# Technical Efficiency of Selected Public Hospitals in Ethiopia[1]

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*Abstract*

*The paper primarily attempts to investigate the level of efficiency at which public hospitals are operating in Ethiopia by taking eight sample hospitals from selected regions of the country. The study employs both descriptive and regression analyses. While the former method mainly focuses on the description of the sample hospitals' major characteristics and the relationships among them, the latter one tries to measure technical efficiency by conducting production frontier analyses on two major health care service areas: outpatient and inpatient services. The major variables included in the production frontier function are the labour time of the technical staff (that consists of physicians, nurses, health assistants, laboratory and X-ray technicians, and pharmacists), the labour time of the administrative and support staff, and values attached to depreciation and supply of drugs.*

*The preliminary tests undergone reveal that some degree of inefficiencies are observed in the provision of outpatient services of three hospitals and inpatient services of only one hospital. According to the production frontier result, the outpatient visits in the efficiently operating hospitals tend to increase with the increase in the labour input of the technical staff and decrease with that of the non-technical staff. But in the inefficiently operating hospitals, the activities of both the technical and non-technical staff are seen to produce a positive impact on the outpatient visits. On the other hand, the values attached to depreciation and costs of drugs are found to strongly and directly affect the production process of only two of the efficiently operating health care providing units and one of the inefficient ones. The inadequate remuneration provided to the technical staff is the main cause for the inefficiency of the outpatient services.*

*With regards to the inpatient services, the activities of the technical staff and depreciation and drug costs are found to positively contribute to the number of inpatient days in the majority of efficiently functioning hospitals. But the production of inpatient health care in the only inefficient hospital is highly and negatively affected by the labour time of the non-technical staff.*

*It can thus be suggested that improving the number and quality of the professional health staff and upgrading the physical and technical capabilities of hospitals increases the efficiency with which they are producing health care services. It would also be necessary to take further policy measures in order to reduce the burden of public hospitals and improve the quality of health care services in the country.*

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# 1. Introduction

## 1.1. Background

Rapid economic development is the key factor for the improvement of health care systems and that expenditure on the health sector is determined largely by other sectors. Growth in the health sector also affects the performance of the rest of the economy. Health and economic development are therefore interdependent means that reinforce each other. As a healthy labour force is a prerequisite for a successful economy, the wealth created by the rest of the economy may be partly earmarked so that the health sector would expand to reinforce other sectors. However, due to low level of income at the household level and concentration of the available health facilities at the urban areas the majority of the population in developing countries has limited access to modern health facilities. This problem is compounded with poor transport system and unaffordable price for the large proportion of the population, albeit the service provided may not be dubbed sufficiently acceptable (Barnum & Kutzin, 1993).

Hospitals as recognizable institutions appeared at different times in different places, reflecting existing social and, particularly, religious context. History recorded the first hospital to be in the Byzantine Empire in the fifth and sixth centuries AD. Hospitals in Western Europe emerged later starting in the monasteries, a bequest reflected by many of present day European hospitals (Mckee & Healy, 2000).

History tells us Ethiopians have been mainly benefiting from traditional health care system comprising both empirical-rational and magical religious elements. A huge set of remedies using traditional plants and medicines made up of animals, inoculation, thermal and holy water, minor surgeries have been serving the people as the integral element of the health care system of the country in terms of both the prevention and cure of diseases (Pankhurst,1965a).

According to Pankhurst though Ethiopia's long standing trade relationship with the outside world goes back to Axumite civilization , its contact to modern medicine may be attributed to the reign of Emperor Libne Dingel (1508-1540) with the arrival of the Portuguese mission. Since then modern health care was being spread by other several Europeans: travelers, missionaries, and members of diplomatic community. Historical records further show that successive rulers of Ethiopia have introduced modern medical care primarily for the benefit of themselves and for the well-being of their families. The Minilik era is recorded as the most important landmark for the expansion of better medical care.

Emperor Minilik had deep interest in modern medical care and other scientific innovations. It is further indicated that while he had good relationship with Italy, he had several Italians engaged in the provision of the modern medical care for himself and his family. However the Italo-Ethiopian War (1885-1889) disrupted the service and was soon replaced by the Russian Red Cross Mission, which is still running one the large hospitals in Addis Ababa. The era had also witnessed the inauguration of modern vaccination, clinics and other health care facilities. It is also recorded that the nucleus of the current Ministry of Health was founded in 1908 under the then Ministry of Interior (Pankhurst, 1965b).

Up to the end of the Imperial era (mid 1974) there were 65 government-owned hospitals with staff members of 377 physicians, 573 nurses, 350 x-ray and laboratory technicians and 1,398 other employees. The distribution of health facilities, particularly that of hospitals, had been very uneven. They were concentrated in the major urban areas where only 10 percent of the total population used to live (CSA, 1978).

Following the downfall of the Dergue regime, measures aimed at implementing the principles of free-market economy have been taken by the government. The new policies instituted allowed the private sector to take part in various economic activities while the role of the government is limited to the areas where the private sector is less willing to involve. Since the private sector is investing only in the areas where it can reap immediate returns, it would not be strange to observe its reluctance to engage in the expansion of the health sector as envisaged. For instance, in the past decade the construction of private hospitals is limited to merely 9 (8 in Addis Ababa and 1 in Mekele), indicating low participation in the major part of health investment by the private sector (EIA, 2000).

Currently available data indicate that the total number of hospitals in the country is 110, of which 72.7% are under the Ministry of Health while 11.8, 8.2 and 7.3 % are owned by the OGA (e.g. teaching hospitals), the private sector, and NGOs, respectively. All these hospitals are endowed with 10,736 beds, 1,366 physicians, 7,723 nurses and 7,386 health assistants, 1,050 lab technicians, 920 environmental health workers, 513 pharmacy technicians, 296 health officers, and 4,379 other health workers. The health system of Ethiopia is also supported by 382 health centers, 2,393 health stations, 1,023 health posts, and 1,170 privately owned clinics of various types. Moreover, 311 pharmacies, 249 drug shops and 1,917 rural drug vendors are operating throughout the nation (MOH, 2000).

Due to various reasons (including limited physical access of the population to health facilities and shortage of health professionals) the total outpatient utilization of government health facilities is, on the average, limited to 0.25 visits per person per year. Studies have found that only 10 percent of people reporting illness certainly received treatment for their conditions from any government or privately owned health facilities. The utilization level of health care providing units by rural population is restricted to 9.5% while that of urban population is 14 % (MOH, 1998).

The health service coverage is estimated to be 48.5%, and this coverage would vary if the coverage of individual programs is examined (MEDaC, 1999). For instance, under EPI program about 47% of children are estimated to have obtained DPT3 immunizations in 1995 while the proportion of pregnant women immunized for tetanus is estimated to be over 30%. The percentage of births attended by trained health personnel is 10% while antenatal coverage is about 30%. All these indicate that the utilization level of health facilities is still at its low level compared to the Sub-Saharan Africa average.

The access of a household to health care providing units is determined by a number of factors: income of the household, quality of the service being provided, age, religion, proximity to health facilities, individuals' perception about specific health care providing units, availability of drugs, and the lifestyle pursued (Folland, et al ,1993).

As health services form part of the basic social needs of a society, health care providing units are not only essential for a society's welfare but also play a major role in the growth of an economy. However, the health status of Ethiopia is among the least in the world. The spread of communicable diseases and poor nutrition are the leading outcomes of poor housing and environmental conditions almost in all parts of the country. Not only shortage of health facilities but also underutilization of the existing health care providing units (arising from many factors including long distance from clinics in remote rural areas, low income, etc) is part of the cause for the miserable state of health in Ethiopia (MOH, 1998).

A study by Abdulhamid (2000) noted that only half of the total population has access to modern medical care services. It is also further indicated that under normal circumstance, 20 percent of the total population needs curative modern medical care. Thus, establishing health care units would be essential to raise the level and promotion of good health, where both the preventive and curative services are important. The objective of public health policy is, therefore, not only limited to the promotion of good health but also it may have political features by which interested groups would be more sympathetic to certain segment of society.

Assuming that all the health care providing units are offering the appropriate services for which they are established and the health personnel are discharging their duties to the maximum capacity possible, one can then embark on measuring the technical efficiency of health care providing units.

As public hospitals are the main health care providing units in the health system of the country, their share in terms of skilled labour (70.1%) and government budget is very significant. A study of 25 developing countries (including Ethiopia) confirmed that 50 – 80 percent of the public sector health resources are being used in hospitals (Barnum and Kutzin, 1993). It is, therefore, no surprise for this study to limit itself to measuring the technical efficiency of some representative public hospitals selected from the three largest regions of the country and Addis Ababa.

## 1.2. Problems, significance and objectives of the study

The theory of economic efficiency is pertinent to both the demand and supply side of the health sector. During evaluating economic efficiency, one requires that the rate (and type) of output be “optimal”. Economic efficiency in demand is related to efficiency in supply through prices. The optimal rate of output appears when the marginal benefit of the last unit equals the price of that unit. Several reasons are given why economic efficiency does not occur on the demand side. For instance, the lack of full information about prices, quality of the physician, the diagnosis process, and the treatment needs makes possible for physicians to manipulate patient demands for medical services (Feldstein, 1999).

With regard to the supply side of the medical care sector, the criterion of economic efficiency is equally important. Generally, the elasticity of any industry’s supply is affected by the industry’s market structure and the nature of the production function for producing its services. Thus, if the various markets within the health care sector are not economically efficient, the cost of health care would be higher than it should be.

By scrutinizing the reasons for the variations from economic efficiency point of view, one can make policy recommendations to upgrade the efficiency of the market and cut the rise in the cost of health care. For instance, the economic efficiency of the supply side of the health sector could have important implications for redistributive policies. If the supply side of the medical care were relatively price inelastic, needing relatively large price increases to produce an increase in health care, it would affect the type of redistribution programs suggested on the demand side. It could in particular affect the considerations that should be given to the relatively disadvantaged group of population. Higher price inelasticity, on the other hand, would benefit the health care providers: the higher the price rises the higher would be the wages and incomes of medical service providers. The rise in prices would of course be financed by the rest of the population, which eventually would have lower incomes.

However, as non-profit institutions, public hospitals have been criticized for providing health care to the public with little consideration of the parallel market prices for the equivalent services. In such a case, it is likely a big potential for technical inefficiency to exist since the operations of public hospitals are at variance with the basic assumptions of perfectly competitive markets, where the most appropriate allocation of resources is assumed.

In the effort being made to improve efficiency through the influence of market forces, cost sharing is one of the mechanisms gaining momentum. However, this mechanism is being criticized as having a tendency of excluding the bottom poor. Though the measurement of efficiency is a multidimensional matter, the concern of this study is limited only to examining the technical efficiency of public hospitals with major health interventions. Hence, those hospitals which are assumed to have been providing significant health care services are included in the sample with the aim of clearly examining and indicating the possibility for better resource allocation in the health sector of the country.

Measurement of technical efficiency being its overall objective, the paper more specifically tries to identify the inputs and outputs that contribute most to the low performances of inefficiently operating public hospitals, and also attempts to draw appropriate conclusions.

# 2. Theoretical and empirical perspectives

## 2.1. General background

Due to the strong need for protecting the public health using the resources available, it would not be surprising if the concerns of governments are focused on issues related to the sources of finance for health services, the ability of the public sector and the efficiency of health services delivery (WHO, 1990). The magnitude of expenditures on health services, constituting 5 percent of the gross domestic product (GDP) and 5 to 10 percent of the government expenditures in developing countries, might justify these concerns (Akin et al., 1987). The 1999/00 data for Ethiopia, for instance, indicate that the expenditure on the health sector accounts for only 1.15 percent of the GDP, implying the need for raising the level of expenditure to the extent that guarantees an improved health status for each citizen (MEDaC, 1999).

**a) The relevance of hospital economics**

The high costs involved and the relatively considerable amounts of resources being used to provide health care services make essential the closer investigation of the operation of hospitals.

During the 1980s hospitals in developing countries tended to be overlooked as the focus of policymakers was almost exclusively on activities related to primary health care, whose coverage was limited to the community level (Barnum and Kutzin, 1993). It is only a recent phenomenon to observe rising interest to look into public resources allocated to hospitals. To this effect, the case studies done by Barnum and Kutzin (1993) have contributed a lot in enriching hospital economics in developing countries.

There is greater desire in dealing with the costs of operating hospitals amid indications of widespread wastage within the health sector. According to WHO (1989) estimate, wastage accounts for as much as 40 percent of the available health resources in the America's. This would probably imply a developing country like Ethiopia to have a higher level of wastage in terms of utilizing the available resources. In such circumstances, the resources that could be derived from the efficiency gains may be considerably high because of the level of resources employed in the large scale hospital operations. For instance, a study conducted in Malawi (Creese, 1990) estimated that simple management correction of inefficient practices could save 44 percent of the nation's major hospital non- personal recurrent costs.

**b) The role of hospitals in the health system**

Lack of integration of hospitals into the primary health care (PHC) system resulted in overcrowding of outpatient services, mainly making referral systems nonfunctioning. The imbalance in human resource allocation among facilities and at different levels of the health care system is another problem area. While it resulted in underutilization of nurses in tertiary hospitals, on the contrary maternal and child health (MCH) nurses in rural health centers failed to meet immunization targets because of overload of work. Due to misallocation of capital budgets it is not also very strange to find underutilized or inoperable high technology equipment in hospitals while health centers lack basic laboratory or diagnostic equipment (Van Lergeghe and Lafort, 1991 and WHO, 1987).

The WHO (1992) assessment of the role of hospitals in the health care system identified the following reasons for the problems observed:

- Attitude toward elitism of hospitals desiring to maintain the status quo and refusing to participate in the PHC approach.
- Negative reactions on the part of non-hospital elements toward the dominance of hospitals in the health system.
- Because hospitals compete with PHC health services for scarce health resources they are viewed as opponents rather than allies.
- Hospitals perform critical functions in the health system that should complement rather than compete with PHC services.
- Hospitals, with their significant level of human, physical and financial resources, have often continued to operate independently of the other elements of the health system.
- The absence of clearly delineated and defined roles and responsibilities results in a fragmented system with widespread disparities in financial and human resources between hospitals and primary health care facilities.

WHO's assessment has also listed the following as main problems hindering the operations of hospitals:

- patients overcrowding in the wards
- long waiting queues in outpatient clinics
- questionable quality of care
- shortages of basic pharmaceuticals and medical supplies
- lack of or inoperable diagnostic and treatment equipment
- low staff morale
- untidy and decaying facilities.

According to the same document, the causes for the above problems of hospitals are:

- lack of a clearly defined role and relationship to other parts of the health system
- organizational weaknesses
- lack of responsiveness to the service needs of the population and communities
- management deficiencies including poor planning and monitoring.

All these problems are directly or indirectly related to the availability and use of resources by hospitals. Experience indicates that there is considerable scope for improving the resource management practices of the hospital sector.

## 2.2. Resource allocation, management and generation in the hospital sector

The resource issues common to hospitals in developing countries may be analyzed under three major topics: resource allocation, resource management and resource (revenue) generation.

### 2.2.1. Resource allocation to hospitals

The distribution of resources to hospitals within the health sector, as well as the allocation among hospitals (e.g., zonal hospitals), geographic regions, and population groups served must be examined in light of cost effectiveness and equity concerns to ensure that the objectives of society and the health system are best served.

The allocation issues are at two levels. Primarily, the system level allocation deals with the allocation of health resources to hospitals relative to other areas of the health sector, and involves making choices among alternative means of providing health services. For instance, decision-makers at national level determine the proportions of government health resources that go to hospitals and PHC facilities. Secondly, the institutional level allocation is concerned with resource allocations between hospitals. Decisions are made (usually at national level) regarding the portion of total hospital resources that go to secondary versus tertiary level facilities, the per capita allocation to hospitals in Region A compared to Region B, urban versus rural hospital resources, or between specialized and referral hospitals.

For resource allocation purposes concepts revolving around production and cost functions are very important. A production function depicts the relationship between an output and various inputs by specifically indicating how inputs are combined in order to produce a given level of output. It also shows the productivity of each input. For instance, Feldestein (1999) has attempted to demonstrate the production function of British hospitals by taking output as weighted mix and inputs comprising hospital beds, medical supplies, nursing and housekeeping.

On the other hand, a cost function represents the relationship between costs of hospitals and their output levels. It also helps to establish the relationship between hospital costs and size, or economies of scale. As in any other production sector, the economies of scale in the health sector can take three forms: constant, increasing and decreasing returns to scale.

### 2.2.2. Resource management by hospitals

Poor management of hospital resources could imply the existence of low level of health services or outputs achieved with far fewer resources. This in turn may imply the need for measuring the efficiency at which hospitals are performing. However, issues pertaining to efficiency in the health sector may not have similar interpretations among scholars as the concept of health is very complex. It is obvious that the type of care needed determines the level of expenditure. Thus, a patient with a complex health problem is likely to require high level of care that entails a relatively high level of per unit expenditure. It is, therefore, evident that a higher unit cost does not necessarily imply inefficiency or wastage of resources since the degree of sickness of a patient determines the level of resources required.

Though the measurement of efficiency in a particular hospital is a dubious issue as mentioned above, the comparison of the efficiency levels of various hospitals is relatively less controversial since it involves comparing ratios. That is, in the comparison of different efficiency levels the input used and the output produced need not necessarily be similar. Consequently, this clearly avoids the measurement problems arising from the complexity of health status.

There are three types of production efficiencies: technical, economic and scale efficiencies (Coelli, 2000).

### Technical efficiency

Technical efficiency in the hospital sector refers to the input mixes that produce a given level of output. In other words, it is a measure of the level of health services a certain hospital produces with the lowest possible level of input mix. For instance, to produce an inpatient stay (the output), the clinical case could be managed by using several combinations of inputs, such as physician time, nursing care, diagnostic services and hotel services. On the contrary, technical inefficiency is said to exist if, for instance, there are excess prescriptions of drugs to patients, where the drugs may be more than necessary for successfully treating the patient.

### Economic efficiency

Economic efficiency relates to identifying the least-cost combination of inputs that produce the desired output level. With this concept two questions may be posed. Given the fixed budget of a hospital, is output (e.g., patient days, admissions, etc) maximized? Or given a fixed quantity of health services to be produced by the hospital, is total cost minimized? The assumption here is that there are various combinations of inputs which could be used to achieve the same qualitative output.

### Scale efficiency

Scale efficiency in general indicates whether a system as a whole is providing services at least cost. From a macroeconomic point of view, economies of scale are important not only for planning the size and number of hospitals in a country but also for planning in individual hospitals since the size of a facility will have an impact on its operating cost and the efficiency that can be achieved in the short- and long-run. In the short-run a hospital's bed capacity and facilities are fixed. This limits the range of input combinations (staff, supplies, equipment, and buildings) that can be used to produce the desired output, which in turn limits the efficiency the hospital can achieve in the term.

Scale efficiencies can be achieved mainly by increasing size through spreading large fixed costs over a large number of patients and by enhancing greater degree of specialization among staff and departments which ultimately result in divisibility of functions.

Finally, it can be concluded that the problems prevailing in the hospital sector can be solved and its resources utilized efficiently and effectively if the following main issues are properly addressed (Feldstein, 1999):

a) *Defining the role of hospitals:*

Clear demarcation of the roles of the different elements of the overall health system will facilitate a way for changes that improve the allocation of the health sector resources. It is therefore important to address the issue of the role of hospitals if there is a need for planning rationally regarding the proper number, type and size of hospitals and allocate the appropriate human, physical and financial resources for their operation.

b) *Improving information about hospitals:*

For the improvement of the hospital sector the following broad categories of information are needed on the hospitals:

- resource allocations
- income and expenditure pattern
- recurrent and capital costs
- behaviour relative to allocation and payment systems
- performance relative to type of ownership (public, private not-for-profit, private-for-profit)

c) *Developing hospital performance indicators:*

For proper assessment of the performance of hospitals, it would be essential to develop appropriate performance indicators that may include**:**

- community, population and services measures
- cost and revenue measures
- quantity or output measures
- quality measure
- inpatient and outpatient case mix measures

d) *Enhancing hospital management capacity:*

Undertaking the actions outlined above would necessitate the need for skilled hospital managers with broad managerial skills necessary to plan, implement, monitor and evaluate the utilization of hospitals' resources. Planners at macro level must also have the necessary skills in hospital management in order to analyze and address the financing and operational issues facing hospitals.

### 2.2.3. Resource generation in hospitals

For its proper provision of health services, the hospital sector undoubtedly needs additional resources. Health insurance, user charges and community financing of hospital services are the most commonly proposed options for generating additional funds. The design of such systems must balance the revenue raising objective against the distributional issues of access to and equity in the use of hospital services (Jack, 1999).

But for developing counties user fees and insurance may be the best options to generate revenues for the provision of hospital services. However, the proportion of revenues raised by public hospitals from user fees may not be sufficient enough to cover their operating costs, usually falling short by 10 percent (Mills, 1990). In addition, concerns pertaining to the issues of equity of access and utilization of hospital services are usually raised when such a scheme is introduced. These, therefore, call for the need to employ financing policies not only to generate additional resources but to realize simultaneously the efficiency, equity and revenue objectives. Furthermore, examining the problems facing hospitals in a developing country like Ethiopia requires not only looking at the expenditures of hospitals but also assessing the underlying policy and management practices that are likely to affect these trends.

Finally, in order to assess the allocation of resources in the health sector, relevant information relating to type of facilities, level of services and geographic location are required to determine the budget and level of expenditure. In addition, the health status and dispersion of the population and difficult topography may be considered as important factors in determining the level of allocation. However, so far there is no as such a suitable mechanism designed for allocating health resources in developing nations, though some developed countries (e.g., the UK) are claiming to have developed such formulas (Newbrander, 1987). It can thus be concluded that a detailed research must be conducted in order to develop appropriate methods by which health resources can be allocated based on the existing situation and national priorities.

# 3. Methodology

## 3.1. Method of analysis and data sources

This study has employed analytical method and for this a stochastic frontier production function approach is applied to estimate firm level technical efficiencies of the sample hospitals for the provision of outpatient and inpatient services.

Hospital level technical inefficiency obtained from the first stage maximum likelihood estimation (MLE) method is considered as dependent variable in the second stage regression analysis while the payment allocated to the two types of labour (i.e. technical and non-technical) is considered as independent variable.

The estimation of the frontier production function has been performed using frontier version 4.1 software developed by Coelli (1994).

Depending on the availability of data the paper has employed different techniques for measuring the level of efficiency of selected public hospitals in Ethiopia. For this purpose eight sample hospitals are selected from the three largest regions of the country (Amhara, Oromiya and SNNP) and from the capital city Addis Ababa. Those hospitals that are assumed to provide significant health care services in selected health programs are included in the sample. In addition, various sets of secondary sources (e.g., MOH, 2000 and CSA, 1999) have also been utilized. Whenever there is information gap different tools (e.g., similar cases of a developing country) have been considered so as to make the estimation process acceptable in the court of academics. Furthermore, in order to corroborate the existing data professional discussions with pertinent medical directors and researchers working in the health sector have also been held.

The following are basic assumptions pertaining to the sample health care units and the data collected thereof.

a) The sampling is fundamentally purposive because the intention is basically to measure the cost-effectiveness of a program intervention in a health care providing unit.
b) To estimate the labour time spent on the provision of health care by medical staff and other supporting personnel, the average daily outpatient visit is assumed to be the output of the health care providing unit.
c) The outpatient visits and inpatient services are assumed to be interchangeable so that aggregating various outputs of the hospital would not be unworkable.
d) As there are no explicit standards regarding the sizes of hospitals, it would not be far from reality if differences in the productivity of hospitals are measured based on the same types of inputs and outputs.
e) Even though there is difficulty of measuring the contribution of capital goods (e.g., buildings), which considerably affect the outcome of the essential parameters, for the purpose of this study the life-span of a building is assumed to be 30 years.

f) As drugs are the major components in the provision of health care, it is important to take them as major inputs for providing health care in the individual hospitals.
g) Excluding exceptional activities in certain areas of health care, it is presumed that there is a reasonable degree of substitution between various types of labour so that the outcome would be the same on the health status of a patient.
h) The explanatory variables involved in the production of health care are assumed to be time invariant since the data used are cross-sectional (i.e., cross-sectional data gathered at some particular time from N health care units).
i) Similar technology is assumed to be in place and access to it is assumed to be non problematic.

## 3.2. Conceptual and measurement problems

Various studies discuss alternative measures of inputs productivity used in the Eastern Europe, such as the productivity for socially necessary output, of direct and indirect labour (using input-output matrices for labour coefficients) and that of embodied labour (Silver, 1984).

The measurement of output and labour input are required in the computation of labour productivity indices. However, the measurement of both seems to be problematic. Though output can most easily be measured by counting the physical units produced of a narrowly defined good, comparing goods produced by different firms may not be easy, owning to quality differences. This might particularly be a problem when comparing the productivity of a service industry (ibid). For instance, comparison of health care services produced by different hospitals across the nation may be difficult since the quality of the health care services is likely to be affected by the type of labour (professional and non-professional), equipment, drugs, etc. devoted to them.

On the other hand, measuring inputs is equally problematic particularly when they are heterogeneous (for instance, in terms of such factors as level of education, age, sex, and type of employment, full- or part-time). In such a case, using appropriate weights would be essential to sum up labour inputs. There is also the question of whether to compute productivity per employee, per production worker, per hour paid, per hour actually paid, or per actually worked (ibid).

Theoretically, one can find a productivity index for a single good and form aggregates for various sectors using weights. However, in the real world one could obtain a productivity index by dividing aggregate output figures to input figures. Unfortunately, output and input indices are usually aggregated separately using different weights.

The estimation of total productivity is envisaged to require the aggregation of outputs produced by similar set of inputs. One approach is first to estimate a production function and find the distance of individual firms (e.g., health care units) from the regression line. One can then derive an index relating actual productivity to estimated productivity. The average regression line fitted, therefore, represents the average level of inefficiency (Figure 3.1)[1]. A practical drawback in this case is the difficulty one would face when comparing firms using different input patterns, particularly when the pattern of the inputs are correlated with the average inefficiencies in use.

Figure 3.1: Estimation of the average regression line

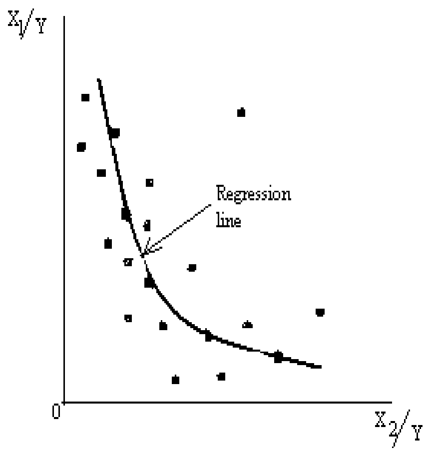
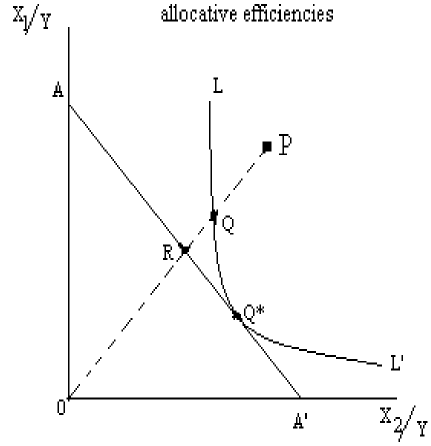



Figure 3.2: Measurements of technical and allocative efficiencies




It is argued that as the production function is defined as the maximum possible quantity of output obtained from a given set of inputs, the traditional regression estimates are observed not to fit in this definition because (a) the regression line in

[1] In Figures 3.1, the ratios $x_1/Y$ *and* $x_2/Y$ represent the proportions of the two inputs used in the production of a single output Y, implying the relative prices of the inputs; and the heavy dots denote the level of production of the various firms (health units in our case).

essence measures the mean output rather than the maximum one, and (b) the regression estimates have either positive or negative residuals (Schmidt, 1986). This is basically the failure of standard statistical techniques in explaining the maximum output attained from a given set of inputs. As a way out, Schmidt proposed to qualify the production function as ‘frontier’ production function.

An alternative means developed by Farrell (1957) was to use two to six boundary observations to define the frontier, and on the assumption that these are efficient firms, to compare other firms to the boundary ones. For this method to work there is a need to set a standard for the firms in question (i.e., health care units) based on which the level of efficiency can be measured without much difficulty.

The estimation of the frontier can be done using linear programming techniques. The method helps one to separate technical inefficiency from allocative inefficiency. The former is measured by the relative distance of a firm from the efficiency frontier, as measured along a ray of current input proportions frontier. Whereas, apparent differences in factor prices paid by firms reflect differences in allocative efficiency. The measurements of inefficiencies would then be followed by hypotheses testing about the sources of inefficiencies. The assumption of constant returns to scale and errors that arise in the measurement of extreme frontier observation are the two major practical limitation and statistical problem of this method, respectively.

To alleviate the statistical problem Aigner, Lovell and Schmidt (1977) developed a statistical approach that has allowed researchers to distinguish between two types of disturbances: the usual normally distributed measurement error and the one-sided inefficiency disturbance (since firms can not be more efficient than the frontier). This actually provides a frontier with identified statistical properties. Moreover, the frontier technique developed by Farrell has an advantage over conventional methods in that it does not specify *a priory* a functional form for the frontier.

The above original ideas of Farrell can be illustrated using two-space diagrams and the associated measures of efficiencies derived in the paragraphs to follow.

Let the isoquant $LL^{/}$ denote the constant level of the single output Y produced by a firm using two inputs $x_1$ and $x_2$ (under the assumption of constant returns to scale). Consider four levels of inputs, lying on and off the isoquant. While the points on the isoquant denote the efficient utilization of the inputs, the points lying off the isoquant (R and P) represent the firm’s inefficient utilization of the two inputs. Such inefficiency levels of the firm can be measured by using rays emanating from the origin. Assume, for instance, the points lying off the isoquant are along the ray emanating from the origin (Figure 3.2). Thus, for point P, the distance QP represents the amount of the inefficiency level that could be reduced. In other words, the technical efficiency level could be measured by the ratio:

$$TE_I = \frac{OQ}{OP}$$
$$= 1 - \frac{QP}{OP}$$

Furthermore, if there is information about the price ratio, the allocative efficiency (also known as price efficiency) of the firm operating at point P is measured by the ratio:

$$AE_I = \frac{OR}{OQ}.$$

Note that at the point where the isoquant is tangent to the line depicting the price ratio (i.e., at point Q*) production is both technically and allocatively efficient. Whereas, at point Q production is technically efficient but allocatively inefficient. Hence, the distance RQ denotes the reduction in production costs that would occur if production were to take place at Q* than at Q.

The overall economic efficiency, therefore, is defined as the product of the technical and allocative efficiencies:

$$EE_I = TE_I * AE_I$$
$$= \frac{OQ}{OP} * \frac{OR}{OQ}$$
$$= \frac{OR}{OP}$$

The above exposition has dwelt on an input-oriented measure of technical efficiency in which the basic question is: how much should quantities of inputs be proportionally reduced without reducing the level of output? Alternatively, the output-oriented measure raises a counter question: by how much should output be proportionally expanded leaving inputs unchanged? For the purpose of comparison, the latter approach is also illustrated below.

In terms of output-oriented efficiency measures, Farrell defines the distance AB in Figure 3.3 as representing technically inefficiency level of production because point A indicates that all the available resources are not efficiently utilized to attain the maximum possible level of output denoted by the production frontier $ZZ'$. Thus, the distance AB implies the amount by which output could be increased without requiring extra inputs. The measures of output-oriented technical efficiency would then be:

$$TE_0 = \frac{OA}{OB}.$$

If the price of the output were known, one could draw the isorevenue line $DD'$ and define the allocative efficiency as:

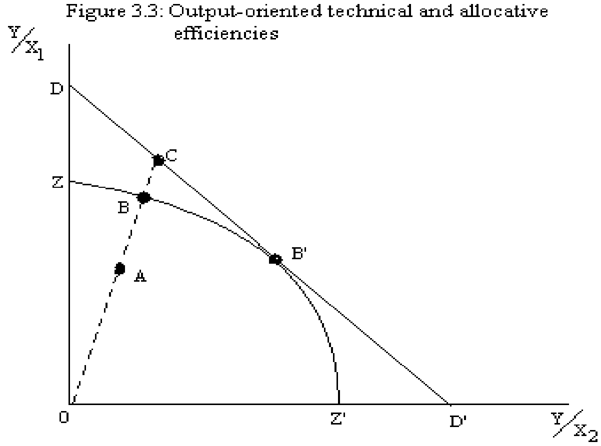
$$AE_0 = \frac{OB}{OC}.$$

Note that this has a revenue increasing interpretation similar to that of cost reducing under input-oriented measure of allocative efficiency. Finally, one may also define the overall economic efficiency as the product of the two measures as:

$$\begin{aligned} EE_0 &= TE_0 * AE_0 \\ &= \frac{OA}{OB} * \frac{OB}{OC} \\ &= \frac{OA}{OC} \end{aligned}$$

In summary, in the exposition of Farrell's proposition one may note that all the efficiency measures (input- and output-oriented) use a ray drawn from the origin to the observed production point. Furthermore, in all cases it is assumed that the relative proportions of inputs (outputs) are constant. This method is advantageous over other methods as it is unit invariant.

Figure 3.3: Output-oriented technical and allocative efficiencies




In light of the above detailed exposition, the basic concern of this paper is examining the efficiency level of government owned hospitals. As health care producing units, since all their inputs and outputs may not be easily measurable, comparative performance evaluation becomes an essential element of managerial control function. And the performance of such service producing units may be measured against time or by comparing them with other similar facilities in the same sector (Chang, 1998).

In this regard, comparative efficiency assessment of how well inputs are utilized to produce health care services becomes an important tool in measuring the performance of a given health care providing unit (ibid). Moreover, since public hospitals are the major health care providers in several countries including Ethiopia, the issue whether the health care units are sufficiently efficient is a major concern. As the efficiency with which state owned sector resources are utilized has also been considered as an engine of a developing economy, understanding the operations of public owned hospitals becomes a pertinent issue in checking whether the economy is progressing on the right track. In addition, as the efficient performance of hospitals may also be associated with other organizational and environmental factors, it would be useful for hospitals to identify and evaluate those factors that influence efficiency.

For evaluating the efficiency level of an economic entity many methods are stated in the literature, such as R*atio Analysis*, *Ordinary Least Square Regression Analysis, Data Envelopment Analysis, Frontier Production Function Approach,* and *Non-Frontier Efficiency Models.* It should, however, be noted that the choice from among these approaches depends on the objective of the study, availability and type of data, characteristics related to technology, etc.

## 3.3 Model Specification: Frontier Production Function Approach

Assuming that hospitals are producing only one type of output (i.e., health care) by combining a number of inputs, a mathematical model that is presumed to capture the interactions taking place in the production process and which can be used to empirically estimate the contribution of each input in the delivery of hospital services can be derived as follows.

Health output $(OH_i)$ is defined as the set containing outpatient visits $(Q_i)$ and inpatient days $(ID_i)$ ,

$$HO_i = f(Q_i, ID_i) \qquad (3.1)$$

Since these variables themselves are the functions of a number of inputs, the health output can be rewritten as a function of these inputs, namely, the labour time spent by different professionals and administrative staff, the budget allocated to drugs available, the number of beds for inpatients, and the depreciation rate of capital goods of the health care providing units. Mathematically,

$$HO_i = F(G_i, N_i, XT_i, LT_i, HA_i, R_i, OT_i, DR_i, B_i, BC_i) \qquad (3.2)$$

where $i = 1,2,3,......,n$ (the number of health care units)

$G_i$ = time spent by the general practitioners of health care unit $i$

$N_i$ = time spent by nurses of health care unit $i$

$XT_i$ = time spent by X-ray technicians of health care unit $i$

$LT_i$ = time spent by laboratory technician of health care unit $i$

$HA_i$ = time spent by health assistants of health care unit $i$

$R_i$ = labour time spent by the registrar of health care unit $i$

$OT_i$ = labour time spent by other staff of health care unit $i$

$DR_i$ = budget allocated to drugs for the $i_{th}$ health care unit

$B_i$ = number of beds for the $i_{th}$ health care unit

$BC_i$ = value attached to the depreciation of the $i_{th}$ health care unit capital goods

As health care provision is believed to be the outcome of team work, one may then justifiably argue that the labour time spent by professional and administrative staff of a health care unit is the best available option to measure the productivity of their respective contributions in the process of health care production.

In order to measure the technical efficiency of hospitals under scrutiny, a stochastic frontier production function of the Cobb-Douglas production type is defined as:

$$Y_i = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + V_i - U_i \qquad (3.3)$$

where $Y_i$ = the natural logarithm of output form the $i_{th}$ health care unit, which is assumed to be non-negative

$X_i$ = the natural logarithm of inputs form the $i_{th}$ health care unit, which is assumed to be non-negative and time invariant

$V_i$ = random error term (or statistical noise) representing events that are outside the control of the $i_{th}$ health care unit, and which is assumed to have a two-sided normal distribution and independent of the $U_i's$.[2]

$U_i$ = disturbance term representing the technical inefficiency of the $i_{th}$ health care unit, but which is assumed to have a one-sided distribution. $U_i$ is expected to measure the level of technical inefficiency in terms of the

[2] $V_i$ is a random variable normally distributed with zero mean and constant variance $\sigma_V^2$; whereas, $U_i$ has a half-normal distribution with unknown mean $\mu$ and variance $\sigma_U^2$. These are mathematically denoted as $V_i \sim N(0, \sigma_V^2)$ and $U_i \sim N(\mu, \sigma_U^2)$.

shortfall of output $Y_i$ from its maximum possible value given by the stochastic frontier function.

However, in order to avoid the problem of micro-numerousity one may classify labour time into two: the labour time of those health professionals (i.e, physicians, nurses, laboratory technicians, etc.) who are directly involved in the delivery of health care services, and that of the administrative staff having supplementary role in the production process. Moreover, the values attached to depreciation and drugs can also be considered as "other" inputs.

Then, based on these simplified representations the functional relationship between the health output and the associated inputs depicted by equation (3.3) may be modified as:

$$Y_i = \beta_0 + \beta_1 T_i + \beta_2 S_i + \beta_3 D_i + V_i - U_i \qquad (3.4)$$

where $Y_i, V_i$ *and* $U_i$ are as defined above, and

$T_i =$ time spent by the technical (professional) staff (e.g., physicians, nurses, etc.) of the $i_{th}$ health care unit

$S_i =$ time spent by the support staff of the $i_{th}$ health care unit

$D_i =$ other inputs comprising the values attached to depreciation and drugs of the $i_{th}$ health care unit

Note that since the estimation is based on cross-sectional data the time subscripts can be assumed away for ease of presentation.

The parameters of equation (3.4) may be estimated by applying either the *maximum-likelihood* (ML) method or using a variant of the corrected ordinary least squares (COLS) method. However, since the ML estimator is asymptotically more efficient than that of the COLS, it may be reasonable to use ML estimators in preference to COLS estimators whenever necessary.

In order to use the ML method one needs to derive a new function, known as the *log-likelihood function,* from the random frontier function and express it in terms of the two variance parameters (i.e., $\sigma_S^2 = \sigma_U^2 + \sigma_V^2$) following Aignor, Lovell and Schmidt's (1977) formulation. And Battese and Corra (1977) also posited the parameter $\gamma = \sigma_U^2 / \sigma_S^2$ mainly because of the advantage it provides in selecting appropriate starting values in the iterative maximization process involved as its value lies between 0 and 1. Then, the ML estimates of $\beta$, $\sigma_S^2$ and $\gamma$ are obtained by maximizing the log-likelihood function. These ML estimators are consistent and asymptotically efficient. Finally, in order to explore the possible causes of inefficient technical situation in each health care unit in terms of interventions made, it would be important to specify the inefficiency model as follows:

$$U_i = \delta_0 + \delta_1 PS_i + \delta_2 AS_i + \omega_i \qquad (3.5)$$

where $U_i$ = inefficiency level for each health care unit

$\delta_0$ = a constant

$\delta_1$ = coefficient of salary paid to the professional staff (PS)

$\delta_2$ = coefficient of salary paid to the non professional (administrative) staff (AS)

$\omega_i$ = the disturbance term that may capture other influencing factors, and which is assumed to be normally distributed with zero mean and constant variance.

# 4. Findings of the study

## 4.1. Descriptive analyses

### 4.1.1. General description

According to the publication of the Ministry of Health (MOH, 2001), there are 110 hospitals, 382 health centers and 2,393 health stations serving over 65 million people. Hence, the eight sampled hospitals constitute 10 percent of the government-owned hospitals suggesting that this would allow one to conduct investigation on the technical efficiency of each hospital, since the data are assumed to be representative of the population (Cochran, 1977).

The data collected have been basically aimed at examining the cost-effectiveness of the major health programs in the country, and the selected hospitals are those in which significant health care services are assumed to have been provided.

The sample hospitals consist of four from Amhara, two from Oromiya, one from Addis Ababa and one from SNNPs regions. The regional distribution of sample hospitals is not uniform since the sampling technique is based on the selection of the health care providing units with major contribution to the public health care in selected health programs.

### 4.1.2. Profiles of the sample hospitals

The general profiles of the sample hospitals are presented in *Appendices I - III*. This sub-section provides highlights on the major characteristics of the hospitals under consideration.

**(a) Composition of the total health staff**

The total health staff comprises the technical staff, which is directly involved with the provision of health care services, and the non-technical staff that consists of the administrative and support staff. Under the former group we have specialist doctors, general practitioners (or MDs), nurses, laboratory and X-ray technicians, health assistants and pharmacists. Comparison of the two groups of personnel reveals that, in the majority of the sample hospitals (i.e., except at *Shashemene, Debre Markos* and *Yekatit 12* hospitals) the number of technical staff exceeds that of the non-technical staff (Figure 4.1).

**Figure 4.1: Total technical and non-technical staff**

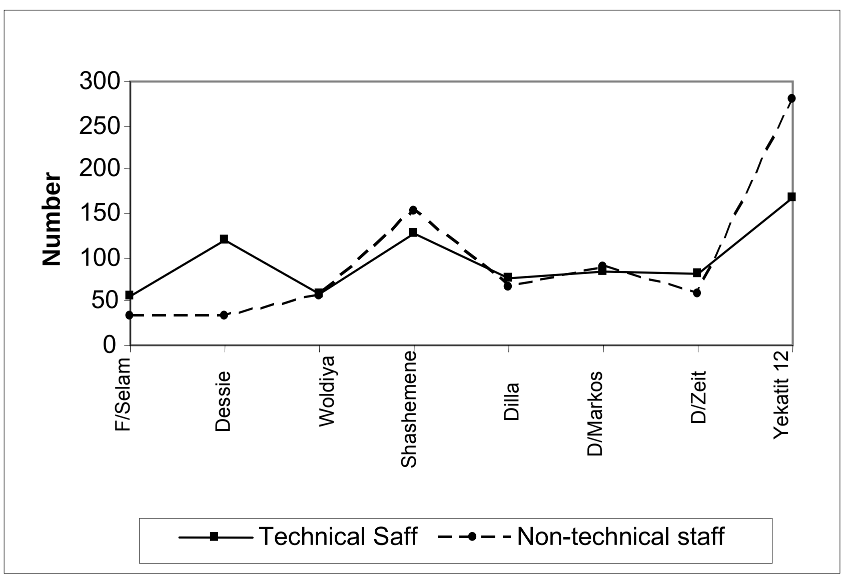
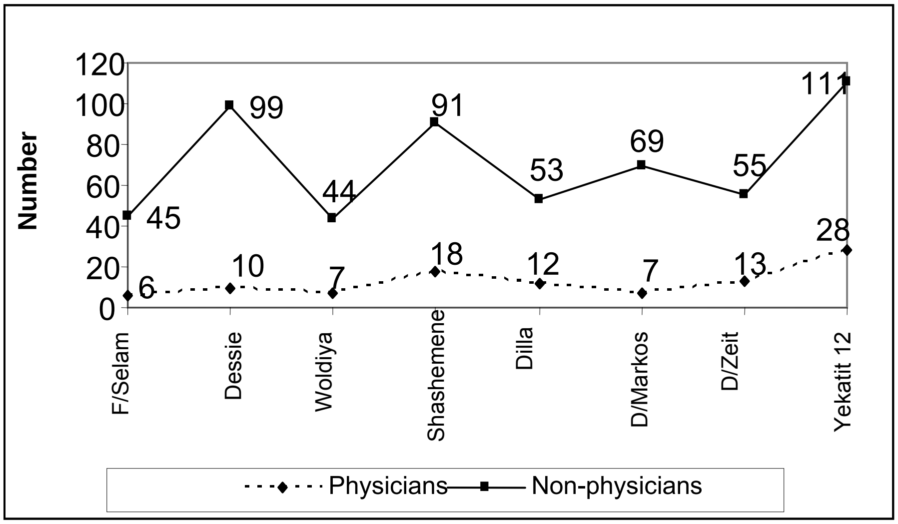


**Figure 4.2: Composition of the technical staff**




In the majority of the sample hospitals the number of specialist doctors is found to be very few, with the exception of *Yekatit 12* hospital where more than 20 specialists were operating at the time of data collection. With regards to the composition of the technical staff, not only small variation is observed among the sample hospitals but also all these hospitals are staffed with relatively lower number of physicians (MDs and specialist doctors). Except at *Shashemene* and *Yekatit 12* hospitals where there are 18 and 28 physicians, respectively, only 6 – 13 physicians are found in the rest of the sample hospitals (Figure 4.2).

On the other hand, large variations are observed in the number of non-physicians (nurses, laboratory and X-ray technicians, health assistants and pharmacists). While *Dessie, Shashemene* and *Yekatit 12* hospitals are staffed with more than 90 non-physicians, the corresponding figure for the remaining sample hospitals is much lower than this.

**(b) Outpatient and inpatient services**

The sample hospitals on average serve about 192 outpatients each day. Though variations are observed between the different hospitals, the majority of them provide outpatient services for more than 200 patients per day. It is only *Finote Selam, Woldiya* and *Dilla* hospitals that are found to serve relatively less number of outpatients. As a zonal hospital whose service is not limited to patients from Addis Ababa alone, Yekatit 12 hospital receives on average 305 visitors per day (Figure 4.3).

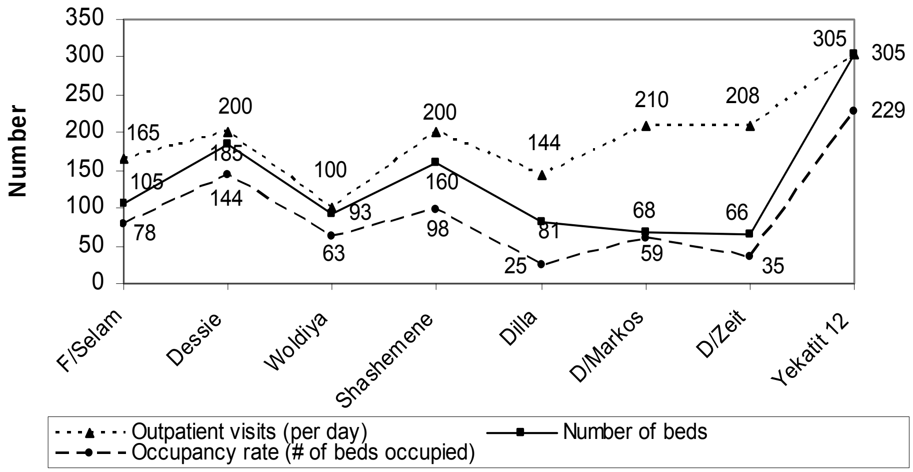



**Figure 4.3**: Outpatien and inpatient services in the sample hospitals

The sample hospitals also show variations in terms of the number of beds they have, the average being 133 beds. Again with 305 beds, *Yekatit 12* hospital is the largest of all the sample hospitals, followed by *Dessie* (185) and *Shashemene* (105) hospitals. The rest are relatively small hospitals with only 66 – 105 beds. However, despite the much talked scarcity of hospital beds, the inpatient intake of the sample hospitals is observed to be limited only to about an average of 91 inpatients per day. That is, only closer to 66% of the hospital beds on average are occupied each day. *Debre Markos* hospital registers the maximum occupancy rate (87%).

The workload of physicians in the surveyed hospitals and the quality of health care services being provided can be examined in terms of outpatient-, inpatient- and bed-physician ratios. Thus, as Table 4.1 shows a physician in any one sample area can treat on average 18 and 8 outpatients and inpatients per day, respectively. In addition, 11 beds on average are available per each physician in the surveyed hospitals. However, *Dilla*, *Debre Zeit* and *Shashemene* hospitals are observed to have the lowest inpatient-physician ratios which are far below the sample average, signifying that these hospitals have better opportunity to provide quality medical services to their patients as the physicians would have reasonable time to devote to each patient.

**Table 4.1: Patients/bed-physician ratios per day**

| Hospital | (O/P)/Physician | (I/P)/Physician | Bed/Physician |
|---|---|---|---|
| Finote Selam | 27.5 | 13.0 | 17.5 |
| Dessie | 20.0 | 14.4 | 18.5 |
| Woldiya | 14.3 | 9.0 | 13.3 |
| Shashemene | 11.1 | 5.4 | 8.9 |
| Dilla | 12.0 | 2.1 | 6.8 |
| Debre Markos | 30.0 | 8.4 | 9.7 |
| Debre Zeit | 16.0 | 2.7 | 5.1 |
| Yekatit 12 | 10.9 | 8.2 | 10.9 |
| **Average** | **17.7** | **7.9** | **11.3** |

*Note*: O/P = Outpatient; I/P = Inpatient; Physician = specialists plus MDs

On the other hand, the outpatient-, inpatient- and bed-physician ratios of the hospitals in Amhara region are relatively higher than those in the other sample areas and the sample average. For instance, the highest ratio observed in the outpatient service unit at *Fintote Selam* hospital may characterize the burden of the health worker in that unit, as a physician in this unit is required to attend as many as 28 outpatients in one day. This may have serious repercussions on individuals' health status. Thus, it would not be unreasonable to conclude that such a large coverage of outpatient services per day can only be attained at the expense of quality service.

The ratios presented above may imply that the medical care services available at any one hospital can be affected mainly by the distribution and quality of the health personnel, the type of diseases prevailing in the area (e.g. malaria in low land areas), the proximity of health facilities and the perception of individual users about a particular health care providing unit.

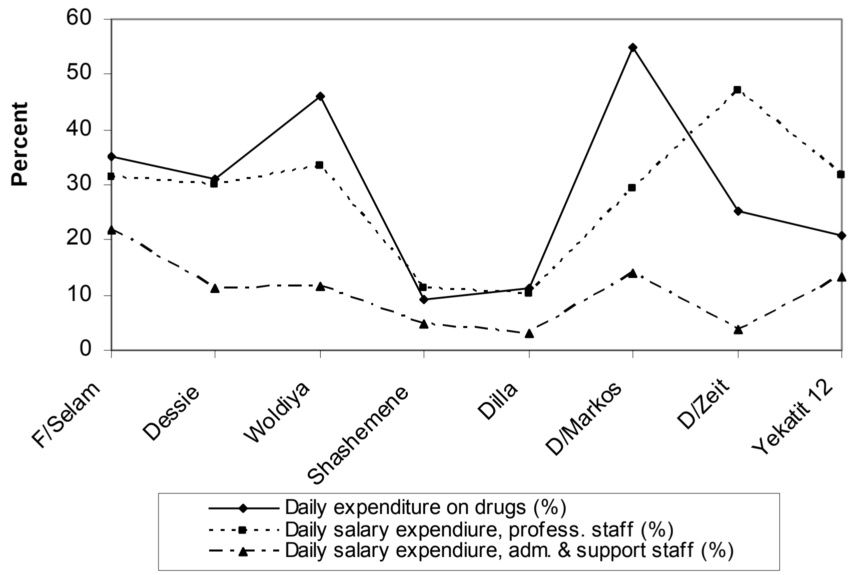
**(c) Average daily budget and expenditures**

With a daily budget ranging from Birr 13.34 – 20.84 thousand, *Dilla, Yekatit 12* and *Shashemene* hospitals, respectively, are the ones with the highest budget allocated for their daily operations. In contrast, the rest sample hospitals are observed to have very low daily budget (Birr 4 – 8 thousand) (Appendix I). Out of the total daily budget the average proportions allocated for drugs, salary of professional staff and salary of administrative staff are 29, 28 and 11%, respectively.

For the majority of the sample hospitals the daily expenditure on drugs is relatively higher than the amount spent on the salary of the professional health care providers.

In this case, *Debre Zeit* and *Yekatit 12* hospitals are found to be exceptions, where not only the former is much lower than the latter, but also a good proportion of the total daily budget (47 and 32%, respectively) is taken by the salary of the professional staff. However, the share of the salary of the administrative and support staff in the total budget is smaller in all the sample hospitals (Figure 4.4).

**Figure 4.4:** Proportion of expenditures out of the total daily budget




### (d) Time spent by total health staff on outpatient and inpatient services

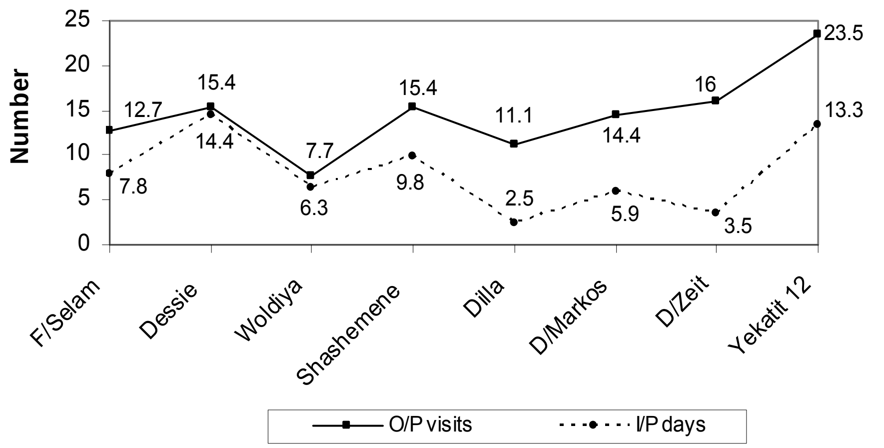
The contributions made by each health staff on the delivery of health care services is analyzed based on some selected intervention areas. Hence, by considering the most prevalent types of diseases common to all the sample hospitals*, 13 and 10 intervention areas were identified for outpatient and inpatient services, respectively. And based on these outpatient and inpatient services, the mean number of outpatient

* *Such diseases may include acute upper respiratory infections, eye infections, tuberculosis of respiratory system, bacillary dysentery, other infective and parasitic diseases, and injuries from external causes, gastric and duodenal complications, pneumonia, sexually transmitted diseases, and other genitor-urinary diseases.*

visits and inpatient days and the average time spent by each of the technical and non-technical staff on each patient is computed (Appendices II and III).

Accordingly, viewed in terms of the selected intervention areas, all the health care institutions under consideration provide health care services on average to nearly 15 outpatients each day and an inpatient on average stays for about 8 days in a hospital. Considering each sample hospital, it can be observed that *Woldiya* and *Yekatit 12* hospitals register the minimum and maximum mean number of outpatients, respectively. On the other hand, while an inpatient stayed in *Dessie* hospital for about 14 days on average at the time of the survey, the mean number of inpatient days for *Dilla* and *Debre Zeit* hospitals ranged between 2 to 4 days (Figure 4.5).

**Figure 4.5**: Mean number of outpatient visits and inpatient days

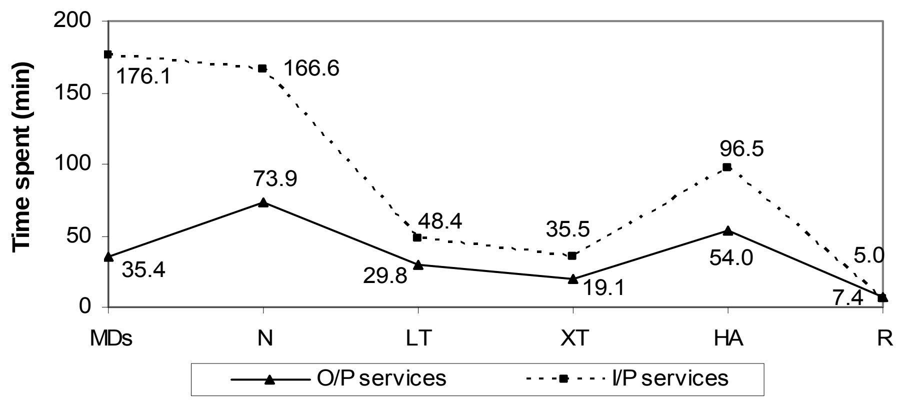



The survey also revealed that the time spent by individual health staff varies depending on the types of interventions made on outpatient and inpatient services. Based on the selected outpatient and inpatient service areas (13 and 10 respectively), all the medical staff are observed to devote much of their time to inpatient services as compared to outpatient services (Figure 4.6*). Hence, the average time spent by the technical staff on inpatient services is observed to extend from about half an hour to 3 hours. In contrast, outpatients receive a time that spans on average between 19 minutes and an hour and a quarter. In both cases, the labour

* In Figure 4.6, MDs denote time spent by general practitioners (medical doctors), N by nurses, LT by laboratory technicians, XT by X-ray technicians, HA by health assistants, and R by the registrar.

time spent by the registrar office is found to be the minimum of all with an average value of less than 8 minutes.

**Figure 4.6**: Average time spent by total health staff on outpatient and inpatient services




However, the contributions made, in terms of the time spent per each intervention, by the different technical health staff are observed to vary significantly between the sample hospitals and the types of services provided. Consequently, the maximum time spent for the outpatient services is registered by nurses with an average time of about 74 minutes per each intervention, followed by health assistants (54 minutes) and medical doctors (35 minutes). Laboratory and X-ray technicians also contribute closer to 30 and 20 minutes, respectively, on average on each intervention area.

With regards to the inpatient services, general practitioner doctors are observed to have spent a maximum of 2.9 hours on average on each of the ten intervention areas. The next highest time is registered by nurses and health assistants (2.8 and 1.6 hours respectively). For the provision of the selected inpatient services laboratory and X-ray technicians are also found to devote on average more than half an hour.

**(e) Values attributed to depreciation and drug supplies**

The nonlabour contribution to the provision of the selected health care services for outpatients and inpatients is expressed in terms of the expenditures attached to the depreciation of the equipment and infrastructure of the sample hospitals under consideration and the values of drugs supplied by them. Accordingly, viewing across all the sample hospitals, one observes that the mean values attributed to depreciation and drug supplies associated with the inpatient services are higher than that of the outpatient services (Figure 4.7). In other words, the daily average expenditure on depreciation and drugs required for the provision of the outpatient services is almost one-third of that for inpatient services, with average expenditure of Birr 133 against Birr 397 per day.

Comparison of the sample hospitals reveals that, with daily expenditure of closer to Birr 1,063 on its inpatient services, *Shashemene* hospital registers the highest depreciation and drug values, followed by *Yekatit 12* and *Dilla* hospitals that expend about Birr 712 and 427 per day, respectively. Since the percentage share of the daily expenditure on drugs in *Shashemene* hospital is lower than the entire sample hospitals (Figure 4.4), such higher value might be due to higher depreciation values of its equipments and infrastructure. On the other hand, there seems to be relatively small variations in the values attributed to depreciation and drugs for the provision of the outpatient services in the majority of the sample hospitals. With a mean expenditure of Birr 344 per day, *Yekatit 12* hospital stands out from among the sample institutions. All the rest expend on average between Birr 65 and 168 on daily basis.

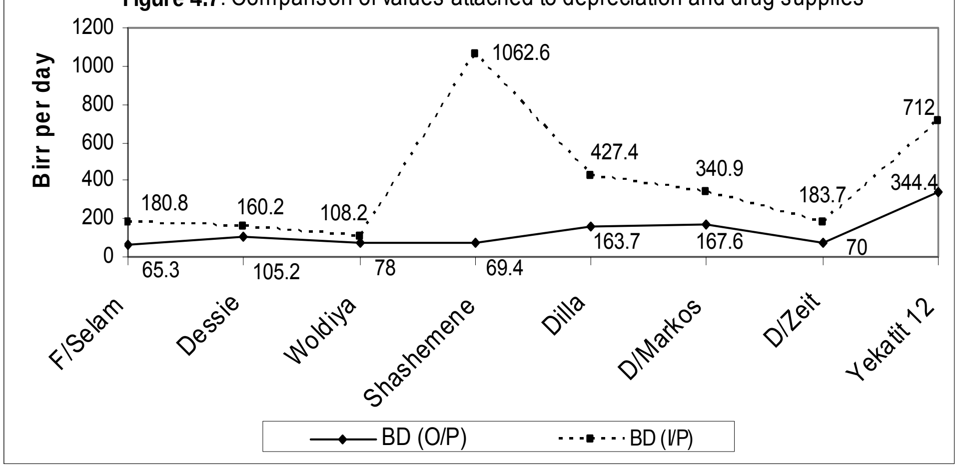



**Figure 4.7**: Comparison of values attached to depreciation and drug supplies

*BD denotes values of depreciation and drug supplies associated with outpatient (O/P) and inpatient (I/P) services.*

**(f) Relationships between outpatient visits and other factors**

Table 4.2 clearly exhibits the relationships existing between outpatient visits and factors related to proximity of facilities, types of medical services (in- and out-referrals) and income levels of the patients. Accordingly, consistent with *a priori* theoretical expectations, proximity to the major urban areas is found to have bigger impact on the utilization of health care units. In this regard, the negative correlation coefficient between outpatient visits and distance from Addis Ababa indicates that the further away a health care unit from Addis Ababa the lesser would be the outpatient visits. The large population in bigger urban areas is believed to increase the probability of making a visit to a health facility.

**Table 4.2**: Relationships between outpatient visits & other factors

| Item | Correlation coefficient (r) |
|---|---|
| Outpatient visit vs distance from Addis Ababa | -0.8521 |
| Outpatient visit vs in-referrals | 0.2965 |
| Outpatient visit vs out-referrals | -0.1206 |
| Outpatient visit vs absolute poverty level | -0.4490 |
| Outpatient visit vs relative poverty level | -0.3374 |

On the other hand, there seems to be negative associations between absolute and relative poverty levels of patients and outpatient visits. Nevertheless, the low level of correlation coefficients suggests that there are other factors than these that play important roles in the outpatient visits. Moreover, the low positive and negative correlations between outpatient visits and in-referral and out-referral services, respectively, further reinforce the significant role of other factors than those discussed here which predominantly affect outpatient services. A case in point could be the number of health personnel.

Table 4.3 exhibits the associations between outpatient visits and the various health care practitioners in the sample hospitals. The results obtained reveal that the availability of health personnel plays an important role in providing the required health care services in a sufficient manner. As demonstrated for individual segment of labour in the table, the highest correlation coefficient is registered between the number of outpatient visits and physicians (82%), indicating that the higher the number of medical doctors in a hospital the larger would be the number of outpatient visits. The coefficient between health assistants and outpatient visits is the second highest (73.8%), followed by fairly strong relationship between the number of nurses and outpatient visits (66.8%).

**Table 4.3: Correlations between outpatient visits and health personnel in the sample hospitals**

| No | Item | Correlation coefficient (r) |
|---|---|---|
| 1 | Medical Doctor vs outpatient visits | 0.8201 |
| 2 | Nurses vs outpatient visits | 0.6679 |
| 3 | Lab.& X-ray technicians vs outpatient visits | 0.5180 |
| 4 | Health assistants vs outpatient visits | 0.7375 |
| 5 | THP* ( = 1+2+3+4) vs outpatients visits | 0.8591 |
| 6 | Administrative staff vs outpatient visits | 0.7229 |
| 7 | THS** ( = 5+6) vs outpatient visits | 0.8405 |

*Note: *THP = Total number of Health Personnel*
***THS = Total number of Health Staff*

The table further demonstrates a stronger relationship between the number of outpatient visits and the total number of health care personnel than between that of administrative staff, signifying the central role being played by the professional health care workers compared to the non-technical staff. This would in general imply the need for appropriate allocation of health personnel, particularly the skilled ones, in order to enable hospitals extend their services efficiently and in the standard required.

## 4.2. Production Frontier Results

A production function is a mathematical statement that establishes a technological relationship between the maximum amount of output that can be produced and a given set of inputs. For the case at hand, a production function for hospital services indicates the maximum level of outpatient/inpatient services that can be produced from a given set of inputs (physician, drugs, etc.).

It should be noted that not all hospitals produce the maximum output possible from a given set of inputs due to various reasons. For instance, various hospitals have different level of technological capacity that would make the output level different. Some may enjoy economies of scale depending on the number of outpatient visits to their service providing units. Thus, it would be hardly surprising to observe higher level of output in hospitals with higher technological capacity. Therefore, in order to avoid complications in measuring the technical efficiency of various service providing units it is necessary to assume homogenous level of technology in all the sample hospitals.

It is also important to remember that production efficiency is attained at that level of output where it becomes impossible to redistribute inputs to produce more of one product without reducing the output of another product. In other words, if the output of one product increases at the expense of another one, then such allocation of inputs is said to be inefficient.

In order to measure the technical efficiency of individual hospitals, different approaches may be employed. Microeconomic theory explains that the maximum output from a given set of inputs may be expressed by the level of technical efficiency. Hence, to measure the level of technical efficiency of a certain hospital in terms of the interventions made one may need to identify the types of interventions in order to examine the contribution of each input to the production process. The production process, which is the outcome of a mix of inputs, can be expressed in terms of the services delivered to visitors of health care units. And the health care services provided by a hospital may be divided into two parts: outpatient services and inpatient days. The differentiation between the two is basically dependent on the burden of the disease on an individual patient. The severity of the illness may determine whether an individual patient be provided with closer care (admitted as an inpatient) or considered as an outpatient.

### 4.2.1. Outpatient visits

*(a) Preliminary Tests*

In order to determine the existence of technical inefficiency, we need to test whether the production function is appropriately represented either by OLS estimate or by frontier analysis. This can be done by testing the null hypothesis $H_0 : \mu = \gamma = 0$ which states that the term denoting the technical inefficiency ($U_i$) has both zero mean and variance, implying the absence of technical inefficiency in the hospitals under investigation, against the alternative hypothesis $H_1 : \mu \neq \gamma \neq 0$ which asserts the existence of technical inefficiency.

Table 4.4 indicates that the OLS and ML estimates of the log-likelihood function show significant differences for only three of the sample hospitals, namely *Dessie, Dilla* and *Debre Markos* hospitals. That is, for these three hospitals the null hypothesis is rejected at 5% level of significance and the alternative hypothesis, that there exists technical inefficiency, is accepted. This would also mean that there is some degree of technical inefficiency in the provision of outpatient services by these three hospitals.

Put differently, all interventions made by the three hospitals have been proved to suffer from technical inefficiency problems.

It has to be noted that rejecting the null hypothesis for the three hospitals would equally mean accepting the alternative hypothesis, which in a way is stating that the production functions of these hospitals are best represented by ML estimates than OLS estimates. By the same token, OLS is found to be the best method of estimation for the remaining five sample hospitals performing without showing any significant level of inefficiency. The level of efficiency of these hospitals may be explained either by the high number of visits frequented by people being served or by less amount of resources allocated to provide the health care services.

**Table 4.4: Hypothesis testing for parameters on deciding the existence of inefficiency in the delivery of outpatient services**

| Name of Hospital | Log-likelihood | | $\chi^2_{cal^{**}}$ | $\chi^2_{2, 0.95}$ |
|---|---|---|---|---|
| | OLS $(H_0 : \mu = \gamma = 0)$ | MLE $(H_1 : \mu \neq \gamma \neq 0)$ | | |
| Finote Selam | 17.23 | 19.33 | 4.19 | 5.99 |
| Dessie | 1.43 | 6.03 | *9.22 | 5.99 |
| Woldiya | 8.83 | 9.83 | 2.02 | 5.99 |
| Shashemene | 25.52 | 26.38 | 1.72 | 5.99 |
| Dilla | -38.18 | -33.18 | *10.00 | 5.99 |
| Debre Markos | 11.54 | 16.19 | *9.30 | 5.99 |
| Debre Zeit | 10.40 | 11.61 | 2.42 | 5.99 |
| Yekatit | 24.76 | 26.41 | 3.30 | 5.99 |

Note: The degree of freedom for the $\chi^2$ test is 2, denoting the number of restrictions

* Significant at 5 percent level of significance

** $LR = -2[L(H_0) - L(H_1)]$

*(b) Production Frontier Analyses*

Using equation *(3.4)* * production frontier estimation has been conducted for each hospital in order to investigate the contribution of each factor included in the model. It

* $Y_i = \beta_0 + \beta_1 T_i + \beta_2 S_i + \beta_3 D_i + V_i - U_i$ where $Y_i$ is output (outpatient visits, in this case), $T_i$ time spent by the technical (professional) staff, $S_i$ time spent by the support staff, $D_i$ values attached to depreciation and drugs, $V_i$ error term, $U_i$ technical inefficiency, and $i$ denoting the $i_{th}$ health care unit.

may be necessary to indicate at the outset that (a) strangely enough the estimated autonomous parameter ( $\beta_0$ ) may have less theoretical plausibility since it seems a bit unclear compared to other estimated parameters; and (b) the estimated parameters for health workers, non technical staff, and the depreciation and drug costs associated with the health provision entail different explanations since the degree of influence on delivering the services depends on the individual characteristics of the inputs. The following two sub-topics provide the analyses of the regression results presented in Table 4.5.

*(b.1) Technically efficient hospitals*

As indicated by the preliminary tests five sample hospitals (*Finote Selam, Woldiya, Shashemene, Debre Zeit and Yekatit 12*) have been found to operate without significant level of inefficiency. For all these hospitals the coefficient estimate of the variable denoting the time spent by technical health staff $\beta_1$ (comprising physicians, nurses, health assistants, laboratory and x-ray technicians, and pharmacists) is found to be statistically significant at 5 percent level of significance. In addition, the positive magnitude of this parameter signifies the direct contribution of the health professionals' labour to the delivery of the outpatient services.

For instance, the parameter $\beta_1$ for Finote Selam hospital is found to be 0.822, indicating that the responsiveness of outpatient visits for a percentage increase in the labour of the technicians would be less than one percent. This means, other things remaining the same, an increase in the time spent by the technicians would attract less proportion of outpatient visits, exhibiting the inelasticity of outpatient visits to the labour involvement of technicians. Whereas, for Yekatit 12 hospital, the largest service providing unit among the sample health care providing units which is relatively well staffed and equipped (Appendix I), the estimated parameter (1.814) indicates that a percentage increase in the employment of health professionals would almost double the outpatient visits.

With regards to the coefficient estimate $\beta_2$ that denotes the impact the labour time of administrative and support staff has on outpatient services, negative association is observed between these variables for all the five hospitals, where an increase in the former leads to a decrease in the latter variable. However, the variation in the number of outpatient visits is found to be significantly explained by the activities of the support staff only for three of the hospitals (*Finote Selam, Wodiya* and *Debre Zeit*), while for the rest two hospitals the variable has no impact at all on outpatient services.

Nevertheless, far less inelasticity of outpatient visits to the labour time of administrative staff is registered. It is estimated, for instance, that a percentage increase in the labour time of the support staff of *Woldiya* hospital would produce a less proportionate decrease (0.02%) in the number of outpatient visits. The corresponding figures for *Finote Selam* and *Debre Zeit* hospitals are 0.24% and 0.34%, respectively. This may be perhaps due to diminishing marginal returns to scale, which in turn implies the presence of already large number of administrative workers in these hospitals (Appendix I).

*(b.2) Technically inefficient hospitals*

The preliminary tests also identified *Dessie, Dilla* and *Debre Markos* hospitals as showing significant level of technical inefficiency in their outpatient health care provisions. In addition, the production process of these health care units is found to be adequately and well represented using the MLE method. The regression estimates of the parameters $\beta_1$ and $\beta_2$, on the other hand, reveal that the activities of both the technical and non-technical staff significantly determine the provision of outpatient health care services.

Hence, for *Dessie* hospital the estimated parameters (-1.069 and -1.214) denote that the responsiveness of outpatient visits to the change in the labour time of technicians and support staff is nearly proportional (i.e., it is almost unitary elastic) but opposite in direction. That means a unit increase in each of these variables would result in decreasing the number of outpatient visit approximately by unity. The case is different for *Dilla* and *Debre Markos* hospitals. As shown, a certain percentage increase in the time spent by health professionals and support staff is likely to induce, respectively, about six and three fold increases in the volume of outpatient visits for *Dilla* hospital, signifying increasing marginal returns to scale. But for *Debre Markos* hospital outpatient services show close to unitary elastic responsiveness (0.994) to the change in labour time of the technical staff as compared to a very small proportionate change (0.026) due to that of the non-technical staff.

Finally, the estimated parameter for 'other' inputs ($\beta_3$), comprising the values attached to depreciation and costs of drugs, is significant enough to affect the production process of only two of the efficiently operating health care providing units (*Shashemene* and *Yekatit 12* hospitals) and one of the inefficient one (*Dessie* hospital). For all these hospitals, a unit increase in costs associated with depreciation and drugs is estimated to more than double the production of outpatient services.

However, for the rest of the sample hospitals this factor is found to produce no significant influence on the production of outpatient health care services.

**Table 4.5: Efficiency levels of sample hospitals for outpatient visits**

| Sample Hospitals | Method of estimation[+] | Coefficients $\beta_0$ | $\beta_1$ | $\beta_2$ | $\beta_3$ | $\sigma_s^2$ [++] | $\gamma$ [+++] | Log Likelihood | Mean Efficiency Level (%) |
|---|---|---|---|---|---|---|---|---|---|
| Finote Selam | OLS | -3.105 (-3.541) | 0.822 (7.161)* | -0.239 (-0.756)* | 0.322 (1.039) | 0.006 | - | 17.23 | |
| Woldiya | OLS | -2.531 (-7.613) | 0.706 (3.123)* | -0.022 (-4.580)* | 0.690 (0.926) | 0.019 | - | 8.83 | |
| Shashemene | OLS | -5.132 (-4.858)* | 0.704 (7.343)* | -0.024 (-1.790) | 0.777 (2.917)* | 0.002 | - | 25.52 | |
| Debre Zeit | OLS | -3.656 (-2.805)* | 0.927 (8.992)* | -0.335 (-2.010)* | 0.499 (1.169) | 0.017 | - | 10.40 | |
| Yekatit 12 | OLS | -8.876 (-8.277) | 1.814 (23.718)* | -0.001 (-0.049) | 1.700 (8.623)* | 0.002 | - | 24.76 | |
| Dessie | OLS | -8.452 (-7.099) | 0.115 (1.084) | 0.226 (0.350) | 2.365 (7.948) | 0.068 | - | 1.43 | |
| | MLE | -8.243 (-7.368)* | -1.069 (-7.378)* | -1.214 (-1.961)* | 2.392 (8.517) * | 0.1018 | 0.999 | 6.04 | 82.43 |
| Dilla | OLS | -13.23 (-0.616) | 6.372 (0.768) | 2.724 (0.364) | -1.244 (-0.272) | 13.93 | - | -38.18 | |
| | MLE | -13.22 (-0.591) | 6.372 (9.276)* | 2.724 (4.419)* | -1.244 (-0.331) | 9.65 | 0.855 | -33.18 | 90.94 |
| Debre Markos | OLS | -0.536 (-0.133) | 1.013 (5.472) | 0.022 (1.140) | -0.494 (-0.508) | 0.014 | - | 11.54 | |
| | MLE | -1.782 (-0.740) | 0.994 (11.281)* | 0.026 (3.025)* | -0.214 (-0.390) | 0.025 | 0.999 | 16.19 | 91.24 |

Note: Figures in parentheses denote t-ratios.
*Significant at 5% level of significance.

Table 4.5 also exhibits the mean technical efficiency levels for those hospitals identified to perform at significant level of inefficiencies. The 82.43% mean technical efficiency level of *Dessie* hospital may represent the less prudent utilization of the available resources. This would logically mean that given the available technology,

[+] For the technically efficient hospitals (Finote Selam, Woldiya, Shashemene, Debre Zeit and Yekatit 12) the coefficients of the production function are best represented by OLS estimates. Whereas, for those identified to have certain degree of inefficiency the frontier estimation that uses MLE method is found appropriate.

[++] $\sigma_s^2 = \sigma_u^2 + \sigma_v^2$

[+++] $\gamma = \dfrac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2}$

the level of inputs may be reduced at least by 17.57 percent so that the level of outpatient services delivery can be improved without incurring additional cost. The mean technical efficiency levels of *Dilla* (90.94%) and *Debre Markos* (91.24%) hospitals could imply that by using the available resources and technology, the technical efficiencies of these hospitals can be raised at least by 9 and 8%, respectively, without resorting to additional resources in the short run.

*(c)The inefficiency model*

The results obtained under *(a)* above would permit one to conduct further investigation to determine the factors affecting the inefficiency levels. Hence, regressing equation *(3.5)*[+] would help identify the major factors causing inefficiencies in the sample hospitals that were found to perform under significant levels of inefficiencies. As discussed above, the two main variables identified as important determinants of the level of outpatient health care provisions were the labour time of the health professionals and that of the administrative and support staff. This part of the paper, therefore, tries to investigate how the remuneration provided to these two groups of personnel contributes to the inefficiency levels of *Dessie, Dilla* and *Debre Markos* hospitals.

As one may clearly observe (Table 4.6) the incentive associated with the remuneration that goes to the technical staff is the main cause for the variation in the inefficient provision of outpatient health care services in all the three inefficiently operating hospitals. In all cases, the salary paid to the professional staff is observed to negatively influence the service delivery of the hospitals under consideration. However, the estimated parameter ($\delta_1$) reveals that the capacity of the salary variable in reducing the inefficiency level is very small. For instance, a 100% increase in the salary of the technical staff is likely to reduce the inefficiency level of *Dessie, Dilla* and *Debre Markos* hospitals only by approximately 4, 0.3 and 0.2%, respectively.

[+] $U_i = \delta_0 + \delta_1 PS_i + \delta_2 AS_i + \omega_i$, where $U_i$ is the inefficiency level for each health care unit, $\delta_0$ a constant, $\delta_1$ coefficient of salary paid to the professional staff (PS), $\delta_2$ coefficient of salary paid to the non-professional (administrative) staff (AS), and $\omega_i$ the disturbance term that may capture other influencing factors.

**Table 4.6: OLS estimates for technical inefficiency model for outpatient visits**

| Name of Hospital | Variable | Coefficient | OLS Estimates | p-value |
|---|---|---|---|---|
| **Dessie** | Constant | $\delta_0$ | -0.2095 (-2.433) * | 0.024 |
| | Salary to PS | $\delta_1$ | -0.0417 (-14.67)* | 0.0015 |
| | Salary to AS | $\delta_2$ | -0.0057 (-7.93) * | 0.079 |
| **Dilla** | Constant | $\delta_0$ | 0.0982 (12.473) * | 0.000 |
| | Salary to PS | $\delta_1$ | -0.003 (-8.256) * | 0.043 |
| | Salary to AS | $\delta_2$ | -0.001 (-0.68) | 0.512 |
| **Debre Markos** | Constant | $\delta_0$ | 0.049 (0.977) | 0.162 |
| | Salary to PS | $\delta_1$ | -0.00197 (11.70) * | 0.027 |
| | Salary to AS | $\delta_2$ | -0.001 (-0.186) | 0.860 |

* Statistically significant at 5% level of significance

The salary paid to the non-technical staff, on the other hand, is observed to have no significant influence on the inefficiency level, except for Dessie hospital where it generates infinitely small proportionate change.

The far less responsiveness of the level of inefficiency to changes in the salary variables would, therefore, indicate that there are other factors rather than remuneration causing inefficiencies in these hospitals. That is, the contributions of other influencing factors would seem to be more important in reducing inefficiency levels than the direct monetary rewards. Thus, in order to curb the inefficiency problems in public hospitals the concerned government bodies need to take various measures including providing opportunities for further training as a form of incentive.

### 4.2.2. Inpatient services

*(a) Preliminary tests*

By making two restrictions on $\mu$ and $\gamma$ one may determine the statistical significance of the specified model (*3.4*) in determining whether there is a certain degree of technical inefficiency in the provision of inpatient services by the hospitals under investigation. In this regard, the tests conducted on the production function for each health care unit using OLS and ML estimation methods show significantly different outcomes only for Debre Markos hospital. Accordingly, the test results revealed the existence of a reasonable degree of inefficiency in this hospital which may not be captured by using the OLS method of estimation. It is, therefore, appropriate to use the frontier estimation for these hospitals so as to have robust estimates for the parameters of the production function. In contrast, the production functions for the remaining sample hospitals are found to be best represented by OLS estimation, implying the absence of significant level of technical inefficiencies in them. Hence, if any technical inefficiency arises in these hospitals it might be due to statistical noises.

**Table 4.7: Hypothesis testing for parameters on deciding the existence of inefficiency in the inpatient service**

| Name of Hospital | Log-likelihood for | | $\chi^2_{cal}$** | $\chi^2_{2,\,0.95}$ |
|---|---|---|---|---|
| | OLS $(H_0: \mu = \gamma = 0$ | MLE $(H_1: \mu \neq \gamma \neq 0)$ | | |
| Finote Selam | 8.06 | 9.41 | 2.7 | 5.99 |
| Dessie | 29.87 | 30.07 | 0.4 | 5.99 |
| Woldiya | 12.96 | 14.74 | 3.56 | 5.99 |
| Shashemene | 10.93 | 10.93 | 0 | 5.99 |
| Dilla | 7.58 | 7.58 | 0 | 5.99 |
| Debre Markos | -20.26 | 14.05 | *12.42 | 5.99 |
| Debre Zeit | 12.38 | 14.41 | 4.06 | 5.99 |
| Yekatit | 25.55 | 25.55 | 0 | 5.99 |

Note: The degree of freedom for the $\chi^2$ test is 2, denoting the number of restrictions

* Significant at 5 percent level of significance

** $LR = -2[L(H_0) - L(H_1)]$

*(b) Production frontier analyses*

Similar to the case of outpatient services, regression analyses is carried out for the production function specified in equation (*3.4*), by letting output to be the level of inpatient services this time (Table 4.8). Also similar to the previous case, as the negative value obtained for the intercept term ( $\beta_0$ ) for the majority of the sample hospitals lacks theoretical backup, it is dropped from the analysis. But unlike for the outpatient visits, OLS estimates for the efficiently operating health care units reveal that the labour time of health professionals and values attached to depreciation and costs of drug are important inputs in the production of inpatient health care services.[+]

For this group of hospitals, the activities of the health professionals are found to positively contribute to the production of inpatient services. One exception is, of course, the case of Finote Selam hospital where inpatient services seem to decline with the increase in the number of the technical staff. Considering the fact that this hospital is one with the highest inpatient-physician ratio (Table 4.1), one may not come up with an outright explanation for such negative association. With regards to the size of the impact, the parameter estimates indicate that a percentage change in the labour time of the technical staff would yield approximately an equal proportionate change in inpatient days in *Dessie, Woldiya* and *Shashemene* hospitals. Whereas, the proportionate change in the number of inpatient days is much more lower than that of the technical staff in *Dilla, Debre Zeit* and *Yekatit 12* hospitals.

The study also revealed that depreciation and drug costs are significant determinants of the delivery of inpatient services in all the seven efficiently operating health care units. Except at *Shashemene* hospital, where inpatient days fall with the increase in expenditure on depreciation and drugs, positive relationships are observed between these variables in the rest of the hospitals. Particularly, changes in these two cost items are observed to produce more than proportionate changes in the levels of inpatient services provided in *Dilla* and *Debre Zeit* hospitals. Moreover, while the responsiveness of inpatient days to costs of depreciation and drugs is nearly unitary elastic for *Woldiya* and Finote Selam hospitals, it is inelastic for *Dessie, Shashemene* and *Yekatit 12* hospitals.

On the other hand, the regression analysis shows that the administrative and support staff have no significant contribution to the delivery of inpatient services in almost all the sample hospitals. However, this variable is observed to positively and negatively affect, though with smaller magnitude, the level of inpatient services at *Dilla* and *Debre Zeit* hospitals, respectively, at 10% level of significance.

As described above, the only hospital operating with significant level of technical inefficiency is *Debre Markos* hospital, its mean efficiency level being about 90%. Not only that, as revealed by the estimated parameters of its production function, neither

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[+] Note that both are significant at 5% level of significance.

the technical staff nor the values associated with depreciation and costs of drugs seem to significantly determine the delivery of inpatient services in this hospital. Only one input, time spent by the administrative and support staff, is turned out to be a significant determinant of the production of inpatient services.

According to the parameter estimate of this variable, the level of inpatient days is highly and negatively responsive to changes in the level of employment of the non-technical staff. That is, the volume of services to be provided to inpatients could be increased by about 12 fold by cutting the time spent by the administrative and support staff only by a unity. Such a high level of marginal diminishing returns to every additional unit of time spent by the administrative staff in the production process, however, is an indication for the presence of overstaffing of the non-technical staff in this particular health care providing unit.

Finally, based on the mean technical efficiency obtained, it can be concluded that, given the available technology, the technical efficiency of *Debre Markos* hospital could be raised at least by 10% without committing additional inputs.

**Table 4.8: The efficiency level of selected public hospitals for inpatient services**

| Sample Hospitals | Method of Estimation | Coefficients | | | | $\sigma_s^2$ | $\gamma$ | Log Likelihood | Mean Efficiency Level (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | $\beta_0$ | $\beta_1$ | $\beta_2$ | $\beta_3$ | | | | |
| **Finote Selam** | OLS | -11.300 (1.264) | -0.446 (-.2.81)* | 6.00 (0.618) | 0.965 (2.511)* | 0.022 | - | 8.062 | |
| **Dessie** | OLS | -3.968 (-25.69)* | 1.02 (15.762)* | 0.018 (0.838) | 0.072 (2.37)* | 0.003 | - | 29.87 | |
| **Woldiya** | OLS | -9.023 (-5.62)* | 0.970 (17.32)* | -0.177 (-1.094) | 1.08 (2.84)* | 0.008 | - | 12.96 | |
| **Shashemene** | OLS | -3.266 (-6.401)* | 1.024 (20.465)* | -0.057 (-0.207) | -0.127 (-2.31) * | 0.019 | - | 10.93 | |
| **Dilla** | OLS | -20.756 (-4.093)* | 0.032 (0.121) | -0.388 (-1.576)* * | 3.62 (3.215)* | 0.05 | - | 7.67 | |
| **Debre Zeit** | OLS | -9.168 (-6.753)* | 0.487 (4.566)* | 0.051 (1.545)** | 1.411 (3.823)* | 0.241 | - | | |
| **Yekatit 12** | OLS | 0.478 (6.440)* | 0.0453 (2.370)* | 0.018 (0.805) | 0.177 (13.08)* | 3.478 | - | 25.55 | |
| **Debre Markos** | OLS | 6.88 (0.001) | 0.158 (0.051) | -12.53 (-0.001) | 0.762 (0.002) | 3.48 | - | -20.26 | |
| | MLE | 7.16 (7.25)* | 0.112 (0.301) | -12.569 (-12.64)* | 0.459 (1.09) | 3.47 | 0.999 | 14.05 | 90.08 |

Note: Figures in parentheses denote t-ratios.
Significant at *5% and ** 10% levels of significance.

# 5. Summary and conclusions

With the major objective of investigating the level of efficiency at which public hospitals are operating in Ethiopia, this study was conducted on eight sample hospitals purposely selected from Amhara (4), Oromiya (2), Addis Ababa (1) and from SNNPs (1) regions based on the contributions they are making in the provision of public health care in selected health programs.

Generally, two major approaches were employed in this study: qualitative and quantitative analyses. In the former part, emphasis was given to the description of the general profiles of the health institutions under investigation, and also the relationships among the various characteristics comprised in the general profiles. And for the latter case regression analyses were carried out on the production frontier functions developed for this purpose.

**1. Descriptive analysis**

Viewed in general terms, the number of the technical staff (that comprises specialist doctors, general practitioners, nurses, laboratory and X-ray technicians, health assistants and pharmacists) exceeded that of the non-technical (administrative and support) staff in the majority of the sample hospitals. However, compared to the other health staff the number of specialist doctors was found to be very low in almost all the sample hospitals.

Though variations were observed between the different hospitals, the majority of them provided health care services for an average of 192 and 91 outpatients and inpatients per day, respectively. Despite the much talked scarcity of hospital beds, only about two-third of the hospital beds on average were occupied each day. On the other hand, the physicians in the sample hospitals were observed to have been overburdened as each of them were forced to treat 18 outpatients and 8 inpatients each day. The high workload of the physicians in the surveyed hospitals was further reflected by a higher bed-physician ratio observed. Thus, it may be possible to conclude that such a large coverage of outpatient and inpatient services per day can only be attained at the expense of quality health care services.

The majority of the sample hospitals were also observed to have very low daily budget, the good proportion (39%) of which was being taken up by the salaries of the professional and administrative staff. The average percentage share of the amount allocated for drug supplies was close to 30% of the total daily budget.

The analysis made by focusing on selected health care services common to all health care institutions under consideration showed that nearly 15 outpatients are treated each day per an intervention area, and an inpatient was admitted on average for about 8 days in any one hospital. It was also observed all the medical staff to have devoted much of their time to inpatient services than to outpatient services. Hence, measured in terms of the time spent per each intervention, significant variations were observed in the contributions made by the different technical health staff. For the outpatient services, for instance, the maximum time spent was registered by nurses, followed by health assistants, medical doctors, laboratory and X-ray technicians, in that order. While physicians were found to contribute more to the provision of inpatient health care services by spending closer to 3 hours on average on each of the ten intervention areas, the order in which the other technical staff contributed remained unchanged.

The attempt made to investigate the factors that are likely to influence the provision of outpatient services indicated that outpatient visits were negatively correlated with distance from Addis Ababa, absolute poverty and relative poverty. In contrast, in-referral and out-referral services were found to have positive association with the number of outpatient visits. However, the low correlation coefficient observed between outpatient visits and the poverty levels and the referral services would imply that there are other factors than these predominantly influencing outpatient services. In this regard, the investigation undertaken to find out the contributions made by individual segments of labour revealed the number of technical staff to have a strong correlation with outpatient visits as compared to the non-technical staff. This, therefore, would emphasize the significant role being played by the professional staff in the provision of the health care services. Particularly, the availability of physicians, health assistants and nurses were observed to strongly affect the number of outpatient visits, in that order. This would in general imply the need for appropriate allocation of health personnel, particularly the skilled ones, in order to enable hospitals extend their services efficiently and in the standard required.

**2. Regression analysis**

In order to investigate the level of technical efficiency at which the sample hospitals are operating, production frontier analyses were carried out on two major service categories: outpatient and inpatient services.

*(a) Outpatient services*

The preliminary tests undergone revealed that while the majority of the sample hospitals were performing without showing any significant level of inefficiency, some degree of inefficiency was observed in the provision of outpatient services in three of the sample hospitals (*Dessie, Dilla* and *Debre Markos*).

The two main variables identified by the production frontier analysis as important determinants of the level of outpatient health care provisions were the labour time of the health professionals and that of the administrative and support staff. Thus, the coefficient estimates indicated that the outpatient visits in the efficiently operating hospitals tend to increase with the increase in the labour input of the technical staff and decrease with that of the non-technical staff. But for those inefficiently operating health care units, the activities of both the technical and non-technical staff were seen to produce a positive impact on the outpatient visits. On the other hand, the estimated parameter for values attached to depreciation and costs of drugs was found to strongly and directly affect the production process of only two of the efficiently operating health care providing units and one of the inefficient ones.

From these it can be concluded that the availability of physicians, nurses, health assistants, laboratory and X-ray technicians, and pharmacists is more important than the administrative and support staff for the provision of outpatient services. Hence, this would imply the emphasis to be placed on resource allocation and strengthening the capacity of the technical staff.

Attempt was also made to investigate the source of inefficiency in the three inefficiently operating hospitals. While the remuneration provided to the technical staff seemed to have a negative but small influence on the delivery of outpatient services, the salary paid to the non-technical staff was observed to have no significant influence on the inefficiency level. This, would, therefore, indicate that there are other factors rather than the direct monetary rewards causing inefficiencies in these hospitals. Therefore, in order to curb the inefficiency problems in public hospitals the concerned government bodies need to take various measures, including providing opportunities for further training as one form of incentive mechanism.

*(b) Inpatient services*

With regards to inpatient services, the preliminary tests revealed only one sample hospital (*Debre Markos* hospital) to have been operating under significant level of inefficiency. The parameter estimates of the production function also showed that neither the technical staff nor the values associated with depreciation and costs of drugs seemed to affect the delivery of inpatient services in this hospital. Only the labour time of the non-technical staff was found to highly and negatively affect the production of inpatient services.

It can thus be concluded that such a high level of negative association between inpatient days and the number of non-technical staff is an indication for overstaffing of the administrative and support staff in this particular hospital. Moreover, as the mean efficiency level of this hospital is 90%, its technical efficiency could be raised at least by 10% without committing any additional inputs.

The parameter estimates of the production function for the seven sample hospitals operating without showing significant level of inefficiency revealed that the labour time of health professionals and values attached to depreciation and costs of drugs were important inputs for the production of inpatient health care services. Hence, both the activities of the technical staff and depreciation and drug costs were found to positively contribute to the number of inpatient days in the majority of this group of hospitals. The regression analysis, on the other hand, showed the administrative and support staff to have no important contribution to the delivery of inpatient services in almost all this hospitals.

The above results would imply that improving the number and quality of the professional health staff and upgrading the physical and technical capabilities of health care units increases the efficiency with which the units are producing inpatient health care services.

Based on both the qualitative and quantitative analyses, the following general conclusions may be drawn. The utilization levels of health services are influenced by many factors ranging from individual choice to the proximity of the health care facility. The performance of the public health care delivery is mainly reflected by the level of health coverage, the availability of health facilities and the finance required to run them. Though the delivery of health care services is a team work, it is observed to have been primarily determined by the availability of skilled health personnel. The number of highly skilled medical personnel determines the number and type of patients as visitors of the health care providing unit.

The ongoing effort for improving organization and management of the health system at all levels should be strengthened so that the provision of health care services would be efficient and its quality be maintained. The management of each hospital in each area would be of great importance to improving the proper use of the available resources.

Finally, it can be suggested that further policy measures should be taken in order to reduce the burden of public hospitals and improve the quality of the health care services in the country.

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## Appendix I: General profile of the sample hospitals

| Profiles | Finote Selam | Dessie | Woldiya | Shashemene | Dilla | Debre Markos | Debre Zeit | Yekatit 12 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| Distance from A/Ababa (km) | 380 | 401 | 500 | 251 | 370 | 299 | 45 | Within A/A | |
| Population served (million) | 0.9 | 2.3 | 1.3 | > 0.11 | 0.66 | 1.2 | 0.97 | na* | |
| Total Health Staff | | | | | | | | | |
| Specialists | - | 4 | 1 | 6 | 1 | 2 | 1 | 23 | 4.8 |
| General practitioners (MDs) | 6 | 6 | 6 | 12 | 11 | 5 | 12 | 5 | 7.9 |
| Nurses | 13 | 25 | 10 | 34 | 12 | 25 | 26 | 26 | 21.4 |
| Lab and X-ray technicians | 7 | 13 | 7 | 9 | 7 | 7 | 5 | 7 | 7.8 |
| Health assistants | 24 | 60 | 26 | 46 | 33 | 36 | 22 | 74 | 36.4 |
| Pharmacists | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 4 | 1.6 |
| Administrative & support staff | 33 | 33 | 56 | 153 | 65 | 89 | 58 | 279 | 95.8 |
| Outpatient visits (per day) | 165 | 200 | 100+ | 200 | 144 | 210 | 208+ | 305 | 191.5 |
| In-referrals (per day) | 2.3 | 3 | na | 8 | na | 2 | 2.5 | 23 | 6.8 |
| Out-referrals (per day) | 3.1 | 3 | na | 1 | na | ~0 | 2 | 3 | 2.1 |
| Value of building (million Birr) | 1.46 | na | na | 1 | 5 | 1.85 | na | 1.5 | 2.16 |
| Number of beds | 105 | 185 | 93 | 160 | 81 | 68 | 66 | 305 | 132.88 |
| Occupancy rate (%) | 74 | 78 | 68 | 61 | 31 | 87 | 53 | 75 | 65.88 |
| Number of beds occupied# | 78 | 144 | 63 | 98 | 25 | 59 | 35 | 229 | 91.4 |
| Total daily budget (Birr per day) | 3,708.5 | 7,944.3 | 3,646.17+ | 20,838.9 | 13,344.4 | 5,808.22+ | 3,616.44 | 15,397.26 | 7637.90 |
| Allocation for drugs (Birr per day) | 1,297.98+ | 2,470.60 | 1,681.90 | 1,890.40 | 1,479.50 | 3,178.10 | 908.85 | 3,178.10 | 2,010.68 |
| Average daily salary expenditures | | | | | | | | | |
| Professional staff | 1,161.92 | 2,383.29 | 1,213.70 | 2,333.10 | 1,381.70 | 1,696.93 | 1,696.93 | 4,861.20 | 2,223.84 |
| Administrative & support staff | 806.80 | 905.65 | 419.10 | 987.40 | 419.30 | 809.10 | 140.90 | 2,059.50 | 820.14 |

** As a zonal hospital it provides services to patients coming from Addis Ababa and the surrounding areas.*
*+Estimated figures (editor)*
*#Occupancy rate is converted to number of beds occupied to serve as a proxy for number of inpatient per day (editor) na: data not available*

**Appendix II: Average time spent (in minutes) by total health staff on outpatient visits at sample hospitals**

| | Finote Selam | Dessie | Woldiya | Shashemene | Dilla | Debre Markos | Debre Zeit | Yekatit 12 |
|---|---|---|---|---|---|---|---|---|
| Number of interventions* | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| Outpatient visits ** | 12.7 | 15.4 | 7.7 | 15.4 | 11.1 | 14.4 | 16 | 23.5 |
| Time spent by MDs | 28.2 | 48.2 | 51.5 | 32.5 | 29.3 | 41.5 | 15.9 | 35.9 |
| Time spent by nurses | 76.2 | 61.5 | 61.6 | 42 | 58.9 | 100.6 | 37.5 | 152.6 |
| Time spent by lab technicians | 24.4 | 40 | 41.9 | 20.9 | 8.9 | 16.2 | 42.8 | 43.5 |
| Time spent by X-ray technicians | 14.5 | 12 | 16.7 | 4.8 | 51.7 | 10 | 31.6 | 11.5 |
| Time spent by health assistants | 14.5 | 21.8 | 27.1 | 53.1 | 51.7 | 142.9 | 24.6 | 96.2 |
| Labour time spent by the registrar | 2.5 | 3.8 | 4 | 4.2 | 4 | 13 | 2.5 | 25.3 |
| Value attached to depreciation & supply of drugs (Birr per day) | 65.3 | 105.2 | 78 | 69.4 | 163.7 | 167.6 | 70 | 344.4 |

** Refer to the types of outpatient services on the basis of which the average time spent on each patient is computed.*

*** Mean outpatient visits registered for the given number of interventions.*

**Appendix III: Average time spent (in minutes) by total health staff on inpatient visits at sample hospitals**

| | Finote Selam | Dessie | Woldiya | Shashemene | Dilla | Debre Markos | Debre Zeit | Yekatit 12 |
|---|---|---|---|---|---|---|---|---|
| Number of interventions* | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Inpatient days** | 7.8 | 14.4 | 6.3 | 9.8 | 2.5 | 5.9 | 3.5 | 13.3 |
| Time spent by MDs | 327.7 | 121.9 | 135.4 | 119.1 | 139.1 | 256.7 | 127.5 | 181 |
| Time spent by nurses | 222 | 137.7 | 160.3 | 228.4 | 247.4 | 151.3 | 46.5 | 139.3 |
| Time spent by lab technicians | 24.8 | 55.8 | 54.1 | 35.1 | 40.4 | 28.9 | 52.5 | 95.9 |
| Time spent by X-ray technicians | 19.5 | 40.5 | 37 | 16 | 22 | 36.2 | 52.5 | 60 |
| Time spent by health assistants | 69.1 | 93.7 | 86 | 181.8 | 199.4 | 29.1 | 55.5 | 57.3 |
| Labour time spent by the registrar | 1.6 | 4.4 | 4.3 | 5.8 | 5.4 | 1.4 | 10.8 | 6.2 |
| Value attached to depreciation & supply of drugs (Birr per day) | 180.8 | 160.2 | 108.2 | 1062.6 | 427.4 | 340.9 | 183.7 | 712 |

** Refer to the types of inpatient services on the basis of which the average time spent on each patient is computed.*

*** Mean number of inpatient days registered for the given number of interventions.*