FORECASTING ACCURACY OF ANTI RETROVIRAL MEDICINES AND ITS CONTRIBUTING FACTORS: THE CASE OF ETHIOPIAN PHARMACEUTICAL SUPPLY SERVICE

Mahlet Tibebu (B.Pharm)

A Thesis submitted to Addis Ababa University, College of Health Sciences, School of Pharmacy, Department of Pharmaceutics and Social Pharmacy for the partial Fulfilment of the Degree of Master of Science in Health Supply Chain Management

Addis Ababa, Ethiopia

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Addis Ababa, Ethiopia

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Declaration

I, Mahlet Tibebu declare that a thesis entitled with "**FORECASTING ACCURACY OF ANTI RETROVIRAL MEDICINES AND ITS CONTRIBUTING FACTORS: THE CASE OF ETHIOPIAN PHARMACEUTICAL SUPPLY SERVICE"** is my original research work and have never been submitted to any other university for any Diploma or Degree. I also declare that all the resources used under this research has been acknowledged clearly.

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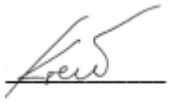
1. Dr. Tariku Jebna Signature_____ Date_____
2. Dr. Andre Kreie Signature  Date_____
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Abstract

Background: *Quantification is one of the core process of supply chain management. Its performance needs to be measured to check whether the set targets are met or not. Performance of quantification is measured by forecasting accuracy. Forecasting accuracy is a measure of how close the actual demand is to the forecast quantity. Accuracy of forecasts heavily relies on data availability, quality of data, quantification procedures and tools, assumptions made, skill and experience of forecasting experts. EPSS have not analysed forecasting accuracy of both RDF and program pharmaceuticals for the previous five years (2014-2018 G.C.).This study was carried out to assess forecasting accuracy of ART medicines and explore reasons for deviation.*

Methods: *A mixed method, sequential explanatory design consisting of five year retrospective forecasting and issue data and in-depth interview was employed. Based on the findings obtained from quantitative study, qualitative study employing in-depth interview with key informants was carried out. Forecasting error was computed mainly using Mean Absolute Percentage Error (MAPE) and the appropriateness of forecasting method was tested using Tracking Signal (TS). The research was conducted in Ethiopian Pharmaceutical Supply Service from December 2018 – June, 2019.*

Results: *The MAPE value of the analysed items ranged from 29.4% for lamivudine 150mg+ zidovudine 300+mg nevirapine 200mg) to 293.5% for lopinavir 200mg +ritonavir 50mg. The MAPE, according to the Lewis MAPE scale of judgement of forecasting accuracy, none of the items has met either highly accurate or good scale of judgement. Only 26.7% of the studied items fall under reasonable scale. The TS analysis indicated only eight of the studied items had appropriate forecasting method and for the rest of the items the method underestimated the actual quantity. Of the analysed forecasting models, moving average was found to produce more accurate forecast in which 86.7% of the items have better forecast accuracy. Inadequate joint planning, supply chain insufficiency, change in treatment protocols, deviation in consumption of pediatric regimens, assumptions made and emergency ordering were identified factors contributing to forecasting accuracy.*

Keywords: *Accuracy, Anti- retroviral medicines, Error, Factors, Forecasting*

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Lastly, I thank my parents, sister and brothers for their continuous encouragement and advice to hold on. And my dearest husband, words cannot express deepest gratitude I have, just thank you for supporting me and picking me up whenever I felt down during my research period.

Abbreviation

ART	Anti-Retroviral Treatment
CHAI	Clinton Health Access Initiative
EC	Ethiopian Calendar
EPSS	Ethiopian Pharmaceuticals Supply Service
FMoH	Federal Ministry of Health
FHAPCO	Federal HIV/AIDS Prevention and Control Office
GHSC	Global Health Supply Chain
HCMIS	Health Commodities Management System
MAD	Mean Absolute Deviation
MAPE	Mean Absolute Percentage Error
MSH	Management Sciences for Health
NNRTI	Non-Nucleoside Reverse Transcriptase Inhibitor
NRTI	Nucleoside Analogue Reverse Transcriptase Inhibitor
PLHIV	People Living with HIV
PSM	Procurement and Supply Management
RDF	Revolving Drug Fund
RMSE	Root Mean Square Error
SCM	Supply Chain Management
SCMS	Supply Chain Management Systems
TS	Tracking Signal
USAID	United States Agency for International Development
WHO	World Health Organization

Table of content

List of Tables

List of Figures

Chapter One

1. Introduction

This chapter comprises of background of HIV/AIDS program, statement of the problem, research questions, research objective, limitation of the study, significance of the study, scope of the study, operational definitions and organization of the paper. Each is presented in subsequent sections.

1.1. Background of HIV/AIDS Program

Human Immunodeficiency Virus infection continues to be global health issue with estimated 38 million people live with HIV accounting for 0.7% prevalence in 2019 (WHO, 2020). Sub-Saharan Africa continues to carry the highest burden accounting for 71% of people living with HIV globally. In Ethiopia, the overall trend of national HIV prevalence has remarkably declined from 4.4% in 2003 to 0.9% in 2020 (HAPCO, 2020).

HIV/AIDS prevention and control program is one of the major health program that the Ethiopian government gives attention to. The country adopted the worldwide 90–90-90 HIV prevention targets for the year 2020 which is a component of strategies designed to eliminate HIV/AIDS epidemic by 2030. In order to achieve the elimination strategy, the country has stated four strategic objectives. These are: sustaining quality of care and treatment, implementing high impact and targeted prevention program, intensifying targeted HIV testing and counselling services and attaining virtual elimination of mother- to- child transmission (FMOH, 2018).

In order to meet the targets set to prevent and care for HIV by FMOH, Ethiopian Pharmaceuticals Supply Service (EPSS) is working towards sustainable supply of ARVs throughout the country (EPSS, 2017).

For selected ART medicines, the EPSS does the forecast. Forecasting is important for financing and procurement decisions and to maintain adequate stock levels in the supply pipeline. This process relies on accurate and up-to-date information regarding the service

provision and consumption, stock levels and funding sources and amount for procurement (MSH, 2011 and SCMS, 2010).

Quantification is one of the core process of supply chain management. Its performance needs to be measured to check whether the set targets are met or not. Performance of quantification is measured by forecasting accuracy, the deviation between forecasts and actual consumption or demand in quantity (USAID, 2009).

Quantification of HIV/AIDS process starts by establishing a national quantification team composed of different stakeholders (including EPSS, FMOH, RHBs, Donors, and Partners). The team analyses available data and then select appropriate data, builds assumptions, calculates forecast requirements, and does comparison/reconciliation of alternative methods to produce the final forecasting output (EPSS, 2017). The team uses Quantimed®, a forecasting software package used to forecast ARVs and medicines for treatment and prevention of opportunistic infections (OIs) (MSH, 2012). Forecasts for adult and pediatric patient population are done separately since they use different formulations and dosing requirements. (WHO, 2006).

However, EPSS has not analysed forecasting accuracy of both RDF and program pharmaceuticals for the previous five years (2014-2018 G.C.). Given sensitivity, financial value and public importance of ART medicines, this study will measure the forecasting accuracy of ART medicines and identify its contributing factors. The findings will provide insight to EPSS and FMOH to take intervention that would lower cost and improve service quality.

1.2. Statement of the Problem

Forecasting demand is crucial to ensure uninterrupted supply of essential medicines including ART medicines. Organizations employ different methods to estimate their future demand. The selection of method depends on availability of data, volatility of demand and maturity of product (Huff and Sultan, 2014).

A study done by McKinsey shows that forecasts of pharmaceutical were either over or under estimated by at least 40% in at least 60% of cases (Cha, Rifai , 2013). Poor estimates of demand can result in shortages, interruptions in treatment, expensive emergency orders or inappropriate medicine substitution. Similarly, over estimation leads to over ordering and depletion of financial resource, occupy storage spaces and wastage. This, in turn, increases the risk of wastage due to expiry and theft (SCMS, 2010).

Relatively high amount of finance and human resources have been deployed for HIV/AIDS prevention, care, and treatment in resource-limited settings. HIV treatment requires lifelong therapy with adherence rate above 95 percent. If stock out occurs, there are no or few substitutions available for treatment, making it more difficult and costly to manage since medicines that are used to manage resistant strains of HIV are expensive. This makes management of ART medicines supply chain challenging (USAID, 2009).

According to SCMS, many countries lack a clear picture of the medicines and supplies required for HIV/AIDS prevention, care and treatment programs. Producing an accurate forecast possess several challenges like taking longer time to agree on assumptions, difficulty in getting reliable treatment data, and incorrect and inefficient use of quantification tools (SCMS, 2010).

Forecasting inaccuracy signals presence of large volume wastage affecting financial capability, shortage or surpluses, inadequate cost effectiveness, irrational financing, inequity of supply and it might also render distorted demand (WHO, 1988, Iqbal, 2017 and Muhia, 2017). According to IPLS assessment in 2019, wastage rate of program medicines including ARTs was found to be 7.1% in 2016/17. This rate was higher than the target set, less than 2%. This wastage rate might be as a result of inaccurate forecasting along with other attributable reasons (USAID, 2019).

Accurate forecast is thus key for ensuring adequate allocation of the scarce resources, timely procurements and delivery of products in an effort to have uninterrupted supplies. If forecast accuracy is improved on an aggregate level, safety stock levels needed will be fulfilled and fill rates can be lowered, then clients in turn will be benefited (Huff and Sultan, 2014).

Decision makers in business firms including in pharmaceutical supply chain, analyse forecasting accuracy to determine whether their current forecasting method is predicting demand accurately or not (Chopra and Mindle, 2013).

The monitoring and evaluation framework of EPSS developed in 2017 marked 75% and above as an accurate forecast value for all medicines it manages. Accordingly, EPSS accepted a forecast error of 25% or less as a standard margin of inaccuracy (EPSS, 2017).

The frame work also stated redundant and extended forecasting with high inaccuracy in the forecast of all health commodities as a key problem (EPSS, 2017). Since the mentioned key problem was not identified in a scientific manner, scientific procedures and standards shall be applied to evaluate forecasting accuracy of the medicines EPSS manages.

A study done in EPSS on anti-TB medicines in 2019 showed that, first line anti-TB medicines experienced forecast inaccuracy over the years 2016-2018. (Abyot, 2019)

Although EPSS procure and distributes billion dollar worth of goods, it has not analysed its forecasting accuracy of program pharmaceuticals including HIV/AIDS for the previous five years (2014-2018 GC). ARVs being the most sensitive and expensive medicines and also due attention given by the FMOH, this study will try to address the forecasting accuracy of Anti-Retroviral (ARV) and identify its contributing factors in the case of EPSS.

1.3. Research Questions

After conducting this research the investigator will try to answer the following questions:

1. To what extent the actual and forecast HIV/AIDS medicines consumption deviate?
2. Which forecasting model gives better forecast for ART medicines?
3. What are the factors that contribute to forecasting inaccuracy?

1.4. Research Objective

General Objective

The general objective of this paper is:

To measure forecasting accuracy of ART medicines, identify the appropriate forecast method and explore contributing factors for the deviation of forecast and consumption data.

Specific Objectives

The specific objectives of this paper are:

- To measure the forecast accuracy of ART medicines.
- To explore factors contributing to forecasting inaccuracy in ART medicines.
- To identify the appropriate forecasting method for each ART medicines.

1.5. Significance of the Study

Since there were not well established studies in pharmaceutical supply chain sector in Ethiopia, this study can be used as a baseline for future studies on pharmaceuticals' forecasting accuracy and contributing factors for inaccuracy.

The findings of this study will provide insight to EPSS, FMoH and other stakeholders regarding the forecast performance of ART products. It also helps in identifying potential contributing factors that could lead to inaccuracy to reduce wastage rate. And most of all, clients will relay and get benefited from continuous and uninterrupted supply of their treatment.

As wastage of pharmaceuticals is hazardous activity to the environment, paying attention to improving forecasting activities will definitely benefits the environment. Overall, when forecasting activities are done appropriately, demand will be secured and the health care system will be trusted.

In addition, testing different forecasting methods for each medicine based on previous consumption data and recommending the appropriate method will help quantification exercise team to use more accurate method for each medicine.

1.6. Scope of the Study

The focus of the study is at EPSS head office. Quantity issued from head office warehouse to branch warehouse was considered as consumption quantity. In addition, forecast quantities were drawn from quantification reports from the years 2014- 2018. These quantities were used to calculate forecasting accuracies of the analysed medicines. While computing forecasting accuracy, only medicines that have been issued throughout the studied 5 years were considered.

1.7. Operational Definitions

For this study;

Consumption data: quantity issued by EPSS's Head office warehouse to branch warehouses.

ART medicines: medicines that are used to treat HIV/AIDS.

1.8. Organization of the Research Paper

The study is organized into five chapters. Chapter one introduces the study by giving background information, the research problem, research question, research objectives, significance of the study, limitations of the study, operational definition of terms and organization of the research paper. Chapter two is literature review section in which relevant literatures on the research topic is narrated. Chapter three discusses the research methodology. It describes the study setting, study design and period, sampling methods, inclusion and exclusion criteria, data quality control, data analysis and ethical consideration parts. Chapter four presents the findings and analysis of collected data. Finally, chapter five presents conclusions and recommendations that were drawn from the research findings.

Chapter Two

2. Literature Review

In this chapter relevant literatures were reviewed to describe and discuss main subject areas of the research. In this chapter status of HIV/AIDS and ART in Ethiopia, ART regimens, demand forecasting, types of forecasting methods, demand forecasting practice in EPSS, measurement of forecasting accuracy, global status of pharmaceuticals' forecasting accuracy and factors contributing to forecasting inaccuracy are discussed in sub sections.

2.1. Status of HIV/AIDS and ART in Ethiopia

Human immunodeficiency virus (HIV) infection continues to be one of the leading causes of morbidity and mortality throughout the world. Since the beginning of the epidemic, around 79.3 million people have become infected and 36.3 million people died from Acquired Immunodeficiency Syndrome (AIDS) related illnesses. Until the year 2020, 27.5 million people living with HIV have accessed ART. As stated by UNAIDS, 54.6% of people that live with HIV are in Eastern and Southern Africa region and 16.0 million are on ART. New infection in this region was 670,000 and close to 50% of global deaths in 2020(UNAIDS, 2020). Sub-Saharan Africa contribute 71% of the total HIV-infected people, 76% of the total new HIV infections, and 75% of the total HIV/AIDS deaths in 2015 (Wang, et al, 2016).

In 1984, the first evidence of HIV epidemic was detected in Ethiopia. Even though HIV shows mixed epidemic in the regions, the national prevalence was 0.93% for adults and 0.34% for adolescent and young people in the year 2019. Regarding regions, Gambela has the highest prevalence in adults, 4.45%, while Somali has the lowest with 0.16% prevalence in 2019(FMOH, 2020). And prevention of transmission of HIV from mother to child also rose from 25% (17–32%) to 69% (50–87%) in 2016 (Girum et al, 2018).

In 2014, UNAIDS set an ambitious treatment targets, 90-90-90, to end the AIDS epidemic by the year 2030. This target was, by the end of 2020, 90% of all people living with HIV will know their HIV results, 90% of all people diagnosed with HIV infection will receive

sustained ART and 90% of all the people receiving ART will have viral suppression (UNAIDS,2014).

In Ethiopia, ART programme was first introduced in 1998. After seven years (in 2005) public hospitals started providing ARVs for free. In this period only 39,535 (less than 1% of the total number of PLHIV) were receiving ART. Since then the treatment spectrum had expanded and the number of clients reached 423,685 in March 2016. Of these, 88% of people who knew they living with HIV were on treatment. Estimated 35% (23-47%) of children and 61% (49-75%) of adults were on ART. And there is 90% decline in new HIV infections in 2016 (2016 Assefa Y et al. 2017 and Tadele et al. 2018).

The progress made towards the ambitious UNAIDS 90-90-90 target in Ethiopia was, 87.4% of PLHIV knew their status, of these 75.7% received ART and 91.2% of the PLHIV on ART had suppressed viral load by the year 2019 (EPHI, 2020). Though people who knew they were living with HIV receiving treatment were 88% in 2016, it declined to 75.7% in the year 2019.

2.2. ART Regimens

As per WHO recommendation, ARV regimens for treatment of HIV have to be highly potent, lower toxicity, highly resistance genetic to barriers, useful across different populations, and should be inexpensive. Providing optimized ARV regimens can improve the durability of the treatment and quality of care for people living with HIV. ART are given to adult and pediatric clients as 1st, 2nd and 3rd line treatment based on client's clinical, virological and immunological staging. And the regimen can be fixed dose in which two or three medicines are combined in one dosage form like lamivudine-efavirenz-tenofovir disoproxil fumarate (TDF) 300+600+300mg/tablet or single where only one medicine is found in dosage form like in the case of efavirenz tablets (WHO, 2006).

The preferred first-line regimen consists of Nucleoside Analogue Reverse Transcriptase Inhibitor (NRTI) backbone with one of the Non-Nucleoside Reverse Transcriptase Inhibitors (NNRTIs). TDF and zidovudine (AZT) combined with lamivudine (3TC) as a backbone

with dolutegravir (DTG) are preferred first line NRTIs in the treatment of naïve patients. Low dose efavirez (400mg) with one of NRTI backbone is considered an alternative first line ART. Either triple or double fixed dose combination are much preferred to loose compounds since patients find them suitable and increase adherence to ART. Regimen choice is based on patients' conditions (WHO, 2021).

When clients fail to respond for first line ART regimen due to virological, clinical or immunological reasons, they will be switched to second line ART regimens. The recommended second line regimen is DTG in combination with an optimized NRTI backbone when non-DTG-based regimens are failing. When DTG based regimens fail, atazanavir or lopinavir boosted with Ritonavir is given with NRTI backbone (WHO, 2021).

When second line treatment regimen fail to suppress viral load or clients' condition get worsen over time, clients take 3rd line regimens. As per WHO, national programs should develop policies for third-line ART (WHO, 2021).

In Ethiopia of 3.5% adult patients on second line ARV 70 % will take darunavir boosted with ritonavir(DRV/r)+ (DTG)+AZT/3TC (600+100+50+300+150) and the rest will be taking DRV/r+ DTG + TDF/3TC (600+100+50+300+300) as third line treatment. Accordingly of 3.5% of paediatrics who were taking second line treatment will switched to AZT/3TC/Raltegravir (RAL) (8%), ABC/3TC/RAL(3%), AZT/3TC/RAL/DRV/r(62%), and ABC/3TC/RAL/DRV/r(27%) (FMOH, 2018 and 2019).

2.3. Demand Forecasting

Quantification is a process used to determine the amount of products required for future consumption along with their financial requirement and sourcing. This process calls for data quality, well experienced quantification experts, involvement of stakeholders and utilization of appropriate quantification tools. It also needs monitoring and evaluation the entire process.

Quantification is composed of two distinct activities; forecasting and supply planning. Forecasting determines how much of the products are needed and their cost based on previous

consumption or morbidity trend. It involves integrated exercise in which all levels of the supply chain take part and information is shared. The shared information foster increased demand visibility within organizations as well improve the performance of forecast (Huff and Sultan 2014). The other activity of quantification proceeding forecasting is supply planning. Supply planning involves with determining how best to fulfil the requirements generated by forecasting activity. The objective of this activity is to balance supply and demand in a manner that achieves the financial and service objectives of an organization (MSH, 2012).

Quantification can be centralized, decentralized or mixed. In centralized quantification, national quantification team does the forecast while in decentralized quantification national team only aggregate and modifies quantifications done by health facilities (Iqbal, 2017 and SIAPS, 2014).

Most countries use decentralized way of quantification in their supply chain. Studies show that using the decentralized quantification produce more accurate quantification since it uses the actual data at service delivery points. In the pharmaceutical sector, deciding whether to utilize decentralized or centralized depends if the product is new or not. If the product is in the market earlier then demand based forecasting fits the case. However, if the product is new, companies take risk on how well their product may penetrate through the market (Himanshue Kunwar, 2021). This slightly leans to centralize forecasting by using population data, disease prevalence, and diagnosis and drug treatment rate. Peru, Dominican Republic, Kenya, Côted'Ivoire, Namibia, Rwanda and Zambia employ the decentralized method while quantifying family planning and ART needs. These countries collect patient based consumption data at health facility level and compute their demand for the coming years (Madsen, 2013 and MSH, 2012).

2.4. Types of Forecasting Methods

Forecasts can be economic, technological or demand. Economic forecasts deal with foretelling of economic indicators like inflation and interest rates. Technological forecasts are those forecasts that predict rates of technological progress and innovation in the future. Meanwhile, demand forecasts foresees future demand depending upon past consumption data (Hassen, *et al.,* 2020). On the other hand, forecasting can be classified based on duration. These can be strategic or tactical forecasting. Strategic forecasting deals with medium to long term

forecasting whereas tactical forecasting foresee short to mid -term planning usually up to 12 months (Sagaert, *et al.*, 2018).

Prior to forecasting, choosing the appropriate type forecasting method depends upon availability of data, experts, sensitivity and maturity of the project. Forecasting method can be qualitative or quantitative. If there are no data or the data available are not relevant or the product being forecasted is new then employing qualitative method is more appropriate. On the other hand, if the data available are numerical information of the past and the considered past consumption pattern is believed to be continuing in the future, applying quantitative method is suitable (Lynn, *et al*, 1999, MSH, 2012).

There are different types of qualitative forecasting methods. To mention some, Delphi method, executive opinion, market survey and sales force composite. In Delphi method group of experts are expected to produce forecast based on their experiences, previous and current knowledge of the market. Delphi method should be considered when the medicine to be forecasted is new or the severity and duration of the disease is beyond the knowledge of the forecasting team (Hassen *et al*., 2020).

When employing executive opinion, decision makers are the key role players in developing and reaching on consensus on forecast. This method is used when historical data for forecasting do not exist, causal relationships have not been identified, or major change has occurred on existing product (Hassen *et al*., 2020).

Market surveying is done by collecting consumers' preferences towards the item that is being forecasted and then projecting future sales. It is a typical method for introducing new product in the market. While employing sales force composite method, sales persons who work in different regions predict how the products will behave in the market and all the predictions will be aggregated and used as a forecast (Hassen *et al*., 2020).

There are two types quantitative method, time series and associative/causal methods. Time series type uses past consumption or sales data and project future consumption or sales while associative or causal models assume different variables that may affect the variable to be forecasted and then project forecast based upon the association the forecast have with the affecting variable. This associations can be linear regression where linear relation is created

with two variables or multiple regression in which there will be different variables that may influence the forecast variable. Both models follow least square method to demonstrate association between and among variables (Lynn, *et al.*, 1999).

Time series models can have trend, cyclic seasonal pattern or random based on data pattern they exhibit. Trend models tend to have increasing or decreasing in reasonably predictable pattern. Whereas in seasonal models pattern seems repeated over a specific period. In cyclical model values of data experience rise and falls that are not of a fixed frequency. Model is said to be random when data do not fall in to the mentioned models (Reid, *et al*., 2012).

Time series can further be parted in to naïve, simple mean average, weighted moving average, exponential smoothing, trend projection and seasonal indexes (Reid, *et al*., 2012).

Naïve method considers the same consumption pattern will continue in the future meaning, next time's consumption is the same as the last one, no increasing or decreasing. Simple mean average method sums the nearest consumption over a certain period and divides for the period of observation while moving average computed by using past consumptions recorded over a period of time then average is then calculated for the previous observations at specific intervals (Reid, *et al*., 2012).

The other time series method is weighted moving average, where more weight is given to most recent consumptions and lesser weight for the most previous ones. Exponential smoothing is more like weighted moving average in which consumption data's weight declines exponentially as the data becomes older (Reid, *et al*., 2012).

When forecasting using exponential smoothing, a smoothing parameter, α, is used with a value of $0 \leq \alpha \leq 1$. This parameter is used to control the weight of data. When α is close to zero then more weight is given to distant past data where it's close to 1 the more recent data will influence the next forecast. This method is good for data that show no trend and seasonal component. The other parameter that is raised along smoothing factor is damping factor, 1-α. The larger damping factor, the more values are smoothed close to actual value. The damping factor is seldom less than 0.8 as the damping has a very strong influence for smaller values when it is less than 0.8. The maximum value of damping factor is 0.98 (Ming, 2019).

Trend projection forecasting is applied for long term demand projection. And it can further be divided into three. These are; graphic method, least square method and Box-Jenkins Method. While employing graphic method, consumption data is plotted on a graph assuming previous trend will continue for the future. Whereas in least square method, trend is fitted in time series data through applying statistical analysis and determine trend of demand. This method has various types, of these linear and exponential trend are the most commonly used ones. Box-Jenkins method is applied when short term predictions are in mind (Ming, 2019, Reid, *et al*., 2012).

Both qualitative and quantitative methods have their own advantage and drawbacks. Though the most up-to-date information is captured while employing qualitative method, one person's opinion may dominate the others. This may incorporate bias to forecast consequently reducing forecast accuracy. In addition, the level of experience the individuals involved may also affect the accuracy of forecast produced. And while using quantitative method the resulting forecast depends upon the quality of data utilized during the process. This method is less prone to bias than qualitative method (Reid, *et al*., 2012).

Forecasting model chosen greatly influences forecasting accuracy. Different forecasting models need to be checked and the one with high accuracy for each product has be considered. Forecasting models are different in kind and applications. From the two quantitative models, the study carried out by Kravet and colleagues showed that time series model was more accurate than causal method (Kravet et al, 2018).

2.5. Demand Forecasting Practice in EPSS

EPSS handles the quantification, procurement, warehousing, inventory management, and distribution of Revolving Drug Fund (RDF) or budget based essential pharmaceuticals and health program (HIV/AIDS, TB, Family Health, Vaccines, Malaria, etc.) (EPSS, 2017).

The Quantification and Market Shaping Directorate leads the quantification process of both RDF and health program pharmaceuticals. For HIV/AIDS commodities takes place every two years, with annual revision, in close collaboration with relevant stakeholders (EPSS, 2017).

EPSS's uses both centralized and decentralized quantification. For those pharmaceuticals that fall under RDF category, it uses decentralized approach. The process starts at health facility level where each heath facility will identify its needs based on EPSS's Pharmaceutical Procurement List (PPL). Based on the services they provide, they estimate their future requirements based on their historical data (consumption, service, morbidity or demographic). After finalizing their forecast, health facilities send the final result to their respective EPSS hub. EPSS hubs aggregate health facilities demand and produce hub based forecast. Respective hubs subsequently send their forecast requirements to head office. Nationally, hubs' forecasts are reviewed, aggregated, and adjusted for anticipated changes in the future (EPSS, 2017).

In contrast, centralized quantification is done for health program products, like HIV/AIDS commodities. The quantification process starts by establishing a national quantification team composed of different stakeholders (including EPSS, FMOH, RHBs, Donors, and Partners). The team analyses available data and then select appropriate method, builds assumptions, calculates forecast requirements, and does comparison/reconciliation of alternative methods to produce the final forecasting output. The team uses Quantimed®, a forecasting software package used to forecast ARVs and medicines for treatment and prevention of opportunistic infections (OIs). The software uses past consumption data, morbidity data or proxy consumption as an input to produce final forecast results. The tool only gives calculated outputs. The outputs are then analysed and judged by experts in the quantification team (MSH, 2012).

Forecasts for adult and pediatric patient population are done separately since they use different formulations and dosing requirements. During forecasting, patients aged 0 to 14 years are categorized as pediatric while those above 15 years are categorized as adults. This age categorization is used internationally in collection and reporting of indicators in HIV care and treatment patient monitoring systems (WHO, 2006).

Based on forecast output, supply plan is prepared and communicated to Tender Management Directorate via the In-bound Deputy Director General (DDG) Procurement process starts

once the supply plan is done and signed by In-bound DDG and the approval of the Director General (DG) (EPSS 2017).

In Ethiopia, ART quantification is being performed since the year 2008(EPSS 2017).

2.6. Measurement of Forecasting Accuracy

Business firms including pharmaceutical supply chain, analyse forecasting error to determine whether their current forecasting method is predicting demand accurately or not. Forecasting accuracy is a measure of how close the actual demand is to the forecast quantity. Accuracy of forecasts heavily relies on quality of data in terms of completeness, reliability, availability, assumptions made, skill and experience of forecasting experts (Chopra and Mindle, 2013).

If actual consumption equals forecast then forecasting accuracy will be 100%. Then, it can be said that needs are met and quantification practice was excellent. Otherwise, smaller percentage of accuracy indicates poor quantification and interruption of service (Chopra and Mindle, 2013).

Forecast is said to be inaccurate when the actual consumption quantity deviates from the forecast quantity. It is the converse of forecasting accuracy (Chockalingam, 2018). It is not surprising when forecasts are found to be inaccurate since forecasts are essentially about predicting the future, usually based on incomplete or unavailable information. As a result, forecast inaccuracy dispose intense criticism since there is always under or over estimation. Overestimated quantities result in allocation of extra amount of budget, wastage and surplus while underestimation render stock-outs and service interruption (Department of treasury, 2008).

Extent of the forecast inaccuracy is measured using forecast error metrics. The metrics are mathematical measures used to evaluate forecast bias and accuracy. Commonly used metrics for measuring forecast accuracy include Mean Squared Error (MSE), Root Mean Square Error (RMSE), Mean Average Deviation (MAD) and Mean Absolute Percentage Error (MAPE) (Armstrong, 2001).

MSE is the average of squared errors; it weights errors according to their squared values thereby giving more weight to the larger errors. While RMSE is the square root of MSE forecasting model, the sum of squared errors is divided by the sample size before the square root is taken. In addition RMSE is the classic statistical error. It is the most common standard of goodness-of-fit and penalizes big errors relatively more than small errors since it squares them first. It is approximately the standard deviation of the errors if the mean error is close to zero (Armstrong, 2001).

Historically, the RMSE and MSE have been popular, largely because of their theoretical relevance in statistical modelling. Yet, RMSE and MSE are more sensitive to outliers hence, it is recommended against their use in forecast accuracy evaluation (Armstrong, 2001).

The other error measuring metric is MAD, it is the average of absolute errors, measures the accuracy of the prediction by averaging the absolute value of each error **(**Khair, 2017). It is the easiest to compute and weights all errors evenly. However, it does not put errors into perspective and it is not easily understood. MAD can be used to estimate the standard deviation of the random component assuming that the random component is normally distributed (Chopra and Mindle, 2013).

MAPE measures the size of the error in percentage terms (USAID, 2006). It measures the mean absolute percentage difference between a forecast previously made over several time periods and the actual consumption or issues data for those same time periods. It is the measure of choice where there is a need to put the errors into perspective (Stevenson, 2009).

MAPE indicates how much error is in predicted value compared with the real value, thus overage and shortfalls are not washed out (Khair, 2017). Although, MAPE at an aggregate level does not reflect product and regional differences, it is the most commonly used measure to determine forecast accuracy (Rayer, 2007).It has also the advantage of being scale-independent, and so it is frequently used to compare forecast performance across different data sets (Hyndman and Koehler, 2005).

MAPE has a disadvantage of being infinite or undefined if consumption quantity is zero at times. Thus, using MAPE measurement as error metric may become impossible when zero values occur frequently (Hyndman and Koehler, 2005). The other disadvantage that it put a heavier penalty on positive errors than on negative errors, however, still the MAPE may still be preferred for reasons of simplicity (Hyndman and Koehler, 2005).

In the study that focuses on the impact of the level of customer aggregation on the accuracy of sales forecasts, the investigators used MAPE to evaluate forecast accuracy to evaluate aggregate and disaggregated models using exponential smoothing forecasting methods (Patak, 2013).

Forecasting error as a result of the employed forecasting method can be evaluated using Tracking Signal (TS). This measure is used to compare the accuracy of alternative forecasting methods and to track error performance over time to decide if attention is needed.

TS is employed to determine whether a forecast method is appropriate for each of the items being forecasted. TS is the ratio of the running sum of errors and the MAD (Chopra and Mindle, 2013). If the TS at any period is outside the range of -4 to +4, this indicates that the forecast is biased and is either underestimated *(TS* < -4) or overestimated *(TS* > +4) (NC state university, 2011).

2.7. Global Status of Pharmaceuticals' Forecasting Accuracy

In a study conducted by GHSC-PSM in 22 countries, MAPE of reproductive health commodities has shown error of 42% for injectable, 57% for implant, 47% for combined pills, 4% for copper IUD, progestin pill with 0% and 22% for condoms (PSM, 2018).

Another study conducted in Kenya showed that pediatric ART products had MAPE ranging between 11.8% and 2198.9%. Similarly, Tanzania has achieved 78 percent forecast accuracy rates for family planning in 2014, 94 percent accuracy rate for ARVs, and 95 percent for anti-malarial in 2015 (USAID Deliver, 2016). In addition, annual report of USAID | DELIVER shown that mean forecast error of six essential contraceptives in Malawi, Ghana

Tanzania and Rwanda in 2010 to be 97%, 33%, 21% and 7% respectively (USAID, 2012). Another study carried out in Namibia has shown that pharmaceuticals forecasting error (MAPE) to be 74 % (Levenger, et al, 2013).

2.8. Factors Contributing to Forecasting Inaccuracy

Forecasting demand might not be accurate since the future is unpredictable, forecasting demand require dedication in every direction regarding quality, accuracy, availability and reliability of data. Most of all involved professionals must be experienced and skilful towards techniques employed during the process. Whenever there is forecast inaccuracy, inventory costs have a significant impact on an organisation's financial position. Most importantly suppliers and customers are directly affected by forecasting practices (Huff and Sultan, 2014).

Forecasting inaccuracy may arise due to different factors. It can happen as a result of information distortion, long lead times, seasonal demand, high product variety and shorter product life cycle. On the other hand, unsuitable software, unskilled or inexperienced personnel and process contamination by biases and personal agenda introduce error during forecasting process. Data availability is also crucial for forecast accuracy as unavailability of data leads to use of assumptions (Cleveland, 2016). Heavy reliance on assumptions has been one of the contributing factors to forecast inaccuracy. In addition, a study by Haloub and Radi in 2013, indicated lack of statistical experts during quantification exercise could lead to forecasting inaccuracy (Haloub and Radi in 2013).

Forecasting for pediatric ART medicines is more complex than for adult ones. Some of the reasons are combination of different ARV formulations and changes in child's weight over time that may necessitate change of formulations and dosages. Medicines formulated for use in adult patients may also be used by children. (Claudia and Chandani, 2006). In general, the reasons for inaccuracies fall in to technical issues like no data or data inaccuracy, forecasting methodology and process.Accuracy of forecasts heavily relies on quality of data in terms of completeness and reliability (Department of Treasury, 2008).

2.9. Conceptual Framework

Forecasting accuracy can be affected by different factors. Figure 1 shows how quantification tools, data quality (demand and consumption data), and quantification procedures affect forecasting accuracy. The Data available is also crucial for forecast accuracy. When data are not available or available data are not quality enough various assumptions will be placed. The quality of the assumptions placed is greatly affected by the skill and experience of experts involved in the quantification process.

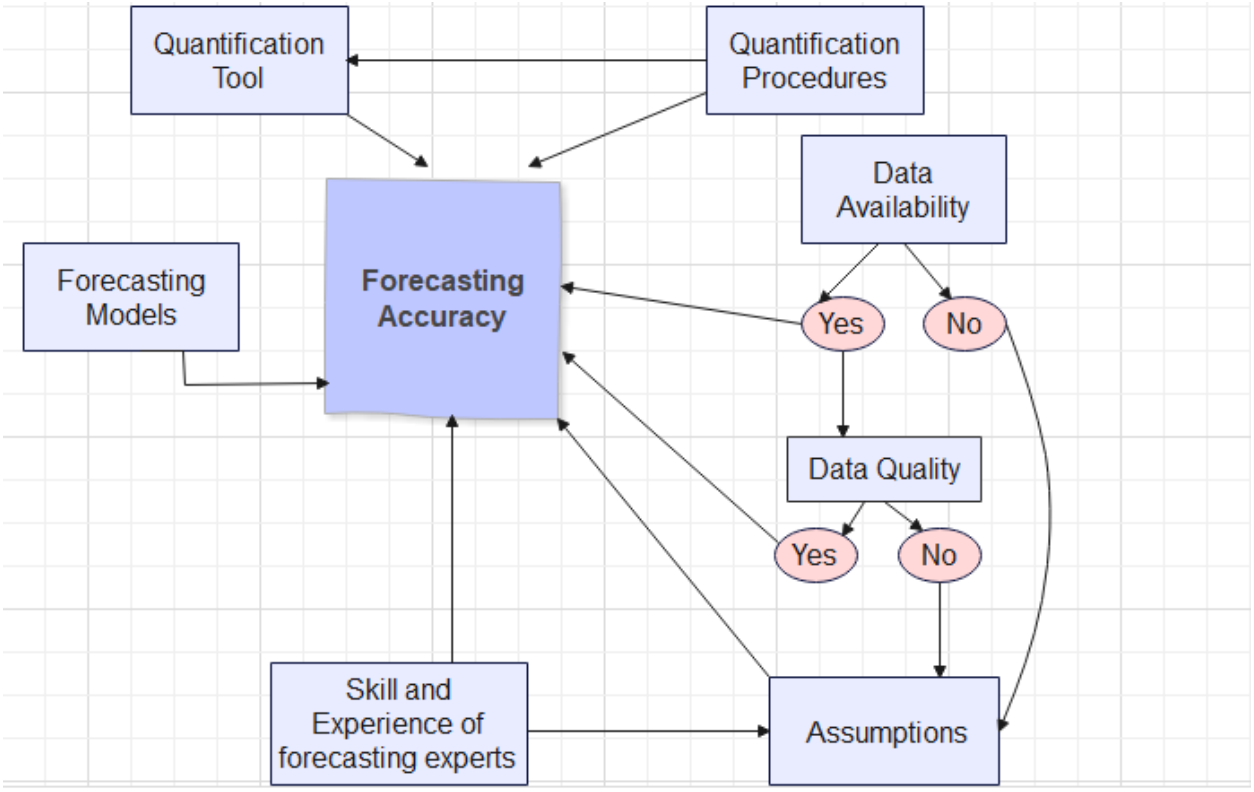

Figure 1: Conceptual Framework

Chapter Three

3. Research Methodology

This chapter discusses research methodology. It describes the study setting, study design and period, sampling and sample size determination, inclusion and exclusion criteria, data quality control, data analysis and ethical consideration parts.

3.1. Study Setting

The study was carried out in EPSS head office, Addis Ababa, Ethiopia. EPSS was established in 2007 by Proclamation No. 553/2007 as part of Pharmaceutical Logistic Master Plan. The Head office is located in Addis Ketema Subcity, in front of St. Paul Hospital. It has 19 functional branches grouped in to seven clusters. Overall, the agency serves over 4000 medical facilities in the country. Currently the agency has 3114 workers of which 2223 are male and 891 females. For this study, specifically, the Quantification and Market shaping Directorate of the agency was the main focus area. The directorate has a total of 28 staff, comprising pharmacists, biomedical engineers and laboratory experts.

3.2. Study Design and Period

A mixed method, sequential explanatory design consisting of cross sectional study of five year retrospective data and in-depth interview was employed. First quantitative research method was employed to gather five year forecasting and consumption data to measure the forecasting accuracy (Annex IV). After measuring the forecast accuracy, qualitative, in-depth interviews, were held with four purposely selected experts to explore their perspectives on HIV/AIDS program and supply chain. The in-depth interview was held directly, face to face and one to one with the participants. The interviews took place in the office of QMSD director office.

The study was retrospective secondary data analysis. The data collection period for quantitative study was from December, 2018- March 2019 and in-depth interview was held in June 2019.

3.3. Sampling and Sample Size Determination

To compute forecasting accuracy of ART medicines, all ART medicines that were being used to treat at the time of data collection period were included in the study (Annex I). For the qualitative part, to gain insight about forecasting inaccuracy, contributing factors and explaining reasons for deviation between forecast and issued data key informants were selected purposefully by considering their experience in the area of program and supply chain management of ART medicines.

3.4. Inclusion and Exclusion Criteria

Inclusion Criteria:

- ✓ For conducting forecasting accuracy, all ART medicines that were being used at the time of data collection.

Exclusion Criteria

- ✓ Medicines that have not been used continuously for the studied five years.
- ✓ Medicines used for treatment of opportunistic infections.
- ✓ Laboratory and chemical reagents that are used to diagnose HIV/AIDS.

3.5. Data Source

For the quantitative part, forecasted quantity of the previous five years was taken from quantification reports. The respective years' consumption quantity by EPSS head office were obtained from the bin cards in HCMIS (quantification and warehouse system). Each items days out of stocks were also captured. Issued quantity data and forecast data were used to calculate error metrics. In order to identify factors contributing to forecasting inaccuracy,

qualitative method employing in-depth interview with key informants was carried out by the investigator.

3.6. Data Quality Control

Data was checked by the investigator for the consistency and completeness. Efforts were made to triangulate the data collected from JSI and the data obtained from EPSS system. Cross checking was made while transferring exported HCMIS data to data collection sheet to avoid errors that possibly could be made while transferring or reformatting. All in all, data quality control was done during data entry, processing, analysis and interpretation of information.

The investigator used an interview guide adapted from published literature. In addition investigator carefully took field notes and used an audio recorder with the consent of the interview participants that enhanced the reliability of the interviews. After the responses are transcribed, a summary of the major findings of the in depth interview were sent for participants to check if all data were captured and transcribed accordingly. Then comments and ideas left unsaid during the interview were incorporated.

3.7. Data Analysis

The data of forecast and consumption of each ART medicine was transferred to an MS Excel spreadsheet. Forecasting accuracy and appropriateness of forecast model analysis were carried out using the MS Excel through feeding formulas.

Table 1. Error measurements and forecasting method with their formulas

Error Metrics	Formulas
Mean Error	$MAD= \frac{1}{n}\sum\lvert Actual\ Concumption - forecasted\ quantity\rvert$
MAPE	$MAPE=\frac{\sum_{y=1}^{n}\left\lvert\frac{Actual\ consumption-Forecast\ for\ time}{Actual\ forecast}\right\rvert}{n} * 100$
Tracking Signal	TS=Running sum Error or cumulative error divided by MAD
Exponential Smoothing	$q_{t+1}= \alpha qt + (1-\alpha)q_t \quad 0\leq \alpha\leq 1$
Moving average	$MA = (q_1+ q_2 + q_3 + q_4 + ... + q_n) / n$

n= number of observation y= year q_{t+1}=forecast quantity, q_t= consumption quantity, α=weighing component

After transferring of collected data to MS excel sheet, the data quality of some items that were found to be inconsistent were checked for their appropriateness on the HCMIS. Then the trend of issued quantity of each item was plotted using line graph.

Then, inaccuracy of each medicine was computed through subtracting forecast quantity from consumption quantity. The error was then put in to absolute value, resulting in absolute error. In order to obtain the Absolute Percentage Error (APE) absolute error was divided by issue quantity and converted into percentage value. To calculate MAPE of five year period of each medicine, the sum of APE of each item was divided by five. The resulted MAPE was compared with target set by EPSS and benchmark set by Smith in 1997, 25%. The smaller the percentage, the better the forecast accuracy (EPSS, 2016 and Smith 1997). The MAPE of those products that do not have consistent consumption over the five years were not calculated.

Based on Lewis MAPE scale of judgement for forecast errors, forecasts with MAPE of 0-10% were termed as highly accurate, 11-20% as good, 21-50% as reasonable and 51% and above as inaccurate (Lawrence *et. al,* 2009). Forecasting accuracy was calculated by subtracting MAPE from 100. For items with negative forecasting accuracy result, forecasting accuracy is assumed zero.

To calculate TS, running sum of items through the five years was computed and divided by MAD. And tracking signal of each item was compared with the normal interval, -4 to +4. The results which fall within the defined interval said to have appropriate forecasting model otherwise termed as inappropriate (NC state university, 2011).

From the collected consumption data set, other forecasting models were tested to see what specific forecasting method is appropriate for each item. These methods were exponential smoothing and moving average. The forecasts were produced using exponential smoothing with 0.8 and 0.9 values of damping factor, and moving average of with 2 and 3 years. And the forecasted values then were analysed for their accuracy using MAPE. The resulting forecast accuracy of both methods were then compared with the agency's forecasting accuracy.

The responses from in depth interview were audio recorded and transcribed verbatim on Microsoft (MS) Word. Then transcribed interview was analysed manually using inductive thematic approach. Content analysis of collected data was done via coding and data were categorized into themes and subthemes. Data analysis was carried out soon after the first three interviews were conducted; such analysis will guide further data collection and saturation of themes. The media of interview was both in Amharic and in English language also most of the explanations were in Amharic. Finally synthesis and some of selected participant quotes was translated from Amharic into English and reported.

3.8. Ethical Considerations

Ethical approval was obtained from the Ethics Review Committee with reference number ERB/SOP/65/04/2019. And support letter from the School of Pharmacy, Addis Ababa University with reference number Ph/ceutics/206/11/2019 was written to EPSS and JSI to access data. The study was conducted after getting permission from EPSS's ODDG to collect forecast and consumption data. The in depth interview participants were informed about the purpose of the study and the importance of participating in the study. They were informed that they can skip question/s that they do not want to answer fully or partly and they can quit the process at any time if they want to do so and their participation is voluntary. After assuring the confidentiality nature of responses and obtaining informed consent from the study subject, the in-depth interview was conducted.

Chapter Four

4. Result and Discussion

In this chapter results of the study along with their discussion is presented. The finding part contains trends of pediatric and adult ARTs through the five years, error metrics and suggested forecasting method for future forecasting exercises along with their forecasting inaccuracies are presented. Findings are demonstrated by graph, table and charts. Then narration of each finding is provided the discussion part.

4.1. Findings

Result of this study is presented in this part. A total of 15 ART medicines were studied; 10 Adult and 5 pediatric.

4.1.1. Issued Quantity Trend

Issued ART products were found to be increasing or decreasing over five years due to several reasons. The following graphs show trend of issue quantity of selected items over the years.

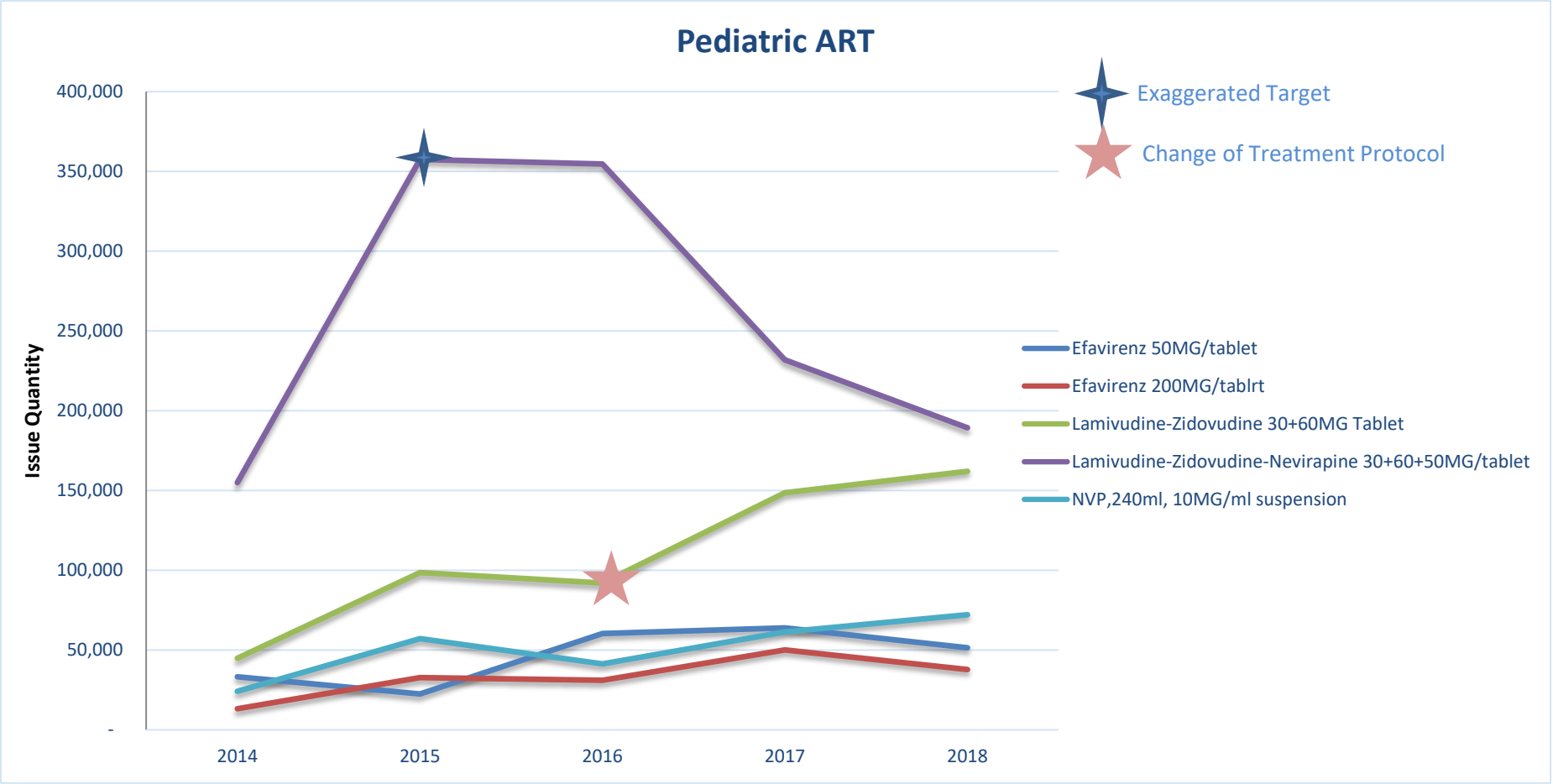

Figure 2. Issue trend of Pediatric ART medicines over 2014-2018 G.C.

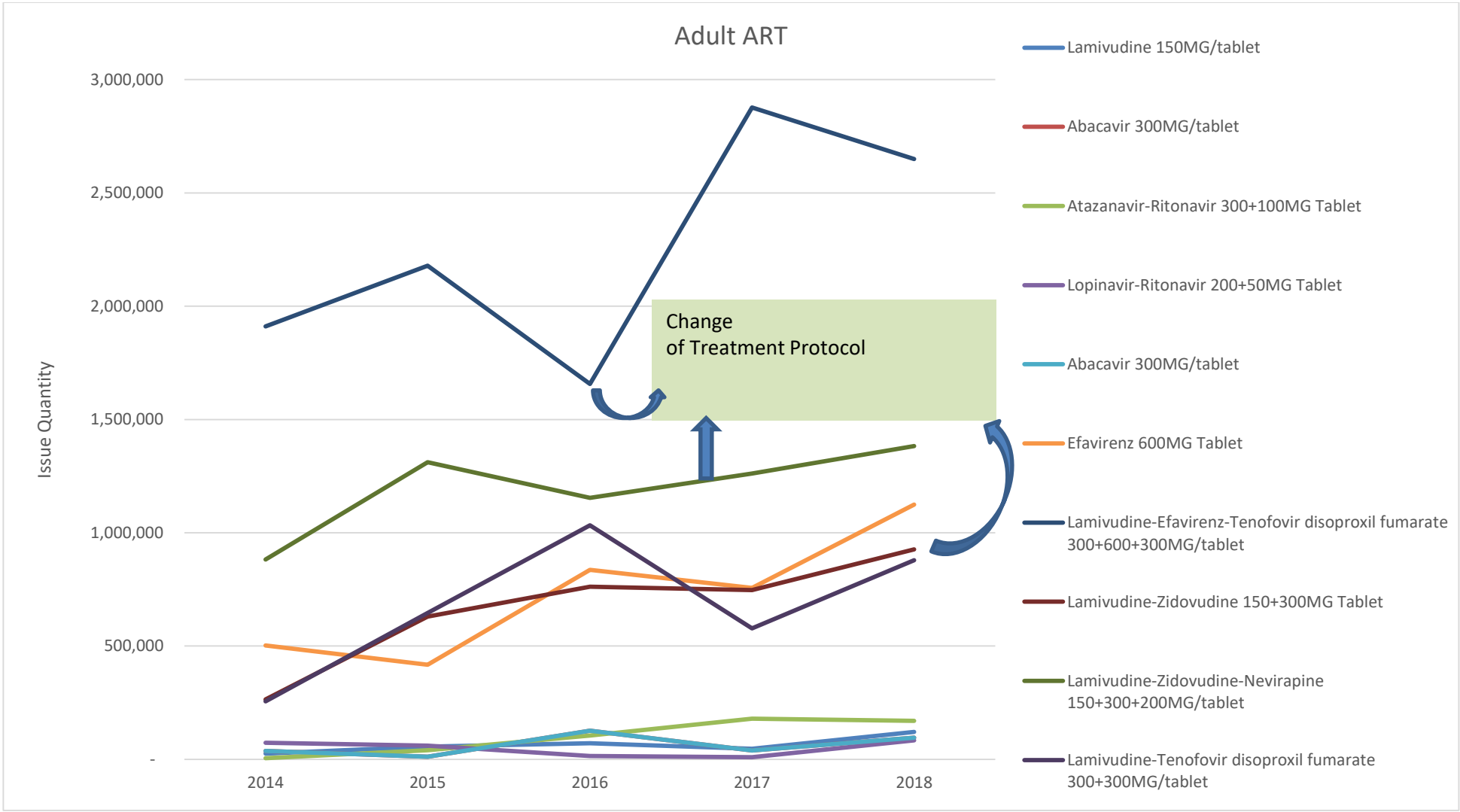

Figure 3. Issue Trend of Adult ARTs over 2014-2018 GC

4.1.2. Error Metrics

4.1.2.1. Mean Error

Mean error result range from – 947,522.4for the fixed dose combination 3TC+ TDF+ EFV to (300+600+300) regimen 43,148.8 for Lamivudine 150mg tablet. Table 2 and Table 3 show the mean error of ART products over the years 2014-2018 for adult and pediatric ART medicines respectively.

Table 2. Mean Error of Adult ART medicines Over Five Years (2014-2018)

S.N	Item Description	Mean Error
1.	Abacavir 300mg/tablet	36,895.89
2.	Atazanavir-Ritonavir 300+100mg Tablet	-82,658.25
3.	Efavirenz 600mg Tablet	24,921.32
4.	Lamivudine 150mg/tablet	43,148.84
5.	Lamivudine-Efavirenz-Tenofovirdisoproxilfumarate300+600+300mg tablet	-947,522.41
6.	Lamivudine-Zidovudine 150+300mg Tablet	-110,266.23
7.	Lamivudine-Zidovudine-Nevirapine 150+300+200mg tablet	-239,336.40
8.	Lamivudine-Tenofovirdisoproxilfumarate 300+300mg tablet	-144,293.07
9.	Lopinavir-Ritonavir 200+50mg Tablet	-47,380.60
10.	Nevirapine 200mg/tablet	-352,351.80

Table 3. Mean Error of Pediatric ART medicines Over Five Years (2014-2018)

S.N.	Item Discription	Mean Error
1.	Efavirenz 50mg/tablet	-27,860.11
2.	Efavirenz 200mg/tablet	-6,989.76
3.	Lamivudine-Zidovudine 30+60mg Tablet	-102,593.72
4.	Lamivudine-Zidovudine-Nevirapine 30+60+50mg/tablet	-112,549.96
5.	Nevirapine 240ml, 10mg/ml suspension	-2,950.28

4.1.2.2. Absolute Percent Error (APE)

The APE of the analyzed ART medicines over the five years have mixed pattern where there was decrease in the year 2015 and increasing pattern in 2016. Over all the pattern shows a decreasing trend. The line graph below shows APE pattern of the studied ART medicines.

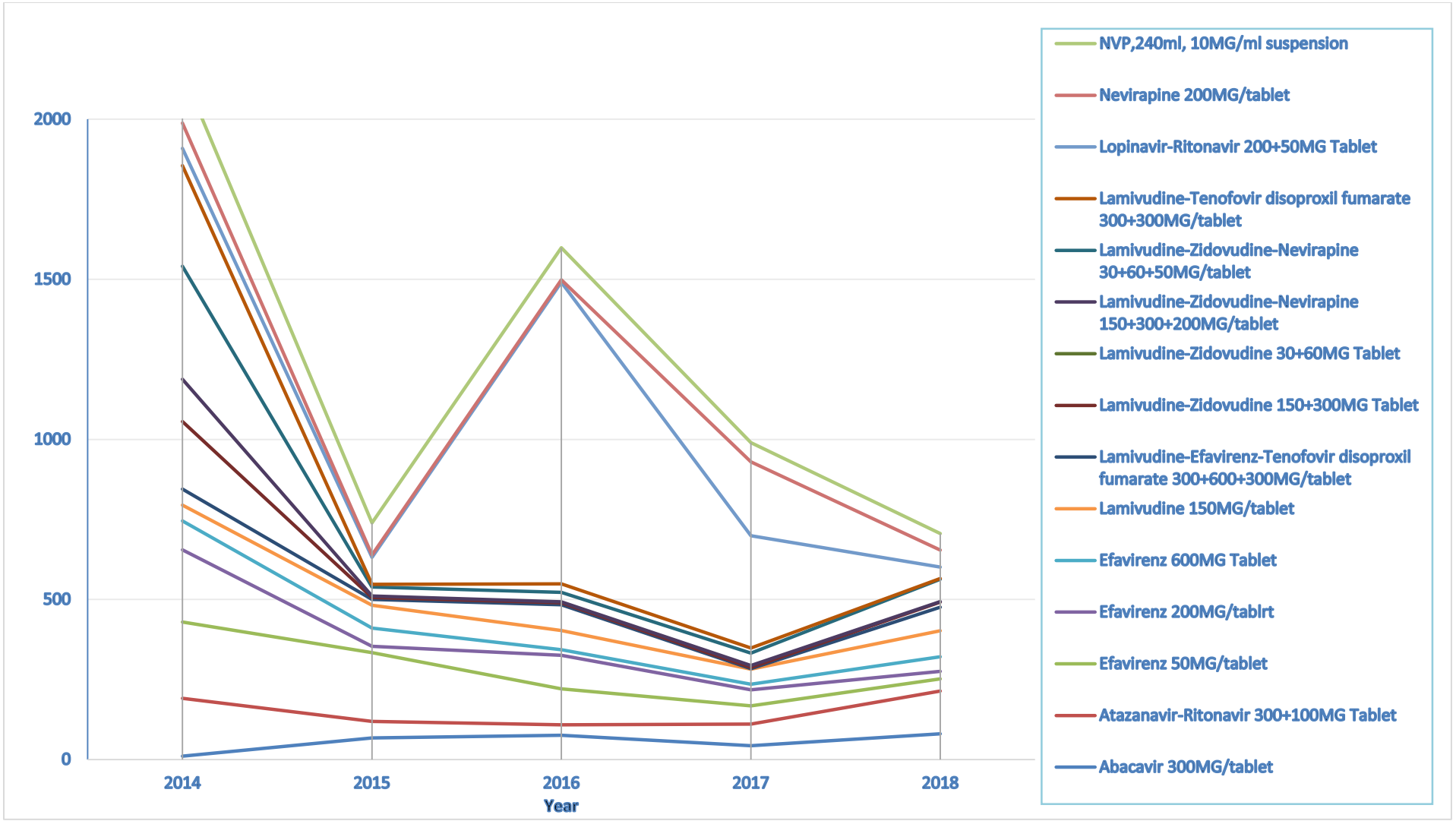

Figure 4.APE trend of ART medicines over Five Years (2014-2018)

4.1.2.3. MAPE

MAPE value ranged from 29.4 % (lamivudine 150mg+ zidovudine 300mg +nevirapine 200mg) to 293.5% (lopinavir 200mg +ritonavir 50mg). Over all, the median accuracy analysed products was found to be 20.1%. The following bar graph shows MAPE distribution of the items.

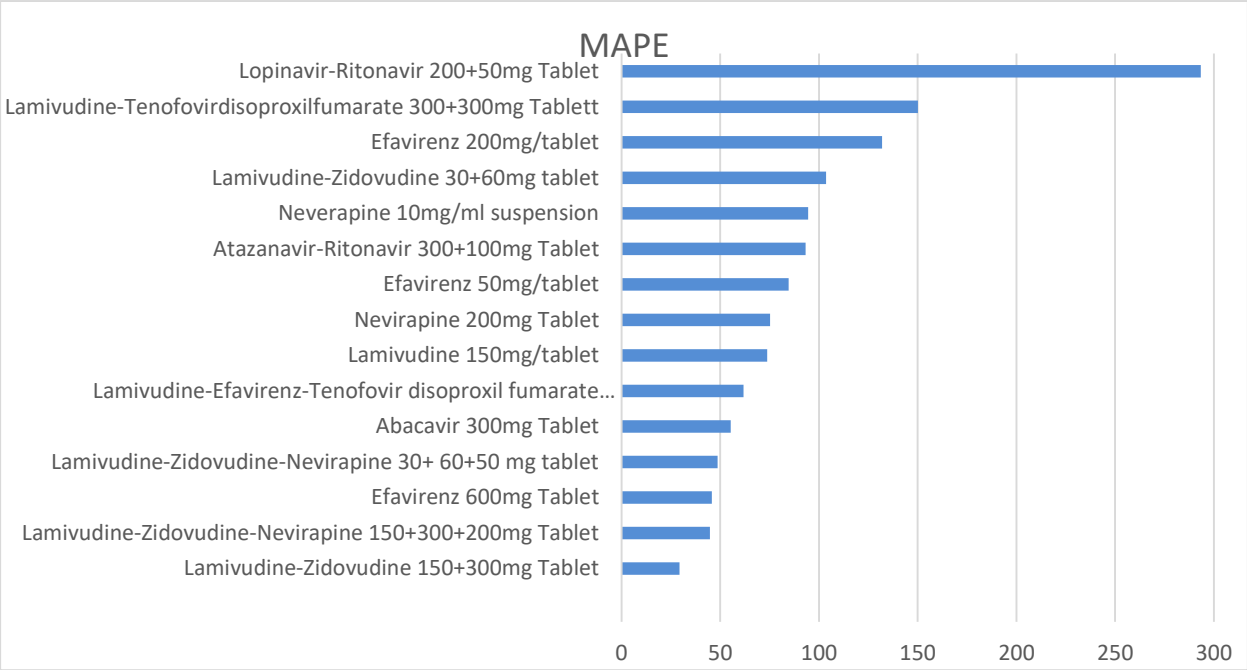

Figure 5. MAPE Distribution of ART medicines

The MAPE, according to the Lewis MAPE scale of judgement, none of the items met either highly accurate or good scale of judgement. Out of the studied items, four of them have reasonable scale while the rest were scaled inaccurate. Only one of pediatric items have reasonable scale the others being inaccurate. The following tables show the MAPE scale of judgement.

Table 4. MAPE Values and Statuses of Lewis Scale of MAPE of Adult ARTs

S.N	Item Description	MAPE	Forecast accuracy (100%-MAPE)	Lewis scale of MAPE
1	Abacavir 300mg Tablet	55.3	44.7	Inaccurate
2	Atazanavir-Ritonavir 300+100mg Tablet	93.3	6.7	Inaccurate
3	Efavirenz 600mg Tablet	45.7	54.3	Reasonable
4	Lamivudine 150mg/tablet	73.7	26.3	Inaccurate
5	Lamivudine-Efavirenz-Tenofovir disoproxil fumarate 300+600+300mg Tablet	61.8	38.2	Inaccurate
6	Lamivudine-Zidovudine 150+300mg Tablet	29.4	70.6	Reasonable
7	Lamivudine-Zidovudine-Nevirapine 150+300+200mg Tablet	44.7	55.3	Reasonable
8	Lamivudine-Tenofovirdisoproxilfumarate 300+300mg Tablet	150.1	0	Inaccurate
9	Lopinavir-Ritonavir 200+50mg Tablet	293.5	0	Inaccurate
10	Nevirapine 200mg Tablet	75.2	24.8	Inaccurate

Table 5. MAPE Values and Statuses of Lewis Scale of MAPE of Pediatric ARTs

S.N	Item description	MAPE	Forecast accuracy (100%-MAPE)	Lewis scale of MAPE
1	Efavirenz 50mg/tablet	84.6	15.4	Inaccurate
2	Efavirenz 200mg/tablet	132.0	0	Inaccurate
3	Lamivudine-Zidovudine 30+60mg tablet	103.6	0	Inaccurate
4	Lamivudine-Zidovudine-Nevirapine 30+60+50 mg tablet	48.6	51.4	Reasonable
5	Neverapine 10mg/ml suspension	94.5	5.5	Inaccurate

4.1.2.4. Tracking Signal

Although, only four of the items had MAPE scale of reasonably accurate, the tracking signal analysis of the forecasting method was appropriate for the eight of the items and for the rest the method underestimated the actual quantity. Table 6 and 7 show tracking signal value and appropriateness of forecasting method of adult and pediatric medicines respectively.

Table 6. Tracking Signal of Adult ART medicines over the Five years (2014-2018 GC)

S.N	Item Description	Tracking signal	Appropriateness forecasting model
1	Abacavir 300mg/tablet	4.4	Not Appropriate
2	Atazanavir-Ritonavir 300+100mg Tablet	-5.0	Not Appropriate
3	Efavirenz 600mg Tablet	0.4	Appropriate
4	Lamivudine 150mg/tablet	5.0	Not Appropriate
5	Lamivudine-Efavirenz-Tenofovirdisoproxil fumarate 300+600+300mg/tablet	-4.9	Not Appropriate
6	Lamivudine-Zidovudine 150+300mg Tablet	-2.8	Appropriate
7	Lamivudine-Zidovudine-Nevirapine 150+300+200mg/tablet	-4.4	Not Appropriate
8	Lamivudine-Tenofovirdisoproxilfumarate 300+300mg/tablet	-2.8	Appropriate
9	Lopinavir-Ritonavir 200+50mg Tablet	-4.0	Appropriate
10	Nevirapine 200mg/tablet	-4.7	Not Appropriate

Table 7. Tracking Signal of Pediatric ART medicines over the Five years (2014-2018 GC)

S.N.	Item Description	Tracking signal	Appropriateness of Forecasting Model
1	Efavirenz 50mg/tablet	-2.8	Appropriate
2	Efavirenz 200mg/tablet	-1.7	Appropriate
3	Lamivudine-Zidovudine 30+60mg Tablet	-5.00	Not Appropriate
4	Lamivudine-Zidovudine-Nevirapine 30+60+50mg/tablet	-2.9	Appropriate
5	Nevirapine,240ml, 10mg/ml suspension	-0.3	Appropriate

4.1.3. Forecast Accuracy for Other Forecasting Models

Forecast results of the other forecast models were more accurate, even much better than the method that the agency uses. When comparing which of the two methods was better, moving average was found to produce more accurate forecast in which 86.7% of the items have better forecast accuracy. Of this items, eleven of them have better forecast with 2 years moving average and two of them with 3 years.

Table 8 shows the forecasts of EPSS, exponential smoothing and moving average along with their forecasting accuracy. The cells filled with green indicate the most accurate forecast for each item analysed.

Table 8. Forecast Accuracy of Forecasting Methods

Sno	Item	Unit	Issued Quantity					EPSS Forecasted Quantity					MAPE (%)	FA(%)	Exponential smoothing (alpha=0.1)				MAPE (%)	FA(%)	Exponential smoothing (alpha=0.2)				MAPE (%)	FA(%)	MA 2 years				MAPE (%)	FA(%)	MA (3 years)			MAPE (%)	FA(%)
			2014	2015	2016	2017	2018	2014	2015	2016	2017	2018			2015	2016	2017	2018			2015	2016	2017	2018			2015	2016	2017	2018			2016	2017	2018		
1	Abacavir - 300mg - Tablet	60	37220	39913	56922	47223	36419	50,809	18,673	31,179	22,518	20,743	55.3	44.7	37,220	39,644	55,194	48,020	21.5	78.5	37220	37759	41591	42718	17.4	82.6	37,489	39,675	42,154	21,368	10.9	89.1	38,857	40,689	28,109	17.3	82.7
2	Atazanavir+Ritonavir - 300mg+100mg - Tablet	30	19767	35074	98243	221812	152730	15,384	60,542	139,442	300,242	397,053	93.3	6.7	19,767	33,543	91,773	208,808	27.4	72.6	19767	22828	37911	74691	30.1	69.9	21,298	30,370	56,301	37,361	26.1	73.9	26,836	45,144	37,544	32.6	67.4
3	Efavirenze - 200mg - Capsule	90	18869	24462	27869	32003	35469	112,684	71,002	127,905	27,709	31,590	132.0	0	18,869	23,903	27,472	31,550	2.8	97.2	18869	19988	21564	23652	8.3	91.7	19,428	20,776	22,608	11,830	7.2	92.8	20,140	21,734	15,075	12.5	87.5
4	Efavirenze - 50mg - Capsule	30	18677	31230	40838	49380	42181	43,223	38,971	63,491	25,039	28,990	84.6	15.4	18,677	29,975	39,752	48,417	15.2	84.8	18677	21188	25118	29970	31.6	68.4	19,932	23,153	27,544	15,001	12.3	87.7	21,661	25,425	18,373	16.2	83.8
5	Efavirenze - 600mg - Tablet	30	476428	744761	701871	936584	895983	997,514	656,084	685,907	638,363	653,938	45.6	54.4	476,428	717,928	703,477	913,273	16.3	83.7	476428	530095	564450	638877	32.2	67.8	503,261	547,272	601,663	319,454	9.0	91.0	523,657	577,807	401,120	9.9	90.1
6	Lamivudine + Efavirenz +Tenofovir - 300mg +600mg+300mg - Tablet	30	1476097	1978149	2213853	3538261	2647278	13,132	15,963	28,655	24,545	22,786	61.8	38.2	1,476,097	1,927,944	2,185,262	3,402,961	26.3	73.7	1476097	1576507	1703977	2070833	31.9	68.1	1,526,302	1,640,242	1,887,405	1,035,433	13.4	86.6	1,585,527	1,783,772	1,258,281	15.9	84.1
7	Lamivudine + Nevirapine + Zidovudine - 150mg + 200mg + 300mg - Tablet	60	1017475	1389094	1310724	1110729	1009471	2,871,307	2,710,785	3,317,510	4,075,714	4,585,833	44.7	55.3	1,017,475	1,351,932	1,314,845	1,131,141	15.1	84.9	1017475	1091799	1135584	1130613	14.4	85.6	1,054,637	1,113,691	1,133,098	565,314	7.6	92.4	1,081,619	1,119,332	755,404	11.0	89.0
8	Lamivudine + Nevirapine + Zidovudine - 30mg + 50mg + 60mg - Tablet	60	133731	392964	321439	257487	333330	1,028,168	669,540	713,134	772,036	838,694	48.6	51.4	133,731	367,041	325,999	264,338	31.9	68.1	133731	185578	212750	221697	39.8	60.2	159,654	199,164	217,224	110,869	17.0	83.0	177,353	206,675	144,829	15.5	84.5
9	Lamivudine + Tenofovir - 300 mg + 300 mg - Tablet	30	775865	750885	663177	1001767	865274	236,476	192,889	279,333	164,192	186,496	150.1	0	775,865	753,383	672,198	968,810	15.4	84.6	775865	770869	749331	799818	13.1	86.9	773,367	760,100	774,574	399,915	8.3	91.7	765,355	773,339	516,387	10.7	89.3
10	Lamivudine + Zidovudine - 150mg+300mg - Tablet	60	716826	653738	743856	1683606	945725	2,040,006	1,255,133	1,188,620	1,345,411	1,358,916	29.4	70.6	716,826	660,047	735,475	1,588,793	36.3	63.7	716826	704208	712138	906432	19.2	80.8	710,517	708,173	809,285	453,225	19.5	80.5	711,057	774,259	539,530	21.0	79.0
11	Lamivudine + Zidovudine - 30 mg + 60 mg - Tablet	60	26919	107969	65255	152915	174406	701,405	257,369	250,356	320,972	321,087	103.6	0	26,919	99,864	68,716	144,495	50.1	49.9	26919	43129	47554	68626	59.6	40.4	35,024	45,342	58,090	34,343	26.3	73.7	39,201	53,103	38,747	18.7	81.3
12	Lamivudine - 150mg - Tablet	60	25615	32185	62074	68164	53891	1,061,115	702,440	755,535	840,639	920,420	73.7	26.3	25,615	31,528	59,019	67,250	27.0	73.0	25615	26929	33958	40799	37.9	62.1	26,272	30,444	37,379	20,419	13.0	87.0	28,834	33,895	24,932	23.4	76.6
13	Lopinavir + Ritonavir - 200mg + 50mg - Tablet	120	57210	52240	53207	20713	68288	112,557	112,210	159,148	41,720	53,876	293.5	0	57,210	52,737	53,160	23,958	58.0	42.0	57210	56216	55614	48634	53.1	46.9	56,713	55,915	52,124	24,344	29.7	70.3	56,347	53,488	34,767	45.2	54.8
14	Nevirapine - 200mg - Tablet	60	473487	586503	533165	604210	917896	1,006,211	616,047	617,405	1,263,034	1,287,323	75.2	24.8	473,487	575,201	537,369	597,526	18.3	81.7	473487	496090	503505	523646	21.5	78.5	484,789	499,798	513,576	261,834	9.4	90.6	491,027	507,747	342,391	10.2	89.8
15	Nevirapine 10mg/ml-Suspension	240 ml	24,199	57,087	41,376	61420.6	72,160	63,018			98,373	109,603	94.5	5.5	24,199	53,798	42,618	59,540	33.9	66.1	24199	30777	32896	38601	44.0	56.0	27,488	31,837	35,749	19,323	17.9	82.1	29,291	34,091	23,847	11.2	88.8

4.1.4. In-depth Interview

In order to identify factors that could contribute to forecasting inaccuracy of the studied ART medicines, in-depth interviews were carried out. Overall, four themes were generated and under the generated themes, nine subthemes emerged during analysis.

The themes identified were; treatment protocol related, quantification process related, supply chain management related, and coordination between program and supply chain. Accordingly the subthemes were, change in treatment protocol, deviation in consumption of pediatric regimen, forecasting method employed, assumptions stated during quantification, quantification tool, knowledge and experience of tool users, emergency ordering, supply chain insufficiency and inadequacy of joint planning

A total of 4 key informants were interviewed two were females and two males. Their experience ranged from 6 to over 12 years.

Table 9. Socio demographic characteristics of respondents (n=4)

Socio-demographic Characteristic of Respondents	**Number**
Gender	
Male	2
Female	2
Age	
25-29	1
30 -35	2
≥35	1
Level of Education	
Degree	1
Master's Degree	3
Work Experience	
5-10cahnge	2
≥10	2

4.1.4.1. Treatment Protocol Related

4.1.4.1.1. Changes in Treatment Protocol

As participants stated treatment protocol was changed three times over the years. First, stavudine and didanosine, adult first line treatment were out of the market in 2014 because of side effects. As a result, zidovudine and TDF based regimens become adult first line treatment as stated in the national ART comprehensive treatment guideline. But the pediatric dosage of stavudine was kept on until 2015. However, the pediatric regimens that contain stavudine also phased out, this being the second treatment protocol change. And thirdly, neverapine is being phased out as treatment option. These treatment shift have direct effect on consumption trend. On the other hand shifting form the existing treatment to new ones takes time, where slow movement of quantified new products due to no/ low consumption and the existing products that are meant to decrease will be kept in use. This greatly affects forecasting accuracy.

"… change in treatment protocol alter consumption trend since implementation of new protocols is taken seriously even if it is notified in the middle of fiscal year …" (Supply chain advisor, 10 years of experience)

"... treatment shifts might not happen as planned. Consumption trend of the old treatment might not show decreasing trend as expected. Also the quantified new products could have slow movement if the old treatments kept on being used."(Team coordinator, 6 years of experience)

" … for example take Nevirapine, we were thinking of switching treatment when the stocked amount is still being utilized in order to minimize wastage, but then donors insisted to switch otherwise they threaten to stop funding…" (Quantification expert, over 12 years of experience)

4.1.4.1.2. Deviation in Consumption of Pediatric Regimens

Exaggerated target set by MoH was cited as one reason. For example, pediatric regimens forecast never met the consumption trend creating massive wastage.

"… there is higher forecast inaccuracy in paediatric ART medicines than the adult ones. This is partly because of the target set in the spectrum analysis, which is much higher than the actual enrolled clients, for example target set for paediatric clients in 2014 was 55,665 but until now (2019) the actual patients enrolled are 22,000. This can have effect on forecasting accuracy." (Team coordinator, 6 years of experience)

4.1.4.2. Quantification Process Related

4.1.4.2.1. Forecasting Method Employed

All the respondents said using morbidity method as a forecasting method for ART methods. They stated new enrolments, rapid program growth and evolving treatment practice can be captured and better forecasts can be produced.

"…by using morbidity method we can capture new enrolments, rapid program growth and evolving treatment practices. But considering consumption method would mislead since it does not consider the mentioned aspects." (Supply chain advisor, 10 years of experience)

"…utilizing consumption method leads to over or under estimation since program scaling up and new treatment protocols might not be considered. This certainly impact forecasting accuracy."(Team coordinator, 6 years of experience)

4.1.4.2.2. Assumptions Stated during Quantification

According to respondents assumptions are made whenever there is change in treatment protocol and target. The quantification team prepare and analyse assumptions with expertise in the area. Then the team presents assumptions on consultative workshop to stakeholders, partners and health facilities for discussion. The approved assumptions are utilized during

quantification. However, regarding targets the can be exaggerated and may impact forecast accuracy. In addition changed treatments might not went as they are planned.

"While building assumptions we invite expertise to provide us with informed opinions relating with what really is happening on the ground. After all this, the changed treatment protocol might not go as planned so we have to revisit our supply plan and extend ongoing requests of the new treatment" (Quantification expert, over 12 years of experience)

"...targets set by MoH and taken as assumption sometimes are exaggerated. After procuring according to targets set consumption of the products might not go as planned."(Team coordinator, 6 years of experience)

4.1.4.2.3. Quantification Tool

Respondents stated that the agency utilizes Quantimed® to produce quantified amount and budget needed. It is user friendly and minimizes work load if the appropriate data are fed in to the tool. Even though they found the tool being very helpful, they noted that if it produces inappropriate result, identifying what went wrong takes much longer time. In addition, the result might need some adjustments since outputs sometimes are not trustworthy. Hence, bias might be introduced while adjusting.

"...if you made a mistake along the process of quantification, there is no way you know where something went wrong. So you have to go through the whole processes in order to find out." (Supply chain advisor, 10 years of experience)

''...after result is produced by Quantimed ® we just don't take it as it is. Some out puts have to be adjusted because they seem unrealistic. Adjustments even produce human made error; this would not happen if the tool always produces realistic output. ''

4.1.4.2.4. Knowledge and Experience of Tool Users

According to the respondents producing a genuine quantification result using Quantimed® greatly depends on the knowledge and experience they have when utilizing the tool and interpretation of produced results. Most of the individuals that have been quantifying ART medicines took Quantimed® training.

"We have been giving Quantimed® training for more than 8 years. These professionals has been involved in the quantification process and they are becoming experts, making the quantification results genuine from year to year." (Quantification expert, over 12 years of experience)

"I took the training 5 years ago. It was very informative and produce quantification result easily. Utilization of the tool became easier as I kept on working with it. It is user friendly as you get experienced."(Team coordinator, 6 years of experience)

4.1.4.3. Supply Chain Management Related

4.1.4.3.1. Emergency Ordering

In the past, there were emergency ordering mainly due to suppliers' delay in delivery of products.

"Consumptions had never outweighed stock on hand over the years. We order quantity that is less than the quantity that is on purchase order so that suppliers would make it on time. For example, supplier of lopinavir 200mg +Ritonavir 50mg delayed from the scheduled delivery time. So we rationed the stock on hand to meet demand somehow. Hence, even though there were delay, service interruptions were not encountered. Because the ordered quantity in emergency ordering does not match the purchase order's quantity, it might have effect on forecasting accuracy."(Team coordinator, 6 years of experience)

4.1.4.3.2. Supply Chain Inefficiency

In EPSS, procurement lead time is long not only for ART medicines but also for most of the pharmaceuticals. Forecast amount might not arrive on the same year it is meant to be utilized. Even though 6 month is stated as standard procurement lead time it might take more than 6 month, even a year until pharmaceuticals arrive. Also consumption data delivery points are not visible for EPSS.

"...as an agency there is longer lead time than expected... " (Team coordinator, 6 years of experience)

"… The HCMIS does not show service point consumption data. So knowing the real demand trend is impossible."(Supply chain advisor, 10 years of experience)

4.1.4.4. Coordination between Program and Supply Chain Management

4.1.4.4.1. Inadequacy of joint planning

The QMS directorate director stated that sometimes there is problem in program implementation. This could be due to program and logistics of ART are managed separately. The program is managed by FMOH and the product is managed by EPSS. There is sometimes mutual exclusiveness between the two sides.

"...Sometimes decisions made from both sides might not be communicated in time. There is mutual exclusiveness. This might have effect on the consumption trend." (QMSD Director, 7 years of experience)

4.2. Discussion and Interpretation

The ART medicines had different consumption trend over the years. Some were increasing while the others were decreasing or ceased along the five years.

Following the replacement of stavudine as a first line treatment in August 2013 by combination of TDF and zidovudine, stavudine had shown decreasing issue trend and finally its consumption came to an end after 2014, while TDF and zidovudine based regimens showed increasing trend after the year 2015.

According to the National Strategic Plan for Elimination of Mother to Child Transmission of HIV (PMTCT) triple FDC of TDF/3TC/EFV, option B+, was implemented as a preferred ART regimen in 2016.The requirement of ART for mothers is considered with the adult first line regimen. Before implementation of option B+, zidovudine alone was used as a medicine of choice for PMTCT. As a result the issue trend of zidovudine was decreased.

In 2014, every child born to HIV positive women started taking nevirapine prophylaxis instead of zidovudine suspension. This change of treatment had caused the issue trend of zidovudine suspension to drop even though it was purchased in case there is adverse drug reaction as a result of nevirapine intake (EPSS, 2013).

TDF 300mg showed decline in issue pattern when ceased being issued as of 2015 due to change in treatment guideline (FMOH, 2018). Since then it has been purchased as a combination with lamivudine and lamivudine and efavirenz as fixed triple combination. As a result the combination versions have an increasing issue pattern. TDF based regimen has become the first treatment choice for treatment naive patients.

Though lopinavir boosted with ritonavir (200+50 mg) quantified for 2016, its delivery was delayed in 2016. As a result, ATV/r was used as an alternative second line. Because of this the issued quantity of ATV/r had increased while LOP/r's decreased.

TDF and lamivudine binary combination and efavirenz had a peak issue quantity in 2016 since health professionals tended to prescribe TDF and lamivudin and loose efavirenz instead of once daily triple fixed dose combination (TDF+3TC+EFV), which thought to enhance adherence to therapy in ART and PMTCT. In other way around, the triple combination had lower flow since health professionals did not have awareness. In the consecutive years the triple combination showed an increasing trend after the implementation of TDF/3TC/EFV roll out and tremendous amount of effort made in awareness creation to health professionals.

Growth in number of clients was higher in 2015 (68,220 adults and 22,240 children in year) due to the change in the criteria for eligibility for ART to ≤500 CD4 count started being implemented from January 2014. This increased the pool of persons eligible for treatment.

Also the 2015 quantification exercise introduced an attrition rate (loss to follow-up, death, etc.) of 6.8% stated by Centres for Disease Control (CDC) to reduce over-estimation caused by assuming all patients require treatment throughout the forecast year (EPSS, 2014). This rendered increase in consumption trend of both adult and pediatric (first and second line) regimens in 2015.

Lamivudine 150mg+ zidovudine300mg+ nevirapine 200mg triple fixed combination was the most accurate of all the studied items having an accuracy of 70.61%. Meanwhile, the highest MAPE value was owned by lopinavir 200mg +Ritonavir 50mg 293.51% this may be as a result of issue quantity decreased due to delayed delivery of the in the year 2016.

The mean error value of twelve items were negative values. This result shows that forecast quantity is greater than consumption quantity foretelling the forecast done for these items overestimated the demand.

Based on Lewis MAPE scale of judgement for forecast errors, forecasts with MAPE of 0-10% were termed as highly accurate, 11-20% as good, 21-50% as reasonable and 51% and above as inaccurate (Lawrence *et. al*, 2009). According to this classification none of the analysed items were found to be either highly accurate or as good. Only four items were found to have reasonable Lewis scale of MAPE. These items were lamivudine-zidovudine 150+ 300 mg tablet, 29.4%, lamivudine-zidovudine-nevirapine 150+ 300+ 200 mg tablet, 44.7%, efavirenz 600mg Tablet, 45.6%, and lamivudine-zidovudine-nevirapine 30+50+60 mg tablet, 48.6. These shows adult ART regimens have better MAPE than those of the pediatric ones. For instance, same combination, lamivudine-zidovudine, the adult dose have lower MAPE while pediatric dose had higher one, 103.6%.

Efavirenz formulations also had same case, the adult dose had reasonable MAPE scale while paediatric doses with 50mg and 200mg had inaccurate MAPE scale of judgement.

When comparing the results with that of the target set by the agency, 25%, none of the studied items met the target. Over all, pediatric ART medicines had higher forecasting inaccuracies. The reason for these dissatisfying result of MAPE may be attributed to target set by the ministry's spectrum analysis during quantification process. This in turn makes the quantity forecast to be either higher or lower.

The other reasons as stated by Laila *et.al*, forecast inaccuracy of ART may be due to extended time taken or failure to implement policy changes, prescribing trends being practiced in the past not changing as hoped-for, the data utilised during quantification being poor or

inadequate. And also, difficulties in forecasting for pediatric ARVs because of weight and age considerations (Laila *et.al,* 2011). The other reason can be assumptions made during the quantification exercise. Assumptions were made whenever the quantification team encounters limited or in-availability of data or poor data quality. The agreed up on assumptions may not have support of study findings. Even though, the interviewed subjects did not agree in the involvement of statistician during the exercise, a study done by Haloub and Radi suggest involvement of statistical experts could alleviate risk of having higher forecasting inaccuracies (Haloub and Radi in 2013).

According to North Carolina state university, tracking signal identifies whether forecasting method is appropriate or not for each item. A forecasting method is said to be appropriate if the result lies in between -4 and +4(NC state university, 2011). If the result is outside the range of -4 to +4, this indicates that the forecast is biased and is either under forecasted *(TS* < -4) or over-forecasted *(TS* > +4) and the method is regarded as inappropriate.

For those items that have inappropriate method, then other methods have to be considered to get more accurate forecast for each medicine. Of the items studied, the method used was appropriate for eight of the items whereas the method seemed to underestimate forecast quantity for atazanavir-ritonavir 300+100mg tablet, lamivudine- efavirenz-tenofovir disoproxil fumarate 300+600+300mg/tablet, lamivudine-zidovudine 30+60mg tablet, lamivudine-zidovudine-nevirapine 150+300+200mg/tablet lopinavir-ritonavir 80+20mg/ml solution and nevirapine 200mg/tablet.

To analyse if other forecasting models would demonstrate better forecast than EPSS's forecast, alternative methods were tested.

Based on the findings moving average with 2 years was found to be more accurate for 11 items. Of the forecasts produced using 2 years moving average, four of the items had highly accurate, five of them were good and 2 of them lied on reasonable according to Lewis MAPE scale of judgement. Two of the analysed items have better accuracy with 3 year moving average forecasts.

When forecasting with moving average with 2 years model, efavirenz 600mg tablet, triple combination adult dose lamuvidine-nevirapine-zidovudine, lamivudine-TDF 300mg+300mg binary combination and nevirapine 200mg tablet scored highly accurate scale of MAPE judgement. Meanwhile, triple combinations lamivudine-efavirenz-TDF and pediatric dose lamuvidine-nevirapine-zidovudine, Abacabir and lamivudine tablets got good scale. This shows forecasting these medicines with 2 years moving average yields better forecast.

Atazanavir and lopinavir boosted with ritonavir tablets show lower forecasting accuracy than the target set by EPSS, 75%. Even if they do not met the target they had better forecast with 2 years moving average than the agency's forecast.

On the other way around, pediatric doses lamivudine-zidovudine binary combination and nevirapine suspension had a better forecast with 3 years moving average model, scoring good scale.

Of the items analysed only efavirenz 200mg and lamivudine-zidovudine 150+300mg tablets had better forecast with exponential smoothing with damping factor 0.9 and 0.8 respectively. According to Lewis MAPE scale of judgment, efavirenz 200mg had highly accurate scale while lamivudine-zidovudine 150+300mg tablet had good scale.

As understood from the in depth interview, the several factors could contribute to forecasting inaccuracy. One was change in treatment protocol which can have great emphasis on the quantity estimated. As described by respondents, treatment protocols had changed three times over the studied years. According to USAID deliver project in 2012, frequent change in treatment guidelines attribute to high forecasting error. Other factor was inadequate joint planning where integration of stakeholders has impact. ART logistics and program are being managed separately, logistics by EPSS and program by the ministry. This may result in some coordination problems. This inadequate coordination or joint planning can render a barrier to good quality forecast and supply plans as stated by the UN Commission on Life-Saving Commodities for Women's and Children's Health.

Issues related with the application Quantimed® might also contribute to producing over or under estimated forecast quantity. Regardless of astonishing assistance the tool provide, the data entered could be mistaken since some data are inscribed manually. Even if EPSS monitoring and evaluation plan stated absence of agreed and defined quantification tool/s, this factor did not seem to contribute to forecasting inaccuracy in ART medicines since Quantimed® is already defined as quantification tool.

The respondents also stated that lack of end user consumption data visibility affect forecasting accuracy. A study carried out by USAID | DELIVER PROJECT in 2012, highest forecasting error rates can be characterized by poor logistics data at service delivery points, or heavy reliance on older data for forecasting. Data availability or poor quality are crucial for forecast accuracy. Lack of data or poor quality of available data led to use of assumptions. Heavy reliance on assumptions had been one of the contributing factors to forecast inaccuracy.

4.3. Limitation of the Study

In order to compute forecast accuracy, consumption data at service delivery points, health facilities, would have produced better output. However, actual consumption quantity from facilities were insufficient due to quality issues and incompleteness. And also issue data from branches to health facility was distorted for the years 2013 and 2014 due to system dysfunction. The investigator was forced to use issue data from EPSS head office to branches as consumption data.

In addition, while carrying out the in-depth interview, the investigator failed to capture program side of ART medicines keeping in mind only logistic part could explain the factors for inaccuracy. Involvement of all the stakeholders during the interview would definitely provide better insight.

Chapter Five

5. Conclusion and Recommendation

Based on the result of the study, this section summarizes the findings in the conclusion part and suggest solutions for the gaps identified in the recommendation part.

5.1. Conclusion

This study found that forecasts of all studied ART items did not meet the agency's target. In addition none the medicines studied were able to satisfy highly accurate or good according to the Lewis scale of MAPE judgement. Pediatric medicines were found to be more inaccurate than the adult ones. Regarding appropriateness of the method, the method used by EPSS was appropriate for 53.3% of the studied items.

Change in treatment protocol, deviation in consumption of paediatric regimens, forecasting method employed, assumptions made, quantification tool, knowledge and experience of tool users, emergency ordering, supply chain inefficiency and inadequacy of joint planning contribute to forecasting accuracy.

Based on other forecasting methods tested, each item studied have different forecast accuracy value.

5.2. Recommendation

Even though forecast accuracy for ART medicines is being monitored biannually, forecasts of each month should be specified to get more accurate data.

Since adherence to ever changing treatment guidelines can affect the consumption trend, regular and extensive follow-up is mandatory. To mitigate forecast inaccuracies as a result of extended time taken or failure to implement policy changes, immediate implementation of policy/protocol must be placed.

In addition whenever there is change in protocol, smaller amounts of the new treatment should be purchased.

The accuracy of forecast using the morbidity-based method depends on the degree to which standard treatment guidelines are adhered to. So, in order to trust morbidity data while forecasting, the percent at which prescriber adhere to ever changing ART treatment guidelines has to be assessed.

To improve data quality particularly at service delivery points, preparing a more comprehensive digitalized reporting format and scheduled reporting must be in place. EPSS has to work hand in hand with its stake holders, hence actual consumption quantity can be obtained to calculate forecasting accuracy in the most convincing way.

This study showed that pediatric regimens tend to have more forecasting inaccuracies than the adult ones. Thus, further analysis of which pediatric regimen given at which age group and weight is encountering forecasting inaccuracy has to be carried out. Hence, specific action to minimize problem can be taken.

According to the findings, the other contributing factor for forecast inaccuracy was assumptions made and skills and expertise of forecasting team. Hence whenever necessary, involvement of biostatisticians while building assumptions might increase the trustworthiness of the forecast result.

From the tested forecasting methods, it is crystal clear that employing different types of methods for each item will give the most accurate forecast. For instance elven items had better forecast with 2 years moving average model. Considering 3 years moving average as a forecast model might be one possible solution to improvise resource utilization and reduce wastage rate. Although trying different methods while carrying quantification exercise might take time, quantification team has to bear in mind, of many of the objectives quantification has is reducing cost and wastage rate.

Using this study findings as a baseline, more research have to be carried out for other program medicines and RDF medicines.

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Annex I: List of ART products currently being used in Ethiopia

S.N	ARV Products	Unit
1	Abacavir 300mg/tab	60
2	Abacavir-Lamivudine 600+300mg/tab	30
3	ABC 120-3TC 60 120mg	60
4	Atazanavir-Ritonavir 300+100mg/tab	30
5	Darunavir 600mg/tab	60
6	Darunavir 75MG/tab	60
7	Efavirenz 200mg/tab	90
8	Efavirenz 50mg/tab	30
9	Efavirenz 600mg/tab	30
10	Efavirenz-Lamivudine-Tenofovir disoproxil fumarate 600+300+300mg/tab	30
11	Lamivudine 150mg/tab	60
12	Lamivudine-Zidovudine 150+300mg/tab	60
13	Lamivudine-Zidovudine 30+60mg/tab	60
14	Lamivudine-Zidovudine-Nevirapine 150+300+200mg/tab	60
15	Lamivudine-Zidovudine-Nevirapine 30+60+50mg/tab	60
16	Lopinavir-Ritonavir[Kaletra] 80+20mg/ml	60ml
17	Lopinavir-Ritonavir 100+25MG/tab	120
18	Lopinavir-Ritonavir 200+50mg/tab	120
19	Lorpinavir-Ritonavir 40+10mg/cap	120
20	Nevirapine 10mg/ml	100ml
21	Nevirapine 200mg/tab	60
22	Raltegravir 100mg/tab	60
23	Doultegravir 50mg/tab	30
24	Ritonavir 100mg/tab	60
25	Ritonavir 25mg tab	60
26	Tenofovirdisoproxilfumarate-Lamivudine 300+300mg/tab	30

Annex II: In depth interview questions

1. Which forecasting method is/are appropriate for ART medicines??
2. How do you compute forecasting accuracy?
3. What measures are taken when there is emergency ordering for ART medicines? And do you think emergency needs affect forecasting accuracy?
4. What are the major challenges while purchasing ART medicines? Was there any delay ever encountered? Do all forecast items (quantity) reach timely for the forecast year?
5. Were there any supply chain inefficiency In HIV/AIDS program? When? What were the reasons?
6. There is an increase in lamivudine 150mg issue trend since 2017. Why is that?
7. What major treatment protocol had been changed in the previous years?

Annex III: የቃለ መጠይቅ ጥያቄዎች

1. የትኛው የትንበያ ዘዴ ለ ኤችአይቪ/ኤድስ መድሃኒቶች ተስማሚ ነው?

2. የትንበያ ትክክለኛነትን እንዴት ያሰላሉ?

3. የ ኤችአይቪ/ኤድስ መድሃኒቶች ድንገተኛ መታዘዝ ሲኖርባቸው ምን እርምጃዎች ይወሰዳሉ? እና የአደጋ ጊዜ ፍላጎቶች ትንበያ ትክክለኛነት ላይ ተጽዕኖ ያሳድራሉ ብለው ያስባሉ?

4. የ ኤችአይቪ/ኤድስ መድሃኒቶችን በሚገዙበት ጊዜ ዋና ዋና ተግዳሮቶች ምንድን ናቸው? መዘግየት አጋጥሞ ያውቃል? ሁሉም የትንበያ እቃዎች (ብዛታቸው) ለትንበያው አመት በጊዜው ይደርሳሉ?

5. በኤችአይቪ/ኤድስ ፕሮግራም ውስጥ የአቅርቦት ሰንሰለት ችግር ነበር? መቼ ነበር? ምክንያቶቹስ ምን ነበሩ?

6. ከ 2017 ጀምሮ የ lamivudine 150mg ጉዳይ አዝማሚያ መጨመር አለ. ለምንድነው?

7. ባለፉት ዓመታት ምን ያህል ዋና የሕክምና ፕሮቶኮሎች ተቀይረዋል?

Annex IV: Data collection sheet for quantitative analysis

Product	Units	Forecast quantity	Issue quantity	Days out of stock
Abacavir 300mg Tablet	60			
Abacavir 60mg Tablet	60			
Atazanavit + Ritonavir (300+100)mg Tablet	30			
Didanosine 125mg Capsule	30			
Didanosine 200mg Capsule	30			
Didanosine 250mg Capsule	30			
Didanosine 400mg Capsule	30			
Efavirenz 200 mg Capsule	90			
Efavirenz 50mg Capsule	30			
Efavirenz 600mg Tablet	30			
Lamivudine 10mg/ml Oral Solution	100			
Lamivudine 150mg Tablet	60			
Lamivudine 300mg/Tenofovir 300mg Tablet	30			
Lamivudine 300mg/Tenofovir 300mg/ Efavirenz 600mg Tab	30			
Lamivudine 30mg/Zidovudin 60mg/Nevirapine 50mg Tab	60			
Lamivudine 30mg/Zidovudine 60mg Tablet	60			
Lopinavir 100mg + Ritonavir 25mg Tablet	120			
Lopinavir 200mg/Ritonavir 50mg Tablet	120			
Lopinavir/Ritonavir 80/20mg/ml Solution	60ml			
Nevirapine 10mg/ml Suspension	100			
Nevirapine 200mg Tablet	60			
Stavudine 12mg/Lamivudine 60mg Tablet	60			
Stavudine 12mg/Lamivudine 60mg/Nevirapine 100mg Tab	60			
Stavudine 6mg/Lamivudine 30mg Tablet	60			
Stavudine 6mg/Lamivudine 30mg Nevirapine 50mg Tablet	60			
Zidovudine 10mg/ml Suspension	240 ml			
Zidovudine 300mg Tab	60			
Zidovudine 300mg/Lamivudine 150mg Tablet	60			
Zidovudine 300mg/Lamivudine 150mg Tablet	60			
Zidovudine 300mg/Lamivudine 150mg/Nevirapine 200mg Tab	60			