency
SFM stochastic frontier models
SSA Sub Saharan African
TE technical efficiency
VRS Variable return to scale
WHO World Health organization

# Chapter One: Introduction

## 1.1. Background

Efficiency – Extended Pareto-Koopmans Definition: Full (100%) efficiency is attained by any decision making unit (DMU) if and only if none of its inputs or outputs can be improved without worsening some of its other inputs or outputs. On the other hand, relative efficiency is when decision making unit(DMU) is to be rated as fully (100%) efficient on the basis of available evidence if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs. Notice that this definition avoids the need for recourse to prices or other assumptions of weights which are supposed to reflect the relative importance of the different inputs or outputs. It also avoids the need for explicitly specifying the formal relations that are supposed to exist between inputs and outputs. This basic kind of efficiency, referred to as "technical efficiency" in economics can, however, be extended to other kinds of efficiency when data such as prices, unit costs, etc., are available for use in data envelopment analysis(DEA) (1,2).

For efficiency to be measured a norm must be specified. The norm set for measuring technical efficiency is that the minimum amount of resources should be used for a given level of output or, alternatively, the maximum amount of output that should be produced for a given level of resource use. If more resources than necessary are used to produce a given amount of output, this implies a waste of resources and therefore inefficiency (the inefficiency score gets closer to zero). Equally, the difference in the amount of output that could have been produced from a given amount of resources and the amount of output that was actually produced can be used as a measure of technical inefficiency (3). Technical inefficiency is a matter of how much unnecessary resources have been used. The size of a health center may sometimes be a cause for inefficiency. A health center may be too large for the volume of activities that it is conducting; and therefore may experience inefficiencies of scale. In the presence of inefficiencies of scale, a health center is inefficiently large, unit costs increase as the scale of production increases. On the other hand, a health center may be too small for its level of operation, and thus experience efficiencies of scale.(4) Inefficiency is the same as to a torn rice sack. If the holes are not identified and sealed, it would be impossible to fill the sack. In a similar way, unless

inefficiencies are identified and eliminated, resources will keep on leaking out of the health care system.(5)

A number of countries in Africa have been inefficient in the use of available resources. The achievement of national and international health development targets requires not only an increase in funding, but also efficient use of available resources and greater equity in financing and accessing quality health care. The inefficiency in the management of health subsystems is well established. There are weak policies related to allocation and timely disbursement of funds to the end users. This may lead to abuse and overfunding of certain health services and avoidable wastage. Reports of WHO indicate that resources wasted through inefficiency are significant. However, governance in some countries is commendable in that the countries are able to achieve more and better results than others at the same or higher level of health expenditure demonstrating for the huge potential for efficiency gains (6).

The Ethiopian health sector has a three-tier health care delivery system: level one is a Woreda/District health system comprised of a primary hospital (to cover 60,000- 100,000 people), health centers (1/15,000-25,000 population) and their satellite Health Posts (1/3,000-5,000 population) connected to each other by a referral system. The primary hospital, health center and health posts form a Primary Health Care Unit (PHCU). Level two is a General Hospital covering a population of 1-1.5 million people; and level three is a Specialized Hospital covering a population of 3.5-5 million people. Significant investments are directed at improving the quality and equitable delivery of health services provided at health center level, with a strategic emphasis on crucial and interrelated elements – accessibility, affordability, and sustainability. These priorities underpin the government's community- centered effort to expand primary health care delivery at the local level through its flagship Health Extension Program (HEP)(7).

Funds are being generously provided for construction and running of health centers by the government, donors and international organizations. The scarce resources available to the health sector are compelling to question efficiency of health centers. Do health centers produce their outputs using the minimum amount of inputs feasible? Are there any inefficiency related to the size of a health center (too large or too small)? If all health centers operate efficiently, what are the possible efficiency savings? What are the lessons that can be drawn from the efficient health

center that are worth emulating by those that are inefficient so as to improve the efficiency of health centers and maximize efficiency savings?(4)

In general coupled with inefficiency, Ethiopia's health spending is lower than the average for Sub-Saharan Africa, with the exception of private expenditures as a share of total spending(8).

*Data envelopment analysis conceptual framework*

Data Envelopment Analysis (DEA) is an approach for evaluating the performance of a set of fairly homogeneous entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. The definition of a DMU in this study is health center. DEA have been used to evaluate performance of many different types of organizations/entities providing different kinds of services. DEA has been used in many different countries to evaluate technical efficiency of health facilities. (2,4,9,10)

DEA is a methodology directed to frontiers rather than central tendencies. Instead of trying to fit a regression plane through the center of the data as in statistical regression, for instance, one of the entities stays well above the rest as a "best practice frontier". Because of this perspective, DEA proves particularly fit at uncovering relationships that remain hidden from other methodologies. For instance, consider what one wants to mean by "efficiency", or more generally, what one wants to mean by saying that one DMU is more efficient than another DMU. This is accomplished in a straightforward manner by DEA without requiring explicitly formulated assumptions and variations with various types of models such as in linear and nonlinear regression models. Relative efficiency in DEA accords with the following definition, which has the advantage of avoiding the need for assigning a priori measures of relative importance to any input or output.(2)

Health facilities that assume the "best practice frontier" are assigned an efficiency score of one (or 100%) and are said to be technically efficient compared to their peers. The efficiency of the health facilities below the efficiency frontier is measured in terms of their distance from the frontier. The inefficient health facilities are assigned a score between one and zero. The larger the score the more efficient a health facility is(11).

For efficiency to be measured a norm must be specified. The norm set for measuring technical efficiency is that the minimum amount of resources should be used for a given level of output or,

alternatively, the maximum amount of output that should be produced for a given level of resource use. If more resources than necessary are used to produce a given amount of output, this implies a waste of resources and therefore inefficiency (the inefficiency score gets closer to zero). Equally, the difference in the amount of output that could have been produced from a given amount of resources and the amount of output that was actually produced can be used as a measure of technical inefficiency (3). Technical inefficiency is a matter of how much unnecessary resources have been used. The size of a health center may sometimes be a cause for inefficiency. A health center may be too large for the volume of activities that it is conducting; and therefore may experience inefficiencies of scale. In the presence of inefficiencies of scale, a health center is inefficiently large, unit costs increase as the scale of production increases. On the other hand, a health center may be too small for its level of operation, and thus experience efficiencies of scale.(4)

Until recently, the traditional methodology for measuring efficiency in economics (including health economics) has been the production frontier approach based on the principles of statistics and econometrics. These functions, which are estimated to determine efficiency, are also known as stochastic frontier models (SFM). During the recent few decades, however, an alternative methodology to the stochastic frontier approach (SFA) has been developed and its application has grown rapidly over the years. This methodology has come to be known as the Data Envelopment Analysis (DEA)(3,12,13). It has been found that there are several compelling methodological and practical advantages for using DEA over the stochastic frontier models(14,15).

On the other hand, DEA estimation can only tell how well a DMU or health center (in our case) is doing compared to its peers but not compared to a "theoretical maximum". In other words since DEA gives a relative measure of efficiency it has the potential of justifying inefficiency i.e. even those that appear to be efficient in the sample might actually be inefficient in absolute terms. This problem can, however, be minimized by using a large sample data set. Another limitation or disadvantage is that since DEA is a non-parametric technique, statistical hypothesis testing is difficult to do.

## 1.2 Statement of the problem

The need to develop strong health financing systems is a common objective of all countries. Even the richest countries are finding it increasingly difficult to keep up with rising health care costs, and the current economic downturn is adding more pressure on health spending. In low and middle income countries, which is where the vast majority of African countries are ranked, scarcity of funds for health is an even more acute problem. Insufficient investment in the health sector is a serious obstacle to improving health outcomes in Africa, particularly considering that the continent bears the bulk of the global morbidity and mortality burden. The major constraint arising from funds shortage in most African countries is that the strategies and mechanisms that underpin health financing systems pose problems(16,17).

It is known that a great deal of fund is being allocated to the health system, from the total fund allocated to the health system worldwide 20% to 40% of all health resources being wasted. If the inefficiency in utilizing resources can be curbed, resources can be used efficiently, health systems can address their customers with better quality health services(5).

The most significant constraints against the rapid scale up of health interventions are the prevailing inadequacy and inefficiency in the resource mobilization and allocation for health(7).
Inefficiencies reduce the extent to which health systems are able to achieve goals of health status improvement, responsiveness to client's rational expectations, and fairness in health care financing. Citizens lose opportunities to achieve health improvements without additional cost because of inefficient use of resources. Developing countries especially in Sub-Saharan African countries there is obvious scarcity of resources and at the same time there is significant problem in utilizing existing resources efficiently (18).
WHO review of experiences, information gaps and research needs on the Health Sector Reforms in Sub-Saharan Africa points to the fact that besides the issue of ever diminishing financial inflows to the health sector, poor quality of health care, mainly occasioned by a variety of inefficiencies at all levels of health care delivery is one of the most important concerns which has precipitated a number of reform initiatives and strategies in nearly all the developing countries(19). There is also a growing concern among policy makers and planners that health services are not being delivered with utmost efficiency. Evidence from the Africa Region

indicates that the problem of scarcity of resources is also combined with technical inefficiency that leads to wastage of the available scarce resources(20).

In Ethiopia the government is majorly concerned with addressing access and coverage issues and there is a knowledge gap as to the level of efficiency of health centers in the overall delivery of health services. To enhance the efficiency of health centers, planners need to develop methods to tackle the problems of accessibility, acceptability, intensity of use and compliance with medical instructions, quality of care, recurrent costs and community ownership.(4) To develop these methods, planners need baseline information of the efficiency levels in the health centers. Unfortunately there is limited literature on efficiency measures of health centers especially in developing countries and particularly in Africa(4). In Ethiopia, there is only one study that measured technical efficiency of 60 health posts by Sebastian and et al.(13) However, as far as the best knowledge of the investigators there is no study measuring health centers technical and scale efficiency of public health centers in Ethiopia.

Health centers at the center of primary Health Care Unit (PHCU), are a vital part of Ethiopia's public health system. Given their strategic location in the midst of communities, they constitute an invaluable vehicle for 'organizing community effort for the sanitation of the environment, the control of communicable infections, the education of the individual in personal hygiene and the organization of medical and nursing services for the early diagnosis and preventive treatment of disease'. As a result, the government is allocating a significant (as much as 75% of the budget allocated to health sector) amount of fund for health centers to address the health service needs of the wide community(7,21). However, not much has been done to assess the efficiency of those health facilities. Moreover, it is important that the scarcely available resources are utilized efficiently. Since, significant fund is being allocated to the primary health care units, it important to assess the efficiencies of those health centers

The real issue is that the absolute level of resources available in relation to the health needs is well below what is needed. The lingering financial crisis in donor countries also means that some are likely to further reduce further the dollar values of their disbursements until their economies start growing again. Greater attention to prioritizing and coordinating spending could yield considerable efficiency gains as well. Ways to do this include increasing use of in-country or south-south technical expertise; integrating the provision of in-service training; and improving

supply chains and other initiatives funded by disease- specific grants so they benefit the wider health system. Efficiency in domestic health spending can also be improved in most countries.(5)

The World Health Report 2010, Health Systems Financing: the Path to Universal Coverage, outlined ten common causes of inefficiency in health systems. The ten common causes of inefficiency in health system are as follows. (5).

## Significance of the study

While some countries lose more than others, most, if not all, fail to fully exploit the resources available, whether through poorly executed procurement, irrational medicine use, misallocated and mismanaged human and technical resources or fragmented financing and administration. But there is nothing inevitable about this and there are many shades of inefficiency. Some countries obtain higher levels of coverage and better health outcomes for their money than others, and the gap between what countries achieve and what they could potentially achieve with the same resources is sometimes enormous.

To date no study in Ethiopia has tried to estimate technical efficiency of individual health centers. Thus, there is need for such a study to bridge that knowledge/information gap.

Assessing the technical efficiency of health centers is very essential in order to be able to utilize the available resources optimally and facilitate the move towards achieving health and development goals. Health services are labor intensive, and thus, it is important to ensure that human resources for health are used efficiently. This study will shade light to how efficiently human resources are being used to optimize health services contributions to improving community's health status.

About 80% of the Ethiopian population live in rural areas. Health needs (preventive, promotive, and curative) of the majority of those people are met by the health centers and health posts. This study will contribute to the health system by identifying inefficiency gaps of health center, and will provide direction to the policy makers and decision makers by leading the way on how and what to improve to provide efficient and quality services to wider community in need.

This study identifies the health facilities with "best practice." In future more detailed studies, could examine and document their operating practices to establish a guide to "best practice" for inefficient health centers to emulate.

Some health centers are not as effective as others and has failed (for various reasons). In such cases, the government have to intervene to ensure efficiency in use of resources. Thus, both the Government and NGOs require information on the extent of technical efficiency in individual health facilities and inputs, and what can be done to optimize their efficiency. This study not only identifies the technical performance of each health center in the sample, but also the

magnitudes of inefficiencies in the use of each input among the inefficient health facilities. Such information would be useful to the policy-makers and district health services managers in their effort of designing appropriate policy and managerial interventions for ensuring efficient use of health care producing resources.

# Chapter Two: Literature Review

## Literature review

**Data Envelopment Analysis**

To assess differences in the productive efficiency of health centers, we use DEA, a mathematical programming based method that converts multiple input and output measures into a single summary measure of productive efficiency. DEA is based on relative efficiency concepts proposed by Farrell but Charnes et al (1994) extended and developed Farrell's approach. (3,15).

The standard DEA model, the relative efficiency of production unit is defined as the ratio of the sum of its weighted outputs to the sum of its weighted inputs. The weights have been determined so as to show the production unit at the maximum relative efficiency(4).

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

In DEA the efficiency of an organization (health centers in this case) is measured relative to a group's observed best practice. This implies that the benchmark against which to compare the efficiency of a particular health center is determined by the group of health centers in the study and not a value fixed by health centers outside of the group.

## *Model specification*

Total efficiency is a combination of technical efficiency (TE), which reflects the ability of a unit to obtain maximal output from a set of inputs, and allocative efficiency, which reflect the ability of a unit to use the inputs in optimal proportions, given their respective prices.

### *Input and output orientation*

TE attempts to address two questions depending on whether it has input- or output-orientation. In input-oriented TE focuses on reducing input quantities used for a given level of outputs. On the other hand, in output-oriented TE the focus is on expanding output quantities with a fix amount of inputs. The choice of the approach is recommended to be based on which side of the orientation (input or outputs) the decision makers in the health facility have more control over. Given their public health orientation, health center staff had a duty to induce demand (through health promotion strategies) for preventive health care services such as antenatal care, family planning services, immunizations, etc. Through their outreach public health work among

communities, PHU staff were also supposed to mobilize community efforts and other resources to provide hygienic human waste disposal facilities, e.g. vented improved pit latrines, especially in rural areas and slums. In this study, both input and output orientation models were applied. (13)

*TE comprises both pure technical and scale efficiency components. Thus, a second consideration in estimating a DEA model is whether to assume constant or variable returns to scale (VRS).*(13)

***Constant Returns to Scale (CRS) model***

Returns to scale implies the changes in output as all inputs change by the same proportion. The constant returns to scale model assumes a production process in which the optimal mix of inputs and outputs is independent of the scale of operation. CRS is when specific amount of input produces the required/expected amount of output. The objective function is to maximize the efficiency score $h_0$ for health center $j_0$, subject to the constraints that no health center will be more than 100% efficient and the coefficient values are positive and non-zero, when the same set of u and v coefficients (weights) are applied to all other health centers being compared.

***Variable Returns to Scale (VRS) model***

The VRS model, though similar to the CRS model, measures pure technical efficiency and returns to scale for each of the sample health centers. VRS is a condition in which the amount of output produced by the health center increases or decreases than the expected output using specific amount of inputs. Scale efficiency can be measured by dividing the CRS efficiency score by the VRS efficiency score. From the VRS model, it is possible to analyze whether a health center's production indicates increasing return to scale, constant return to scale, or decreasing return to scale by the sign of the variable $\mathbf{z_{j_0}}$. Increasing returns to scale exists if the value of $z_{j_0}$ is greater than zero ($z_{j_0} > 0$), constant returns to scale if the value of $z_{j_0}$ is equal to zero ($z_{j_0} = 0$), and decreasing returns to scale if the value of $z_{j_0}$ is less than zero ($z_{j_0} < 0$). Thus, we can analogize the existence of efficiencies of scale similar, confirm the most productive scale size (minimum efficient scale) of a health center and estimate the number of health centers operating at the efficient scale(4,22).

This is so because the VRS model isolates the pure technical efficiency component and scale efficiency which related to the size or structure of the decision making unit (DMU). Health centers that are overall efficient exhibit constant returns to scale. The size of a Health center may sometimes be a cause for inefficiency. A health center may be too large for the volume of activities that it is conducting; and therefore may experience inefficiencies of scale. On the other hand, a health center may be too small for its level of operation, and thus experience efficiencies of scale. Inefficiency due to congestion refers to too many inputs (staff, funds, drugs, etc) leading to decreased output or what is commonly known as inefficiencies of scale which to some extend are realistic assumption for a developing country like Ethiopia where irrational reasons affect the establishment of facilities such health centers(4).

The past ten years have been a difficult time for Africa in terms of allocating sufficient fund for health sector due to external and internal economic factors. Many of the countries are highly dependent on donor funding for up to 20% of their health expenditure. Varies activities of the government in the production, distribution and allocation of health care funds are now being redefined. All these changes have far-reaching consequences on equity, access, quality, effectiveness, efficiency and sustainability of health care services. The extent contribution to health financing by which governments in SSA is varied.(23)

About 20–40% of resources spent on health are wasted, resources that could be redirected towards achieving better access for health service. While raising more money for health is crucial for lower-income countries striving to move closer to universal coverage, it is just as important to get the most out of the resources available. Finding the most efficient ways to meet the multiple challenges health systems face is also an issue for those countries that might be struggling to sustain high levels of coverage in the face of constantly increasing costs and growing demand.(5,24)

*Efficiency of primary health care units using data envelopment analysis*

The TE of 60 health posts in rural Tigray, Ethiopia was estimated by Sebastian and Lemma (13). The inputs were number of health extension workers and of voluntary health workers (traditional birth attendants and community health workers). The outputs for each health post were health education sessions given by health extension workers (HEWs), number of persons who

repeatedly visited the family planning service, pregnant women who completed three antenatal care visits, diarrheal cases treated in children under-five, child deliveries, visits carried out by community health workers, total new patients attended, and malaria cases treated. The mean scores for technical and scale efficiency were 0.57 (SD = 0.32) and 0.95 (SD = 0.11), respectively. Fifteen (25%) health posts were found to be technically efficient and 38 (63.3%) were operating at their most productive scale size.

In Ghana Akazili et al (4) calculated the TE of 89 health centers. The inputs used were non-clinical staff including laborers, clinical staff, beds and cots, and expenditure on drugs and supplies. The outputs were general outpatient plus antenatal care visits, deliveries, children immunized, and family planning visits. Thirty-one (35%) health centers were technically efficient. The inefficient health centers had an average TE score of 57% (SD = 19). Nineteen (21%) health centers were scale efficient, and the inefficient health centers had an average scale efficiency score of 86% (SD = 14).

The degree of technical, allocative and cost efficiency among 40 health centers in Lusaka, Central and Copper-Belt provinces of Zambia was estimated by Masiye et al (25). Fifty eight per cent were government owned and 42% private-for-profit enterprises. The study used the numbers of clinical officers, nurses and other staff as inputs, and the number of outpatient visits as output. The average TE, allocative efficiency (AE) and cost efficiency (CE) scores for the private health centers were 70%, 84% and 59%, respectively. These scores were 56%, 57% and 33%, respectively, for government health centers. For the whole sample, the averages were 61.9% for TE, 68.5% for AE and 44.5% for CE. Of the 17 private health centers, 5 had a TE score of 100 and 4 had AE and CE scores of 100%. Contrastingly, only 1 of the 23 government health centers had TE, AE or CE scores of 100%.

Renner et al (10) investigated TE and SE levels among a sample of 37 public PHUs in Sierra Leone. The six outputs for each PHU were (i) antenatal plus postnatal visits, (ii) child deliveries, (iii) nutritional/child growth monitoring visits, (iv) family planning visits, (v) immunized children under five years and pregnant women immunized with tetanus toxoid (TT), and (vi) total health education sessions conducted through home visits, public meetings, school lectures and outpatient departments. In Sierra Leone PHUs did not provide curative care services but were dedicated to health promotion and disease prevention services. The two inputs were (i)

technical staff (community health nurse, vaccinators and maternal and child health aides) and (ii) nonclinical staff, including traditional birth attendants, porters and watchmen. Twenty-two (59%) of the 37 health units analyzed were found to be technically inefficient with an average score of 63% (SD = 18). On the other hand, 24 (65%) health units were found to be scale inefficient with an average scale efficiency score of 72% (SD = 17).

Osei et al (11) estimated the TE of 17 district hospitals and 17 health centers in Ghana in 2000. The DEA model was estimated with four outputs: child deliveries; fully immunized children under the age of five years; maternal visits for antenatal care, postnatal care and family planning, and childcare visits for nutritional and child growth monitoring; and outpatient curative visits. The two inputs were technical staff including medical assistants, nurses and paramedical staff, and support or nonclinical staffstaff including cleaners, drivers, gardeners, watchmen and others. Eight (47%) hospitals were technically inefficient with an average TE score of 61% (SD = 12). Ten (59%) hospitals were scale inefficient manifesting an average SE of 81% (SD = 25). Out of the 17 health centers, 3 (18%) were technically inefficient with a mean TE score of 49% (SD = 27) and 8 (47%) were scale inefficient with an average SE score of 84% (SD = 16).

Kirigia, Emrouznejad, Sambo et al (26) measured the TE of 32 public health centers in Kenya. The six inputs used were clinical officers and nurses; physiotherapists, occupational therapists, public health officers, dental technologists, laboratory technicians and laboratory technologists; administrative staff; non-wage expenditures; and beds. The four outputs were visits for diarrhea, malaria, sexually transmitted infections, urinary tract infections, intestinal worms and respiratory disease; visits for antenatal care and family planning; immunizations; and other general outpatient visits. Fourteen (44%) health centers were technically efficient, and the average TE score was 65% (SD = 22). Nineteen (59%) health centers were scale efficient, and the average SE score was 70% (SD = 19).

Kirigia and Asbu (27) estimated the TE of secondary public community hospitals in Eritrea. The inputs were Health workforces, which includes Physicians, Nurses and midwives and Laboratory technicians, Beds, Medicines & supplies, and Capital inputs such as buildings, equipment, vehicles. On the other hand the output includes Outpatient visits and Inpatient department discharge. From the total of 20 hospitals 68% hospitals were variable returns to scale technically efficient; and only 42% hospitals achieved scale efficiency. On average, inefficient hospitals

could have increased their outpatient visits by 5.05% and hospital discharges by 3.42% using the same resources. The second- stage analysis this study shows that the ratio of outpatient visits to inpatient days and average length of inpatient stay are significantly correlated with hospital inefficiencies. This study shows that routinely collected hospital data in Eritrea can be used to identify relatively inefficient hospitals as well as the sources of their inefficiencies.

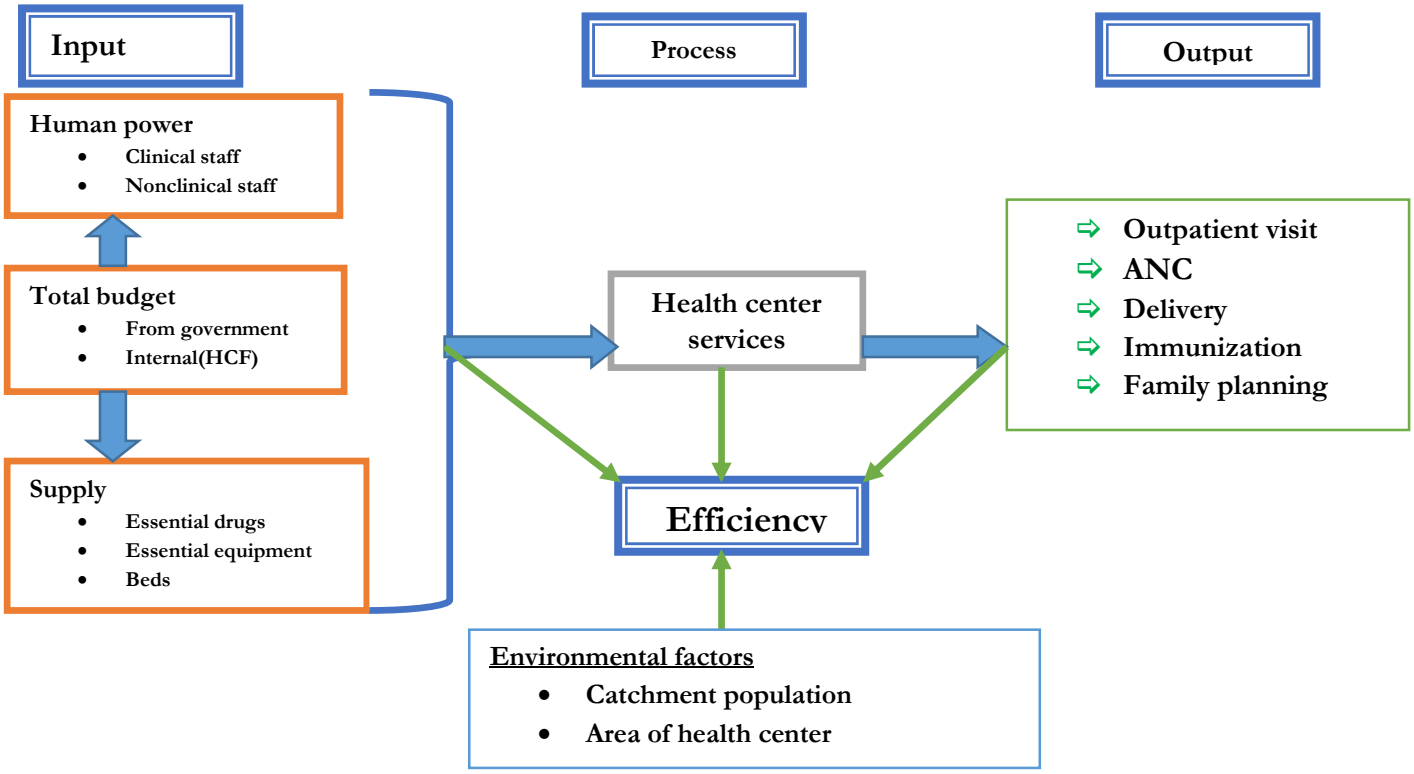
Kirigia, Sambo and et al investigated TE of primary health units in Kailahun and Kenema districts of Sierra Leone. The three outputs for each individual health centre were the number of outpatient, maternal, child health and family planning visits, plus immunization visits; the number of vector control activities; and the number of health education sessions. The two inputs were the number of community health officers, MCH aides and state enrolled community health nurses; and the number of support staff (including cleaners, drivers, gardeners, watchmen and others). The average score for CRSTE was 62.4% (SD = 32.7), for VRSTE it was 69.2% (SD = 32.7) and for scale efficiency it was 88.8% (SD = 13.5). The mean of 69.2% for VRSTE implies that the inefficient CHCs ought to increase their output by 30.8%. The findings indicate that 77.8% of the MCHPs, 59.1% of the CHCs and 66.7% of the CHPs were variable returns to scale technically inefficient. The 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.(28)

*Factors for efficiency*

Some studies have applied a Tobit regression to identify the correlation of DEA scores with environmental and institutional variables that may influence the health centers production process, such as catchment population, distance, location (urban/rural), ownership (profit/not-for-profit), payment source (out-of-pocket/health insurance), outpatient visits as a proportion of in- patient days, and quality, outpatient visits, the number of clinical staff and the number of clinical staff.(27,29,30)

In Greece Kontodimopoulos, et al assessed the relationship of environmental characteristics, with efficiency. Two explanatory variables, were chosen to be included in a Tobit regression: i) catchment population (small, medium and large) location (urban/ semi-urban vs. remote/island) to account for accessibility and population demographics. Systematically lower technical efficiency scores corresponded to the medium- and large-sized centers, and to urban/semi-urban areas.(31)

## Conceptual framework




Source: adopted after reviewing literatures.

Figure 1- Relationship between inputs and the production process and resulting outputs

This study focuses on the human power part of input. Due to lack complete Data on the nonwage expenditure and supplies were not included in the study.

## Chapter Three: Objectives and Hypothesis

# Objective

## General objective

To measure efficiency of public health centers using DEA in three Woredas of Jimma zone, Oromia, south west Ethiopia.

## Specific objectives

1. To calculate the magnitude of individual health center's technical efficiency.
2. To measure the magnitude of individual health center's scale efficiency.
3. To estimate the amount of input reduction and/or output increases needed to make inefficient health centers efficient.
4. To identify factors associated with technical efficiency of health centers.

# Chapter Four: Methods and Materials

## Methods and materials

### 4.1 Study area and period

The study was conducted from September 2013 to August 2014, Jimma Zone, Oromia Regional State, which is located 335 Kilo meters to the south west of Addis Ababa, the capital city of Ethiopia. And the data collection period was from March (1-15) of 2015. The total population of Jimma zone is 2,928,151. It has 18 districts. The total number of health centers in Jimma zone is 112. The average number of health center in each Woreda is six.

### 4.2 Study design

Health facility based cross sectional study, using data envelopment.

### 4.3 Populations

#### 4.3.1 Source population

All health centers in Jimma zone.

#### 4.3.2 Study population

All health centers in *Mana*, *Kersa* and *Seka chekorsa* Woredas/districts of Jimma zone.

### 4.4 Inclusion and exclusion criteria

#### 4.4.1 Inclusion criteria

- Health centers which had complete data of inputs and outputs in the year of 2013/2014.

#### 4.4.2 Exclusion criteria

- Health centers which started working after 2013/2014.

## 4.5 Sample size determination and sampling techniques

Jimma zone has 18 Woredas. Out this three Woredas were selected by convenience sampling technique, due to logistic reasons. The Woredas include Mana, Kersa and Seka Chekorsa. The number of health centers in the Woredas were 6 in Mana, 6 in Kersa woreda and 7 in Seka chekorsa Woreda. Out of the 19 health centers only 16 health centers were included in the study. The rest three health centers two from Seka chekorsa and one in Mana Woreda just started working in 2015.

## 4.6 Data collection procedures

### 4.6.1 Data collection instrument

The instrument was prepared after reviewing different literatures. The Ethiopian standard for health centers requirement(32) and other literatures(4,10,28,29) were used to prepare the document review check list to collect the data from the health centers. The contents of the document review checklist (data collection instrument) includes, input and output data and environmental factor such as catchment population of those health centers in the year of 2013/2014.

### 4.6.2 Data collectors

Two public health officer and one BSC Nurse Data collectors were employed. One MPH graduate including the principal investigator were supervising the data collection procedure. The other qualities required from data collectors was the ability to fluently speak the native language Oromifa. In addition, the data collectors were required to have at least a one year experience of working in health center. The supervisor and the data collectors were trained for two days on the content and objective of the study.

### 4.6.3 Data quality control

The data were collected using a document review check list developed for the study after extensive review of literatures to obtain information on the inputs utilized by the health centers and outputs produced. Data for environmental factors associated with efficiency of health centers were also collected using document review checklist.

The 2013/2014 input and output data of the health center were used for the study. The inputs of the health centers considered in this study was human power (clinical and nonclinical). Nonwage expenditure and expenditures on other supplies were not included due to lack of data. The clinical/technical staff included in the study were health officers, clinical and BSC nurses, Midwife, Laboratory technician/ technologist, Pharmacy technician/ druggist, Pharmacist and Environmental health professionals. The nonclinical staff are the administrative and general (cleaners and watchmen) staff. The outputs include total number of outpatient visit, four and above ANC visits, children vaccinated for pentavalent vaccine three times, deliveries and family planning services.

## 4.7 Study Variables

**Data envelopment analysis (DEA) variables:**

**Input variables**

- Human resources
    - Number of administrative
    - The number of genitors and guards
    - Number of health officers
    - Number of Nurses: clinical and Midwives
    - Number of laboratory technician and technologist
    - Number of pharmacy technician and pharmacists
    - Number of occupational therapists
    - Number of physiotherapists
    - Number of Environmental health

**Outputs**

- Output 1: General outpatient visits
- Output 2: Number of antenatal care visits
- Output 3: Number of deliveries
- Output 4: Number of children immunized
- Output 5: Number of family planning visits

**Factors for efficiency**

**Dependent variable**

- ⇨ Technical efficiency score of the health centers.

**Independent variables**

**Environmental factors**

- ✓ Catchment population
- ✓ Location of health center

**Intuitional factors**

- ✓ Number of clinical staff
- ✓ Number of nonclinical staff

## 4.8 Operational definitions

**Health center**; is a health system unit which provides, the majority of the people in rural parts of the country, basic maternal and child health Services; control of communicable diseases environmental sanitation; health education to the public; medical care and collection of basic health statistics etc. A health center is intended initially to serve 25,000 to 30,000 people.(32)

**Technical efficiency**; measured using Charnes, Cooper and Rhodes (CCR) DEA model. The efficiency score is between 0 and 1. Health center is 100% efficient in comparison to its peers if they have efficiency score of 1, the larger the efficiency score the more efficient the health center is. Overall, measures the ability of the health center to produce a given level of output using the minimum amount of input or alternatively the maximum amount of output using a given amount of input. The formula is given by;

$$Max\ ho = \frac{\sum_{r=1}^{s} u_r y_{ijo}}{\sum_{i=1}^{m} v_i x_{ijo}}$$

**Subject to**:

$$\frac{\sum_{r=1}^{s} u_r y_i j_o}{\sum_{i=1}^{m} v_i y_i j_o} \leq 1, j = 1, \ldots . j_o, \ldots . n$$

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

$y_{rj}$ = amount of output r from health center j

$x_{ij}$ = amount of input i to health center j

$u_r$ = weight given to output r

$v_i$ = weight given to input i

n = number of health centers

s = number of outputs

m = number of inputs

**Constant return to scale efficiency (CRS)**; measured using Charnes, Cooper and Rhodes (CCR) DEA model. Again, efficiency score ranges from 0 to 1. Measures health centers ability to produce expected/required amount of output from a given amount of input.

$$Max\ h_o = \sum_{r=1}^{s} u_r\, y_{rjo}$$

Subject to:

$$Max\ h_o = \sum_{r=1}^{s} u_r\, y_{rjo} = 1$$

$$Max\ h_o = \sum_{r=1}^{s} u_r\, y_r - \sum_{r=1}^{s} v_i\, x_{ij} \leq 0 \quad j = 1, \ldots, n$$

$$u_r, v_i \geq 0$$

**Variable return to scale efficiency (VRS);** measured using Banker, Charnes and Cooper (BCC) DEA model. The efficiency score range is from 0 to 1. The highest VRS efficiency score is 1 and as the score gets close to 1 the more efficient the health center is.

$$Max\ h_o = \sum_{r=1}^{s} u_r\, y_{rjo} + z_{jo}$$

Subject to:

$$Max\ h_o = \sum_{r=1}^{s} v_{ir}\, x_{ijo} + z_{jo} = 1$$

$$Max\ h_o = \sum_{r=1}^{s} u_r\, y_r - \sum_{r=1}^{s} v_i\, x_{ij} + z_{jo} \leq 0 \quad j = 1, \ldots, n$$

$$u_r, v_i \geq 0$$

**Scale efficiency**; is the ration of constant return to scale and variable return to scale. Measures efficiency of health center related to the size or structure of the health center.

***Total efficiency;*** is a combination of technical efficiency (TE), which reflects the ability of a unit to obtain maximal output from a set of inputs, and allocative efficiency, which reflect the ability of a unit to use the inputs in optimal proportions, given their respective prices.

**Clinical staff**; health professionals at the health centers who provide service for the clients. This includes; health officers, all types of nurses, laboratory technician and technologist, druggist and pharmacists.

**Nonclinical staff**; administrative, guard and genitors working in the health centers.

## 4.9 Data analysis procedures

First, data were coded and entered into Epi data 3.1 then transported to Stata 13.1. Descriptive statistics of all input and output variables were calculated by using Stata 13. The mean, standard deviation (SD), minimum and maximum values of all input and output variables were presented. Subsequently, the technical efficiency, scale efficiency scores and input reduction and/or output increases were computed using the DEA Programme, version 2.1 (DEAP 2.1) developed by Tim Coelli (15). In the analysis, the efficient health centers were removed one at a time and efficiency scores are recalculated(33).

## Two stage -Tobit analysis

To identify institutional and environmental factors contributing to efficiency or inefficiency of the health centers, Tobit regression model was estimated. Tobit model (or censored normal regression model) was estimated, because DEA efficiency results are bounded between 0 and 1. According to literatures some of the factors that affect health facility efficiency include, catchment population, outpatient visits, clinical staff and location of health center. Thus in stage two the estimated technical efficiency scores obtained from the DEA was considered the dependent variable and regressed against the set of institutional and environmental variables using a Tobit model (13,29,34).

$$Tobit(y_i) = \beta_0 + \beta_i X_i + \varepsilon$$

The $y_i$ is the technical efficiency score for the $i^{th}$ health center, the $X_i$ is the explanatory variable, $\beta$ is the coefficient whose values cannot be interpreted but whose signs are helpful for this study, and the ε are the disturbance term assumed to be normally distributed with mean μ and standard deviation σ.

Using the technical efficiency score as a dependent variable and given that the scores are right-censored (i.e. upper limit of 1), a Tobit regression model was used to estimate the adjusted efficiency scores for each health center. Since, by definition, the DEA scores take on values between 0 and 1, and since some of the data tend to concentrate on these boundary values (i.e., censored at 1), the regression cannot be estimated by ordinary least squares. The variable is said to be significant if the p-value is less than or equal to 0.05. Stata 13.1 was used to estimate the Tobit regression model.

## 4.10 Ethical Consideration

Prior to data collection, ethical clearance was obtained from Research and Ethics committee of the College of Health sciences of Jimma University. Written permission letter was also obtained from Jimma zonal Health Office, and other concerned bodies in the study area. During data collection, each respondent was informed about the purpose, scope and expected outcome of the research, and appropriate informed verbal consent, which describes the objective, and relevance of the study was taken from the respondents. During the training of data collectors and supervisor, ethical issues were addressed as important component of the research.

## 4.11 Dissemination plan

The findings of this study will be presented to Jimma University College of public health and medical science scientific community, distributed to Jimma Zonal Health Department and to respective health centers and Woredas non- governmental organizations working on health centers. The findings may also be presented in different seminars, meetings and workshops and published in peer reviewed scientific journal.

Subsequently, attempts will be made to present it on the annual and biannual meetings of Oromia heath Bureau; moreover, attempts will also be made to present it on scientific conferences and publish it on scientific journals. Reports will be submitted to JU College of public health and medical sciences, Oromia Health Bureau, Jimma Zone health Department, and to the donor/sponsoring organization.

# Chapter Five: Results

Out of the 19 health centers in the three Woredas of Jimma zone the data were collected from 16 health centers. From the 16 health centers 6 were from kersa, 5 from Seka chekorsa and the rest 5 from Mana Woreda.

**Descriptive Statistics of input and output data**

Table 1 and table 2 presents the descriptive statistics (minimum, maximum, sum, mean and standard deviation) for inputs and outputs of the sixteen health centers in three Woredas of Jimma zone. All health centers together used 25 Health officers, 106 clinical Nurses, 30 Midwives, 29 laboratory technicians, and 19 Druggists to provide 163698 outpatients, 11077 pentavalent three times for children, four and more ANC $4^{+}$ for 12279 pregnant women, delivery care for 9504 mothers, family planning for 33249 women.

**Inputs**

From the total of 351 workforce in the 16 health centers, 60.11% (211) were clinical staff of the health centers while the rest 39.99% (140) nonclinical staff of the health centers.

Table 1 shows the distribution of workforce in 16 health centers, in three Woredas of Jimma zone southwest Ethiopia, 2015.

| No. | Manpower | Minimum | Maximum | Sum | Mean | SD |
|---|---|---|---|---|---|---|
| 1. | Administrative staff | 2 | 13 | 80 | 5 | 2.8 |
| 2. | Cleaners and guard | 2 | 7 | 62 | 3.9 | 1.15 |
| 3. | Health officers | 0 | 3 | 25 | 1.56 | .73 |
| 4. | Clinical Nurse | 1 | 11 | 106 | 6.6 | 2.63 |
| 5. | Midwife | 1 | 3 | 30 | 1.9 | .5 |
| 6. | Lab technician/technologist | 1 | 3 | 29 | 1.8 | .5 |
| 7. | Druggist/pharmacist | 0 | 2 | 19 | 1.9 | .66 |

Of all the clinical staff majority 106 (50.2%) account for Nurses, followed by Midwives 30 (14.2%), then laboratory technician and technologist 29 (13.7), 25 (12%) health officers and finally pharmacist/druggist contribute 19 (9%) to the clinical staff of 16 health centers in the three Woredas.

**Outputs**

The major services provided by the health centers were outpatient, immunization service, antenatal care, delivery service and family planning. Out of all health centers the maximum number of outpatient service 25100 was provided by HC14 health center and the minimum was HC04 health center. Among the services provided by all health centers the least was delivery care. The maximum 1280 pregnant women gave birth to their child at HC14 health center, while the minimum number of delivery care 274 was provided by HC02 health center.

Table 2 shows descriptive Statistics outputs produced by the 16 health centers in three Woredas of Jimma zone, southwest Ethiopia, 2015.

| No. | Services | Minimum | Maximum | Sum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| 1. | OPD | 2068 | 25100 | 163698 | 10231.1 | 6587.6 |
| 2. | Pentavalent 3 times | 164 | 1125 | 11077 | 692.3 | 316.3 |
| 3. | ANC four and more | 134 | 1345 | 12279 | 767.4 | 323.4 |
| 4. | Delivery | 274 | 1280 | 9504. | 594 | 295.9 |
| 5. | Family planning | 196 | 4471 | 33249 | 2078.1 | 1338.3 |

In all health centers outpatient service is majorly consumed service 162178 (72.4%) followed by family planning 30219 (13.5%) then ANC $4^{+}$ 115225(5.2%), immunization service 10616 (4.7%) and delivery 9353 (4.2%).

**Inputs and outputs among efficient and inefficient**

The mean of outpatient visit in the efficient health centers is 13848.5 and 6614 in the inefficient health centers. The amount of people served for all types of services i.e. outpatient, children vaccinated pentavalent vaccine three times, four or more ANC for pregnant women, delivery care and family planning services in the efficient health centers outweighs the amount of people served by inefficient health centers. The mean of children vaccinated three times for pentavalent vaccine in the inefficient health centers is 1659, while it is 767.6 in the efficient.

Table 3 shows the difference between efficient and inefficient health centers by the inputs used and outputs they produced. There was a little difference of human power among efficient and inefficient health centers. The mean of nonclinical staff working at efficient health centers was 8.9, whereas 8.6 for inefficient health centers with the standard deviation of 5 and 2.4 respectively. While the mean of clinical staff working at the efficient health centers was 13.3,

whereas 13.1 at the inefficient health centers with standard deviation 3.8 and 2 respectively, which is relatively equal. However, the output produced by both efficient and inefficient health centers was quite different. For example, the total sum of outpatient provided was 110788 with mean of 13849 (SD = 6940) by the efficient health centers, on the contrary a total of 52910 with mean of 6614 (SD = 3862.6) outpatients were served by the inefficient health centers.

Table 3 shows the difference of inputs used and outputs produced among efficient and inefficient health centers, in three Woredas of Jimma zone southwest Ethiopia, 2015.

| No. | Services | Efficient | | | Inefficient | | |
|---|---|---|---|---|---|---|---|
| | | Mean | SD | Sum | Mean | SD | Sum |
| 1. | Nonclinical staff | 8.9 | 5 | 71 | 8.6 | 2.4 | 69 |
| 2. | Clinical staff | 13.3 | 3.8 | 106 | 13.1 | 2 | 105 |
| 3. | OPD | 13848.5 | 6940 | 110788 | 6614 | 3862.6 | 52910 |
| 4. | Pentavalent 3 times | 767.6 | 321.6 | 6141 | 617 | 313 | 4936 |
| 5. | ANC four and more | 975.6 | 271.9 | 7805 | 559 | 226.1 | 4474 |
| 6. | Delivery | 716.2 | 362.1 | 5730 | 471.7 | 150 | 3774 |
| 7. | Family planning | 2429.5 | 1325.3 | 19436 | 1726.6 | 1341 | 13813 |

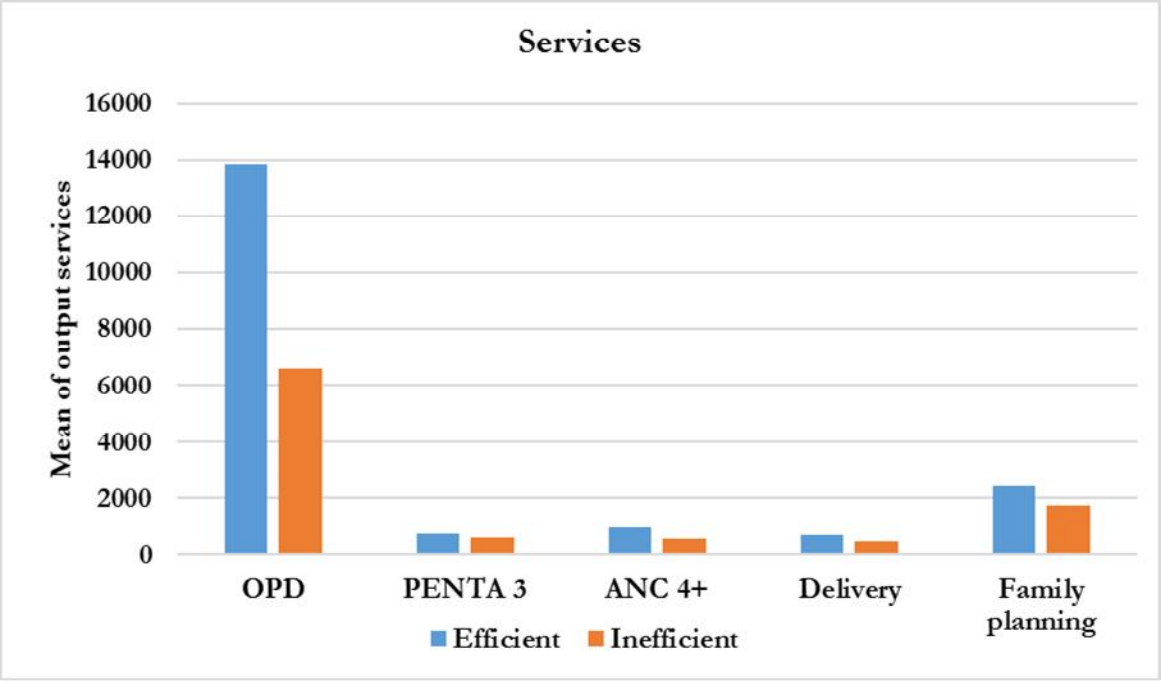



Figure 2 shows distribution of outputs produced by efficient and inefficient categories of health centers, in three Woredas of Jimma zone southwest Ethiopia, 2015.

**Efficiency analysis**

The overall average score for technical efficiency was 77% with SD of 16%, CRTS technical efficiency 90% (SD = 17%), for VRTS technical efficiency the average score was 94% (SD = 11%), and for scale efficiency (SE) the average score was 94% (SD = 9%).

**Technical Efficiency**

Table 4 presents scores for technical efficiency, constant returns to scale, variable returns to scale, scale efficiency, and returns to scale of 16 health centers. Technical efficiency and scale efficiency ranges from 0 to 1(100%). Out of the 16 health centers from the three Woredas, only 3 were technically efficient, whereas the rest 13(81.25%) were technically inefficient. Among the inefficient health centers 6 had technical efficiency of less or equal to 67%, 5 technical efficiency between 68-83%, 2 had technical efficiency between 84-99% and the rest 3 had technical efficiency of 100%. The average technical efficiency of the 13 inefficient health centers is 72% with a standard deviation of 12%. This indicates that on average they could reduce their utilization of all inputs by about 28% without reducing output. These inefficient health centers could also potentially increase the outputs by 28% using their current input available if they were to operate efficiently. Two of the efficient health centers were from Seka chekorsa Woreda, HC12 and HC13 health centers and the other one is HC14 health center from Kersa Woreda.

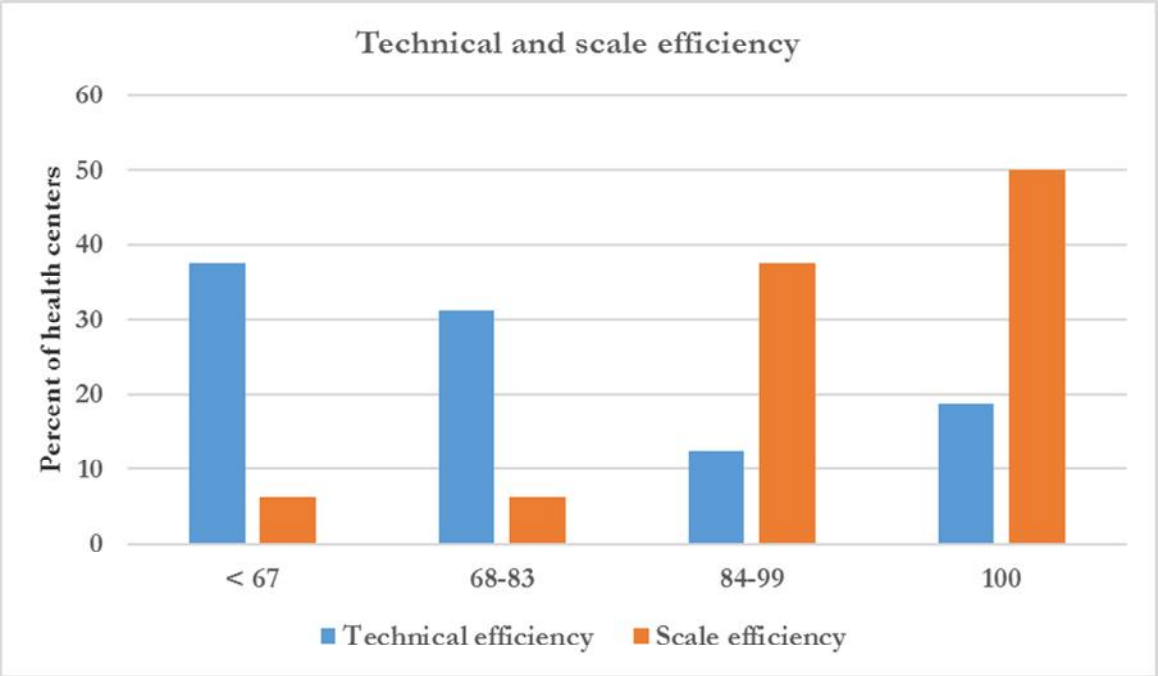



Figure 3 presents the distribution of technical and scale efficiency scores of the 16 health centers, in three Woredas of Jimma zone southwest Ethiopia, 2015.

**Return to scale**

**Constant return to scale (CRTS)**

Efficiency score ranges from 0 – 1 (100%). From the total of 16 health centers involved in the analysis eight had a constant return to scale technical efficiency of 100%, and the rest 8 health centers were constant return to scale inefficient. Out of the 8 CRTS inefficient health centers 4 had a score between 91-99.99%, two had a score between 50-59%, one a score of 68%, and another 1 health center had a score of 87% constant return to scale technical efficiency.

**Variable return to scale (VRTS)**

The findings of VRTS model shows that 10 (62.5%) of the health centers had a score of 100%, and the rest 6 were found to be inefficient. Among the inefficient 3 had a score between 91-99.99% and other three different health centers had a score between 60-90%, two scored 87% and 75%, and one scored 63%. The VRTS inefficient health centers include HC01, HC04, HC05, HC09, HC15, and HC16 health centers.

**Scale efficiency**

Scale efficiency is the ratio of constant return to scale and variable return to scale. Out of all the 16 health centers half were found to be scale efficient, whereas the rest 8 were scale inefficient. From the scale inefficient health centers 5 had a score between 91–99.99% and the rest three different health centers had a score of scale efficiency between 65-90%. The inefficient health centers had an average scale score of 89% (with a standard deviation of 11%); implying there is potential for increasing total outputs by about 11% using the existing capacity/size. This can also indicate that if these health centers had an optimal size, output would have increased by about 11% without increasing the input uptake.

Return to scale has three dimensions: constant return to scale (CRS), increasing returns to scale (IRS) and decreasing returns to scale (DRS). In the case constant return to scale the health centers produce expected amount of output from certain amount of inputs, whereas increasing returns to scale, a one per cent increase in all inputs will be followed by more than one per cent increase in outputs. In contrast, if the DMU is experiencing decreasing returns to scale, a percentage increase in inputs will not result in a percentage increase in output, but less.

Table 4 shows 8 of health centers in the three Woredas of are scale inefficient. Implying that they are either too small or too large. Increasing returns to scale was the predominant form of scale inefficiency. Of the 16 health centers, 5 operate in increasing returns to scale (IRS) indicating these health centers should expand both their inputs and outputs, 8 reveled constant returns to scale (CRS) implying they are operating at their most productive scale sizes and 3 are working in decreasing returns to scale (DRS). Table 4 presents Returns to scale values for each health centers.

Table 4 presents technical, scale, constant return to scale, Variable Return to scale and return to scale values of each health center, in three Woredas of Jimma zone southwest Ethiopia, 2015.

| DMU | | TE | CRTS | VRTS | SE | RTS |
|---|---|---|---|---|---|---|
| 1 | HC01 | 0.81 | 0.89 | 0.92 | 0.98 | Decreasing |
| 2 | HC02 | 0.78 | 1 | 1 | 1 | Constant |
| 3 | HC03 | 0.87 | 0.97 | 1 | 0.97 | Decreasing |
| 4 | HC04 | 0.82 | 0.94 | 0.96 | 0.98 | Increasing |
| 5 | HC05 | 0.54 | 0.5 | 0.75 | 0.67 | Increasing |
| 6 | HC06 | 0.73 | 1 | 1 | 1 | Constant |
| 7 | HC07 | 0.55 | 1 | 1 | 1 | Constant |
| 8 | HC08 | 0.67 | 0.91 | 1 | 0.91 | Increasing |
| 9 | HC09 | 0.55 | 0.68 | 0.87 | 0.78 | Increasing |
| 10 | HC10 | 0.8 | 1 | 1 | 1 | Constant |
| 11. | HC11 | 0.67 | 1 | 1 | 1 | Constant |
| 12. | HC12 | 1 | 1 | 1 | 1 | Constant |
| 13. | HC13 | 1 | 1 | 1 | 1 | Constant |
| 14. | HC14 | 1 | 1 | 1 | 1 | Constant |
| 15 | HC15 | 0.92 | 0.96 | 0.96 | 0.99 | Decreasing |
| 16 | HC16 | 0.63 | 0.54 | 0.63 | 0.85 | Increasing |
| | Mean | 0.77 | .90 | .94 | .94 | |
| | STD deviation | 0.16 | .17 | .11 | .09 | |

When we see the distribution by Woreda health centers in Seka chekorsa reveled an average score of 89.2% (SD = 10.2%), and 99.5% (8%) technical and scale efficiency respectively, which is higher when compared to the other to Kersa and Mana Woredas (see table 5). While the Kersa Woreda health centers showed lower 64.2% (SD = 9%) technical and 87.3% (13%) scale efficiency.

Table 5 shows the distribution of efficiency score of health centers by Woredas, Jimma zone southwest Ethiopia, 2015.

| Woredas | Efficiency | Mean | SD |
|---|---|---|---|
| Seka Chekorsa | TE | 89.2 | 10.7 |
| | SE | 99.5 | 0.8 |
| Mana | TE | 73.6 | 12 |
| | SE | 96.2 | 5.6 |
| Kersa | TE | 64.2 | 9 |
| | SE | 87.3 | 13 |

**The slacks**

**(A). Increasing outputs**

Based on the results of technical efficiency 13 health centers were inefficient. For those facilities to be efficient they need to either increase their output or decrease their input. Since input requirements of health centers are decided at centrally, they have to enhance health service needs of the community. In order for 13 inefficient facilities to become efficient as a group, they would have needed to increase their outpatient department visits by 23177 (77%), family planning by 4390 (14.5%), immunization by 1010 (3.3%), ANC $4^{+}$ by 970 (3.2%) and delivery care by 694 (2.3%). (See table 6 and 7)

**(B). Reducing health centers inputs**

The inefficient health centers can become efficient by reducing their inputs. In this case they can become efficient by reducing 22 nonclinical staff as a group. (See table 6 and 7)

Table 6 presents the overall input reductions and/or output increases required to make inefficient health centers efficient, in three Woredas of Jimma zone southwest Ethiopia, 2015.

| No. | Inputs/outputs | Input Reductions/ Output Increases |
|---|---|---|
| 1. | Nonclinical staff | 22 |
| 2. | Clinical staff | 0 |
| 3. | OPD | 23177 |
| 4. | Pentavalent 3 times | 1010 |
| 5. | ANC four and more | 970 |
| 6. | Delivery | 694 |
| 7. | Family planning | 2224390 |

Table 7 presents Input reductions and/or output increases needed to make individual inefficient public health center efficient, in three Woredas of Jimma zone southwest Ethiopia, 2015.

| | HC16 | HC10 | HC04 | HC07 | HC03 | HC05 | HC08 | HC02 | HC11 | HC06 | HC01 | HC15 | HC09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nonclinical staff | 1.4 | 3.2 | 3 | 0 | 2 | 0 | 2 | 4 | 1 | 3 | 1 | 0 | 0 |
| Clinical staff | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OPD | 0 | 0 | 8925 | 176 | 0 | 412 | 0 | 8308 | 0 | 0 | 2753 | 1205 | 1398 |
| Pentavalent 3 times | 469 | 0 | 3 | 0 | 0 | 193 | 0 | 0 | 286 | 0 | 0 | 0 | 59 |
| ANC four and more | 579 | 0 | 0 | 23 | 0 | 73 | 0 | 0 | 22 | 0 | 0 | 198 | 75 |
| Delivery | 102 | 0 | 0 | 0 | 0 | 249 | 0 | 155 | 46 | 0 | 0 | 0 | 143 |
| Family planning | 1157. | 0 | 0 | 79 | 0 | 107 | 0 | 754 | 0 | 0 | 1643 | 649 | 0 |

**Role model health centers**

The efficiency of the 16 health centers analyzed depicts that only 3 health centers were 100% technically efficient. Those three health centers can be considered as best practice health centers, hence role model for the other 13 inefficient health centers. DEA model has identified efficient health centers for each inefficient health centers that could be used to show how they do their business to become efficient. Moreover, the inefficient health centers are expected to learn from their efficient peers by studying their production process.

## Tobit regression analysis

**Descriptive statistics of institutional and environmental factors affecting efficiency**.

The 16 health centers all together serve around 449,461 population. The maximum catchment population getting service at one health center was 50,201 population and the minimum was 14,269. The mean age of all workers in the 16 health centers was 28.24 (SD = 2.2) (see table 8). The detail descriptive statistics of institutional factors were discussed at the beginning of result section.

Table 8 shows descriptive statistics of institutional and environmental factors affecting efficiency, in three Woredas of Jimma zone southwest Ethiopia, 2015.

| | Minimum | Maximum | Sum | Mean | SD |
|---|---|---|---|---|---|
| Catchment population | 14269 | 50201.00 | 449461.00 | 28091.3125 | 10340.09308 |
| Output | 6978 | 32863.00 | 223891.00 | 13993.1875 | 7261.95505 |
| Nonclinical staff | 4 | 20.00 | 140.00 | 8.7500 | 3.76829 |
| Clinical staff | 8 | 20.00 | 211.00 | 13.1875 | 2.92617 |
| Mean age | 25.55 | 32.93 | 451.85 | 28.2406 | 2.17009 |

Tobit regression results

Tobit regression — Number of obs = 16

LR chi2(5) = 24.95

Prob > chi2 = 0.0001

Log likelihood = 12.59

Table 9 presents Tobit regression model result, in three Woredas of Jimma zone southwest Ethiopia, 2015.

| **Efficiency** | **Coef.** | **P** | **[95% Conf. Interval]** | |
|---|---|---|---|---|
| Catchment population | 7.80E-06 | 0.013 | 2.03E-06 | 1.36E-05 |
| Outpatient visit | 7.04E-06 | 0.120 | -2.17E-06 | 1.62E-05 |
| Clinical staff | 0.06063 | 0.000 | 0.036432 | 0.084827 |
| Nonclinical staff | -0.02501 | 0.039 | -0.04847 | -0.00156 |
| Age | 3.64E-05 | 0.998 | -0.02584 | 0.025911 |
| _cons | -0.10668 | 0.762 | -0.86388 | 0.650522 |
| /sigma | 0.079686 | | 0.044311 | 0.115062 |

| | | | |
|---|---|---|---|
| Obs. summary: | 0 | left-censored observations | |
| | 13 | uncensored observations | |
| | 3 | right-censored observations | at Efficiency>=1 |

The coefficient for catchment population, outpatient attendance, clinical staff and mean age has a positive sign. However, only catchment population and clinical staff are statistically significant at the 5 percent level of significance. A 1000 increase in catchment population would lead to 0.08% increase in efficiency of health center, holding all other variables in the model constant. Again holding other variables constant, if the clinical staff the health center increases by one person expected efficiency of that facility would increase by 6%.

The coefficient for nonclinical staff shows negative sign and statistically significant at the 5% level of significance. If one nonclinical staff is added to the of health center, it would lead to 2.5% decrease in efficiency of that specific health center

## Chapter Six: Discussion

Public health centers provide affordable, preventive, promotive, and basic curative care to the population under their catchment area. Their proximity to the community makes them critically important to address health care targets of Ethiopian MOH and other international treaties.

The findings of the study revel that 13 (81.25%) of health centers were technically inefficient. Though, technical inefficiency is widely prevalent according to studies conducted in some of sub- Saharan African countries, the findings of this study is a little bit higher than others. The majority of studies in those countries present above 50% of technical inefficiency, for instance 65% of public health centers in Ghana (4), 59% of peripheral health units in Pujehun district of Sierra Leone (10), 56% of Public Health Centers in Kenya(26), 78% of Public Health Centers in Ghana (35) were all found to be technically inefficient.

The average technical efficiency of the 13 inefficient health centers is 72% with a standard deviation of 12%. This indicates that on average they could reduce their utilization of all inputs by about 28% without reducing output. These inefficient health centers could also potentially increase the outputs by 28% using their current input available if they were to operate efficiently.

According to this study eight (50%) of the health centers were found to be scale inefficient. Compared to other sub- Saharan Africa countries finding of scale inefficiency of this study is a bit lower. Some studies done in those countries indicate, they suffer from scale inefficiency. Majority of these sub-Saharan African countries exhibit above 50% scale inefficiency, some of the findings were 59.1% of primary health units in Kailahun and Kenema districts of Sierra Leone(28), 58% of hospitals in Eritrea(27) 66% of primary care units in rural Burkina Faso(29), 60% of Zambian(1) hospitals, and 61.9% of hospitals in Botswana(36) were deemed to be scale inefficient.

The inefficient health centers had an average scale score of 89%; implying there is potential for increasing total outputs by about 11% using the existing capacity/size.

Differences of technical and scale efficiency results of this study with other findings in sub- Saharan Africa countries discussed above could be attributed to different reasons. First, the sample size for this study is very small in comparison to those other studies. Second, it might also be due to the differences of health care system and their performances. Moreover, health insurance scheme in Ghana, Kenya and Sierra Leone enable people to use health services – promotion, prevention, treatment and rehabilitation

– without incurring financial hardship, which induces demand for health care and increases output produced by the health facilities.

The return to scale results shows that, out of the 16 health centers 8 exhibit constant return to scale, 5 show increasing return to scale and the rest 3 display decreasing return to scale. Health facilities exhibit constant return to scale when they produce optimum output at their optimal size. Increasing return to scale (IRS) and decreasing return to scale (DRS) are the two forms of scale inefficiency. The former one is the most predominant form of scale inefficiency in this study. Increasing return to scale is a situation in which a unit increase in inputs results in more than one unit increase in output. IRS may arise due to some health inputs, greater specialization, innovation (may be as a result to research and development), and/or increased performance of human resources for health (may be due to increased motivation)(37). DRS may arise because of shortages of complementary inputs (e.g. medicines), low levels of staff motivation and leadership problems (e.g. related to coordination and supervision).

Increasing the amount of outputs requires an increase in the demand for health care. Since, input needs of health center are standardized, reduction of inputs is not an option. In order for 13 inefficient facilities to become efficient as a group, they would have needed to increase their outpatient department visits by 23177 (77%), family planning by 4390 (14.5%), immunization by 1010 (3.3%), ANC $4^{+}$ by 970 (3.2%) and delivery care by 694 (2.3%). Making inefficient health centers efficient could be achieved through different strategies. First, health promotion strategies to augment demand for essential preventive public health services that were being under-utilized. Some of the demand-inducing ways might include: (i) health information, (ii) health education, (iii) screening and individual risk assessment and (iv) social marketing, which were suggested by the study from Sierra Leone(10).

Second, the barriers to effective access to health services can also be addressed through a number of ways according to other recent study from Sierra Leone(28): (i) planned abolishment of user fees in public health facilities, to increase health service utilization(5,38); (ii) strengthen provision of free ambulance services; (iii) improvement of transport in rural areas, where most of health centers are situated and (iv) improvement in health workforce motivation and supervision to make them more responsive to non-medical expectations of patients, and by so doing reduce patient waiting, diagnosis and treatment time

The second DEA stage analysis identified two significant factors which have positive association with efficiency. This factors were the size of catchment population and clinical staff of the health centers. Catchment population was also found to be significantly associated with efficiency according to a study

from Greece(31). On the other hand, nonclinical staff was found to affect efficiency negatively. The health center and Woreda health office can modify those factors i.e. increasing the number of clinical staff and cautiously monitor the number of their nonclinical staff. Whereas, nothing can be done to modify the catchment population of the health centers. However, the Woreda health office and other developmental army members in collaboration with health centers can work on improving health seeking behavior of the community.

**Strengths and limitations of the study**

**Strengths of the study**

- ⇨ We applied data envelopment analysis.
- ⇨ We also used Tobit regression to assess the factors associated with efficiency.

**Limitations of the study**

Even though we chose to use DEA, we were fully aware that it has two main limitations. Firstly, it attributes any deviation from the "best practice frontier" to inefficiency, while some could be due to statistical noise, e.g. epidemics or measurement errors. Secondly, given that DEA is deterministic/nonparametric technique, it is difficult to conduct statistical tests of hypotheses concerning the inefficiency and the structure of the production function. (15)

- ⇨ Recently, Ethiopian health system has undergone health management information system reform, and it was expected to improve data handling system. However, during data collection at the health centers or the Woreda health office problems of data handling were identified.
- ⇨ Expenditures on pharmaceuticals and non- pharmaceutical supplies and other nonwage expenditures among the inputs were not included in the study due to the lack of data.
- ⇨ The study also didn't take into consideration the differences that may exist between the categories of diploma nurses and BSC nurse/HO in the various health centers. In addition, even within the same health workforce category, the quality of labour input may vary depending on individual health worker skills, professional experience and health status.
- ⇨ Variation of health centers by type i.e. the difference between A, B and C type health centers was not considered. All health centers were considered to be the same.

# Chapter Seven: Conclusion and Recommendation

## Conclusion

- ⇨ The study has revealed that majority of the health centers were technical inefficient.
- ⇨ Only half of the health centers are found to be scale efficient.
- ⇨ There was barely a difference between the eight efficient health centers and the other eight inefficient health centers, in the amount of health care workers they used. However, clients/patients who were served at the efficient health centers were more than twice in number than those clients who were served at inefficient health centers.
- ⇨ If the Woreda health office and zonal health office chose to use input orientation, from the inefficient health centers all together more than one fourth of the nonclinical staff can be transferred away from those health centers without reducing output they produce.
- ⇨ On the other hand, if they chose output orientation the inefficient health centers all together can increase their output by one fourth of what they are producing using their current staff.
- ⇨ The second stage analysis has revealed that catchment population and the number of clinical staff the two variables significantly associated with efficiency positively. On the other hand, the number of nonclinical staff was found to be negatively associated with efficiency.
- ⇨ Considering the scarce resource available to the health sector, the findings indicate that performance improvement measures have to be taken. Provided that primary health care is instrumental for achieving goals set by MOH and addressing the wider health care needs of the community, efforts have to be made to make inefficient health centers efficient. Furthermore, a significant amount resources could be saved and/or they could also expand their services without any additional inputs. Therefore, performance improvement measures should be put in place to curb the waste.

## Recommendations

Health facilities are expected to perform at the highest level possible. Health sector in developing countries including Ethiopia, needs investing additional resources to increase the coverage and quality of health service provided to the people. Hence, health system cannot afford this high inefficiency.

Health centers;

- ⇨ There are two options to make inefficient health center efficient, the first one is reduction of inputs (nonclinical staff) for which health centers have no jurisdiction. The second option is increasing the outputs, which is in the hands of health center. Increasing the output can be achieved by inducing demand for health care through health promotion strategies such as health information, health education and social marketing.
- ⇨ The inefficient health centers should learn and emulate the efficient health centers way of providing service for their clients.

Zonal health office and Woreda health office;

- ⇨ Woreda health office is the one with jurisdiction to acquire the workforce for the facilities and if there is a need, the office should transfer 22 nonclinical staff from inefficient health centers to efficient health centers.
- ⇨ The Woreda health offices should also organize experience sharing events among the efficient and inefficient health centers.
- ⇨ They should also continuously follow and provide supportive supervision for the health facilities.

Woreda health office and other development armies

- ⇨ Increase output: improving health seeking behavior and inducing demand for health care through health promotion strategies such as health information, health education and social marketing.

Suggestions for Future Research

- ⇨ Large scale studies should be conducted to assess the performance of health centers.
- ⇨ Studies assessing technical efficiency of all health facilities needs to be undertaken, hence the facilities include hospitals, health centers and health posts. Moreover, private-for profit and private nonprofit should also be investigated.
- ⇨ Detailed studies among relatively efficient peer health centers would facilitate identification and dissemination of good operating practices that can lead to improved efficiency not only for relatively inefficient health centers but also for relatively efficient ones.

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**Annex: English version questionnaire**

## Questionnaire

# Technical Efficiency of public health centers in three Woredas of Jimma Zone, southwest Ethiopia.

### Introduction and Consent Form

Hello, how are you? Hello, my name is _____. I am with _____ (Organization).

The aim of this study is to measure the technical efficiency of public health centers. This study is also aimed at identifying environmental and institutional factors associated with technical efficiency of the health centers.

The study is beneficial for improving the technical efficiency of human health centers. The study will be published in peer-review journals showing with the technical efficiency score of human health centers. The names of participants will be made confidential that only the investigator will have access to this information. The participation of health centers and health departments is voluntary and that they can abstain from participation or withdraw consent any time in the process of the study. Withdrawal of consent will not have financial or other repercussions.

The data will be collected through document review. The record review will only take 1 hour of your time.

Do you wish to participate in this study? Tick here: Accepted Declined

If the request is accepted, ask the interviewee to sign and sign your name and record the date. If declined, move to the next health facility.

Name of health facility ID. Code

| SECTION 1: HEALTH CENTER IDENTIFICATION | | |
|---|---|---|
| **1** | Location of health center | 1. Urban<br>2. Rural |
| **3** | Name of the health center | |
| **4** | Woreda /district | |
| **5** | Kebele/ village | |
| **6** | Catchment population (2013) | Total population:<br>Number of males:<br>Number of females: |

| SECTION 2: HUMAN RESOURCES | | | |
|---|---|---|---|
| | ***Type of post*** | ***Total number of personnel*** | |
| **H1** | Administrative staff | | |
| **H2** | General Staff | | |
| **H3** | Health officers | | |
| **H4** | Clinical Nurse ( all type) | | |
| **H5** | Midwife | | |
| **H6** | Laboratory technician | | |
| **H7** | Laboratory technologist | | |
| **H8** | Pharmacy technician/druggist | | |
| **H9** | Pharmacist | | |
| **H10** | Physiotherapist | | |
| **H11** | Other post, specify_____ | | |

| SECTION 3: OUTPUTS PRODUCED BY THE HEALTH CENTER IN LAST FISCAL YEAR | | | |
|---|---|---|---|
| **No.** | **Questions and filters** | **Coding category** | **Skip rule** |
| **O1** | Number of total outpatient visit | | |
| **O2** | Number of adult (15 or more year olds) outpatient visits | | |
| **O3** | Number of child (14 or less year olds) outpatient visits | | |

| | | | |
|---|---|---|---|
| **O4** | Number of in-patient admissions | | |
| **O5** | Number of children vaccinated three times for pentavalent | | |
| **O6** | Number of mothers who received four or more antenatal care | | |
| **O7** | Number of mothers who received delivery care at the health | | |
| **O8** | Number of mothers who received family planning services | | |