UNIVERSITY OF Global Health EQUITY

Capstone Practicum Report (40%)

Assessment of the health system cost of phase-one of the Breast Cancer Early Diagnosis (BCED) program in Burera district, Rwanda from April 2015 to April 2017

by

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Declaration

We, Lysa Carolle Niteka and Rashidah Nambaziira, hereby declare that the practicum capstone thesis has been written by us without any external unauthorized help, that it has been neither presented to any institution for evaluation nor previously published in its entirety or in parts. Any parts, words, or ideas, of the thesis, however limited, which are quoted from or based on other sources, have been acknowledged as such without exception.

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Dedication

I dedicate this research to the Almighty God, for His grace, protection, and blessings during this journey. To my amazing husband, wonderful family, and fantastic friends. With you by my side, life has been an easy ride.

This work is also dedicated to breast cancer patients, survivors who bravely fought against this giant. Their courage, strength, and resilience are applauded.

To my mentor, faculty, and classmates that I have been fortunate to meet throughout my education; I am glad to be on this global health journey with such great companions**.**

Lysa Carolle Niteka

I dedicate this capstone to my parents who support my endeavors with an open mind. To my sisters - my greatest cheerleaders. To our children who inspire me to advocate for equity at every chance I get. To my friends whose constant encouragement nurtures my endurance. And to my practicum partner, whose patience and solidarity made this capstone a graceful experience.

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Abstract

Background: Breast cancer is the most diagnosed cancer worldwide with approximately 2.3 million new cases recorded in 2020. Breast cancer survival rates are low in low- and middle-income countries (LMICs) because of late-stage diagnoses, and inadequate resources for diagnosis and treatment. In Rwanda, studies have shown that more 70% of breast cancer patients are diagnosed at late stage. With the aim of downstaging breast cancer in Rwanda, a breast cancer early detection program initiated in Burera District of Rwanda in 2015 showed an increase in early-stage diagnoses. However, the cost of implementing this program is unknown.

Objective: To determine the health system cost of the Breast Cancer Early Detection (BCED) program in Burera district from April 2015 to April 2017.

Methods: Cross-sectional study included patients' visits at seven health centers in Burera district and Butaro Cancer Center of Excellence (BCCOE) at Butaro district hospital from April 2015-April 2017. Direct observation and secondary data review were used during data collection. A costing analysis was done using Time Driven Activity Based Costing methodology to calculate the total cost of the BCED program. The allocated cost of each resource used in the BCED program was calculated and the total cost per patient visit was obtained from the sum of the cost of all resources utilized by patients undergoing the care cycle of the BCED program.

Results: From April 2015 to April 2017 a total of 1220 patients' visits in the BCED program were recorded. Out of 1220 visits, 1010 (83%) were health center visits while 210 (17%) were visits to BCCOE, the district's hospital. The median of the total allocated cost per patient visit for all resources used at the health center level was \$3.27, and \$58.93 at referral level. The highest cost drivers per patient visit were personnel with a median cost of \$1.60 (49%) across health centers, and consumables at \$27.29 (46.3%) at the hospital level. The lowest cost drivers at health center and BCCOE level were indirect costs at \$0.10 (3%) and drugs at \$0.83(1.4%) respectively.

Conclusion: The cost per patient visit in the BCED program at health centers was similar to previous cost analyses of other outpatient department services in rural health centers in Rwanda. However, variations in resource utilization such as using different cadres of personnel led to slight cost differences across health centers. At BCCOE level, some inefficiencies were due to shortage of providers available to process biopsy, requiring patients to have two hospital visits rather than one for diagnostic services. From our findings, a recommendation to decentralize some preliminary diagnostic services to district hospital was made.

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CHAPTER 1: INTRODUCTION

1.1 Background

Breast cancer is the most prevalent cancer globally with 2.3 million women diagnosed, and 685,000 deaths in 2020 (Sung et al., 2021). While breast cancer incidence rates are higher in high-income countries (HICs), the mortality-to-incidence ratios (MIR) are higher in low-and middle-income countries (LMICs) (DeSantis et al., 2015). The breast cancer MIR in sub-Saharan African countries (SSA) is as high as 0.55 compared to 0.16 in North America, with Rwanda having a MIR of 0.51 (Sung et al., 2021, DeSantis et al., 2015). High mortality rates and lost years due to disability lead to a high socio-economic burden on individuals and families especially in the already low-income settings of LMICs (Gouda et al., 2019, Daroudi et al., 2015). Late-stage diagnoses are a major contributor to high breast cancer mortality in LMICs, with over 50% of breast cancers diagnosed at advanced stage (Unger-Saldaña et al., 2014, Gakwaya et al., 2008, Lopes et al, 2015) . In Rwanda, women experienced a median of 15 months between the onset of breast symptoms and breast cancer diagnosis, and three-quarters are diagnosed with stage III or IV disease. (Pace et al., 2016).

Late-stage diagnosis of breast cancer decreases survival chances by up to 60% (Joko-Fru et al., 2020). Population-wide screening of asymptomatic women with mammography reduces breast cancer mortality (Weir, 2003, p. 1278., Sant el al, 2004) and early evidence suggests that clinical breast exam screening programs may also reduce breast cancer deaths. However, due to the high cost of population-wide screening programs, limited resources in LMICs, and delays experienced by patients who already have breast symptoms (Unger-Saldaña, 2014), programs seeking to target symptomatic patients and facilitate earlier breast cancer diagnosis ("early diagnosis programs") are recommended as a first step in low-resource settings (WHO, 2007., Yip et al., 2008). Even so, only a few early diagnosis programs have been implemented and described in literature to date. The BCED program in Rwanda is one of the early diagnosis programs that has been studied in SSA, combining community sensitization with training of health care workers on performing clinical breast exams and breast ultrasound in symptomatic women to facilitate timely referral for further diagnosis (Pace et al, 2019).

Even though the impact of the few early diagnosis programs in LMICs has been documented, not much literature exits on the cost of implementation. Costing of these existing programs is essential to assess their feasibility and determine cost-effectiveness in their context, and to inform effective scale-up in similar low-income settings. To our knowledge, no micro-costing analysis has been done for a breast cancer early detection program in SSA. This study aims to assess the health system cost of the BCED program in Burera district, Rwanda, using Time-Driven Activity-Based Costing (Kaplan et al, 2014). Results will inform scale-up of the program in Rwanda and add to the limited body of existing literature on the cost of implementing of breast cancer early detection programs. This will also inform planning and prioritization of breast cancer early detection programs in other low-resource settings.

1.2 Problem statement

The health-system cost of the BCED program in Burera district, Rwanda is not known.

1.3 Research question

What was the health system cost of the BCED program in Burera district from April 2015 to April 2017?

1.4 Objectives

Main objective

To determine the health system cost of the BCED program in Burera district from April 2015 to April 2017 by August 2021.

Specific objectives

1. Describe patient volume of the BCED program in Burera District from April 2015-April 2017, including the number of patients seeking health center services, patient referrals to BCCOE by August 2021.
2. Calculate the total cost of the phase one of BCED program from April 2015-April 2017 using time-driven activity-based costing method by August 2021.
3. Compare the total cost of the BCED program across the different health facilities involved in phase one of the program by August 2021.

1.5 Organization of the report

This practicum report is organized in six chapters

Chapter 1 (Introduction): describes the background of this study, highlights the problem statement and its magnitude, and provides justification for conducting the study. It also presents the general and specific objectives of the study.

Chapter 2 (Literature review) reviews available literature on the burden of breast cancer globally, in sub-Saharan Africa, and specifically in Rwanda. The chapter also describes breast cancer, its diagnosis and treatment, and existing early detection interventions. In addition, the chapter reviews the importance of health system costing and the different costing approaches, specifically the time-drive activity-based costing approach. Lastly, the chapter identifies gaps in the literature and explains the justification for this study.

Chapter 3 (Methodology) describes the study design, setting and study population, and data collection procedures. It also states the data collection tools, data management processes, costing analysis, and data analysis. Lastly, ethical considerations during the research process are detailed.

Chapter 4 (Results). Results of the study are presented in tables with a summary of each table showing descriptive statistics.

Chapter 5 (Discussion) discusses significant findings and how they compare with results of similar studies. Challenges and study limitations are also highlighted in this chapter.

Chapter 6 (Conclusion and recommendation) summaries the findings of the study in relation to the study objectives and highlights the implication of the results to the Rwandan health system. The chapter further summarizes recommendations to the health system of Rwanda and other LMICs, including future research relating to breast cancer early detection programs.

CHAPTER 2: LITERATURE REVIEW

1.1 Global burden of breast cancer

1.1.1 Global breast cancer incidence, prevalence, and mortality

Female breast cancer is the most diagnosed cancer in the world and the fifth leading cause of cancer deaths causing 685,000 deaths (Sung et al.,2020). In 2020, approximately 2.3 million new cases were recorded worldwide, surpassing lung cancer as the number one most diagnosed cancer. The incidence rate of breast cancer is higher in High Income Countries (HICs) at 55.9 cases per 100,000 than in Low-Middle-Income Countries (LMICs) at 29.7 new cases per 100,000 (Sung et al.,2020). However, the breast cancer mortality rate is higher in LMICs at 15 deaths per 100,000 than HICs at 12.8 deaths per 100,000 (Sung et al.,2020). This discrepancy can be explained by the wide availability and utilization of screening programs in HICs which results in high detection rates, while there are limited resources in LMICs needed to provide preventive and curative programs (Sung et al.,2020).

1.1.2 Social economic burden of breast cancer

Cancer is known to negatively impact the economy due to the disability and premature death it causes. In sub-Saharan Africa, cancer contributes to 11.2% of the total NCD burden with 16.9 million Disability Adjusted Life Years (DALYs) (Gouda et al., 2019). Breast cancer is a chronic disease that puts a burden on the patients, families, and the economy due to high productivity loss (Daroudi et al., 2015). For instance, significant losses in productivity in the USA were associated with breast cancer deaths among women in the labor-force. This productivity loss is assumed to be greater in sub-Saharan countries considering their fragile gross domestic product (Ekwueme et al., 2014).

The economic burden associated with breast cancer is mainly attributable to the high medical cost, which is usually significantly higher than the average patient's income (Azubuike et al., 2018). As a result, the depletion of individual and household resources for the treatment of breast cancer compounds poverty, especially in countries with fragile health systems without financial protection for patients.

In sub-Saharan Africa, the low survival rate of breast cancer affects families. A study showed that more than 48% of breast cancer deaths in sub- Saharan Africa occurred in women less than 50 years of age (Galukande et al., 2020). This has had an intergenerational effect by having twice the number of new orphans younger than 18 years of age for every 100 women who died of breast cancer below the age of 50. Consequently, children’s education and development have been affected by breast cancer deaths (Galukande et al., 2020).

1.2 Breast cancer

1.2.1 Description of Breast cancer

Breast cancer is a disease characterized by an abnormal cellular growth in the breast tissue, caused by a series of molecular alterations at the epithelial cell level. This results in malignant cells with immortal features and uncontrolled growth (Breast Cancer Histology, 2020). The etiopathophysiology of breast cancer is complex and poorly understood. Nevertheless, there are known risk factors that increase the likelihood of contracting the disease. These include lifestyle factors, reproductive and hormonal factors, and family history/genetic predisposition (Francies et al., 2020).

1.2.2 Treatment of breast cancer

Despite being a global burden, breast cancer is universally treatable. It requires a multidisciplinary approach consisting of surgical, radiation, and medical oncology. This approach has been shown to reduce breast cancer mortality by 18% (Kesson et al., 2012). Breast cancer treatment depends on disease stage at diagnosis. Breast cancer is classified in four stages based on the international Tumor, Node and Metastasis (TNM) staging system. The classification is made upon the extent of the disease by considering the size of the primary tumor (T), involvement of lymph nodes (N) and presence or absence of metastasis (M) (Giuliano et al., 2017). Furthermore, Breast cancer can be classified in two groups; nonmetastatic breast cancer for stage I, II and III, and metastatic breast cancer for stage IV as the disease has already spread to distant sites in the body (Waks & Winer, 2019). The stage at diagnosis is a strong predictor of survival. Studies have shown that patients diagnosed at an early-stage (stage I and II) had more than a 60% chance to survive compared to those diagnosed at a late-stage (stage III and IV) with less than 35 % chance (Joko-Fru et al., 2020). Therefore, early detection is essential to reducing breast cancer mortality.

1.2.3 Breast cancer early detection

The clinical stage at diagnosis is the most important predictor of survival in breast cancer (Burstein et al, 2011). The average five-year survival rates for breast cancer were 73% in HICs, 57% in LMICs, and can be as low as 37% in Sub-Saharan Africa (Parkin et al., 2005, p. 84). Poor survival rates in LMICs could be attributed to late-stage diagnosis, poor diagnostics and limited treatment resources (Hisham & Yip, 2003, p. 921). Less than 25% of breast cancers in HICs were diagnosed at late stage as reported for Canada at 20% and Denmark at 22%. On the other hand, over 50% of breast cancers in LMICs were late stage with Egypt at 50%, Nigeria at 78% and Black South Africans at 77% (Unger-Saldaña, 2014). Similar results were seen in other LMICs where the percentages of breast cancer patients presenting with late-stage disease in Uganda, Rwanda, and Angola were around 78% (Gakwaya et al, 2008.; Pace et a l, 2016., Lopes et al, 2015).

Early diagnosis of symptomatic disease is critical to the survival of breast cancer patients. Studies showed that patients with delays of more than three months had 12% lower five-year survival rates than those with shorter delays (Richards et al, 1999). Delays can be patient-related: due to lack of knowledge among patients and health seeking behavior, or provider-related: due to lack of skills and knowledge among health workers, and poor access to diagnostic services (Saldana et al, 2014). When the delay between discovery of symptoms and initiation of cancer treatment is over three months, it is called total delay (Saldana et al, 2014).

Early detection is also critical in reducing the cost of treatment. A systematic review showed that the treatment cost increases by 32% from stage I to II and can be over 109% more when at stage IV compared to stage I (Sun et al., 2018). Reducing delays in diagnosis and treatment is necessary to increase the survival rate as well as to reduce the costs of care (Kaplan, 2011). Total breast cancer delays can be reduced by screening of asymptomatic women and early diagnosis of symptomatic disease (WHO, 2017).

Screening is used to identify preclinical symptoms of breast cancer in asymptomatic patients (WHO, 2017). Screening is either organized population screening (initiated by the government or public sector) or opportunistic screening (initiated by individuals or their health providers) (Miles et al., 2004, p. 1203., WHO, 2017). While screening using mammography is the gold standard for breast cancer (Smith, 2003) and organized screening has been attributed to favorable survival rates in HICs (Weir, 2003, p. 1278., Sant el al, 2004), it is not feasible for LMICs because of several factors. According to WHO, 70% of the population at risk must be covered by the mammography screening for it to be effective (WHO, 2017), which is not feasible or affordable for most LMICs. Additionally, the Breast Health Global Initiative (BHGI) guidelines recommend that screening programs should not be implemented until adequate diagnostics and treatment are established, which is not the case in many LMICs (Anderson et al, 2006). Furthermore, several studies show that screening programs are not cost-effective in low resource settings, especially because of the low incidence of breast cancer in the rural settings (Barfar et al, 2014., Hatam et al., 2014, Sun & Yang, 2017). Therefore, for low-resource settings, Breast Health Global Initiative (BHGI) and WHO recommend first prioritizing early diagnosis (WHO, 2007., Yip et al., 2008).

Early diagnosis is the early identification of cancer in symptomatic patients with a goal of identifying the disease at the early stages and linking the patient to diagnosis and treatment (WHO, 2017). Essential steps of early diagnosis are: (a) public sensitization to ensure that patients are aware of early signs and symptoms of breast cancer, and they can seek care, (b) accurate clinical evaluation, diagnosis, and timely referral through training of first line health professional and (c) access to timely, quality, and affordable treatment through improvement of referral processes (WHO 2017). All these steps are necessary components of a screening program, so an early diagnosis approach can help lay a foundation for subsequent implementation of population-based screening.

A limited number of early diagnosis programs have been implemented in LMICs and described in the literature. For instance, an early diagnosis program in Kamuli, a rural district in Uganda diagnosed breast cancer in four out of 212 symptomatic women, two of whom had early-stage diagnosis (Matovu et al., 2016). Similarly, a cluster randomized trial of a Breast Cancer Early Diagnosis Program (BCED) in Rwanda evaluating symptomatic women led to 19 cancer diagnoses in the intervention group, of whom 47.6% had stage I or II disease. Among communities in the control group, 10 women were diagnosed with breast cancer, and 2 (20%) had stage I or II disease. The incidence of early-stage breast cancer was statistically significantly higher in intervention regions (Pace et al, 2019). To enhance feasibility in low resource settings, both of these early diagnosis programs trained and utilized already existing community health workers to sensitize the communities on breast cancer signs and symptoms, and trained health center level front line health providers to perform and interpret Clinical Breast Examinations (CBE). To ensure timely access to diagnosis and treatment, both programs established referral systems to hospitals for biopsies and initiation of treatment (Matovu et al., 2016., Pace et al, 2019).

Despite growing recommendations to facilitate early diagnosis of breast cancer and promising findings from existing studies, little research has been conducted to establish the implementation costs of these programs. Studies assessing the cost-effectiveness of various breast cancer control studies in LMICs have typically considered the cost of several interventions, including mammography screening, clinical breast exam screening, and/or mass media awareness raising alone (Zelle & Baltussen, 2013, Zelle et al., 2012). However, the cost of screening programs is likely to be more expensive than an early diagnosis program focused on symptomatic individuals. Further, it is not clear in any of the published studies whether the awareness raising campaigns also consider the requirement for training of health care workers and building system capacity for addressing the needs of patients subsequently seeking care with breast concerns, a necessary step in a health system where breast cancer has not been an area of focus. In addition, no empiric costing analysis has been done of an existing breast cancer early diagnosis project in a low-income country. Empiric assessments are important to decrease reliance on assumptions and ensure that the full range of costs and activities are considered. Without such information, it is not possible to assess the cost-effectiveness of these programs in LMICs (Zelle et al., 2012). Cost analyses can also help governments and organizations identify the resources needed to plan early diagnosis programs.

1.4 Health systems costs

1.4.1 Importance of costing

In health care delivery, the goal is to improve the value provided to patients by offering quality services at the lowest possible cost (Porter, 2010). To promote the value of health care delivery, it is important to understand the correct estimate of cost of care and to minimize assumptions during decision making, planning, and budgeting for healthcare (Abualhaija, 2020). However, health care systems in LMICs generally lack data on costs of resources required to provide health care such as cancer care (Neal et al., 2017).

In LMICs where resources for cancer care are scarce, it is essential to implement interventions that add value to healthcare services (Brown et al., 2006). A costing study that compared different breast cancer interventions in Ghana showed that clinical breast examination screening coupled with treatment at all stages was the most cost-effective intervention for breast cancer control (Zelle et al., 2012) Therefore, costing of healthcare interventions is important in cost-effective analysis.

1.4.2 Methods of health care costing

Different approaches can be utilized to estimate the cost of healthcare. Gross costing and micro-costing are two commonly used classifications of health care costing approaches, which differ on the level of disaggregation, identification, and measurement of resources. Gross-costing methods are top-down approach that estimates the mean cost of a healthcare intervention by dividing the total expenditure of the intervention by total number of patients served. Resources in gross costing are costed at an aggregated level (Špacírová et al., 2020, Kaplan et al., 2011). Micro-costing methods are bottom-up approaches that estimate cost of healthcare interventions at the patient level based on individual resources used (Kaplan et al., 2011). Time-driven activity-based costing (TDABC) is an example of micro-costing methods.

1.4.3 Time-driven Activity based costing (TDABC)

1.4.3.1. Description of TDABC

TDABC is a micro-costing method used in healthcare to calculate the costs of delivering a full cycle of care for a specific medical condition at patient level (Sharan et al., 2016). The costing process starts with developing a process map of all clinical and administrative steps involved in the full care cycle. McBain et al (2016) advise that the process map includes clear start and end points of the cycle, and details of all resources required at each step – personnel, space, equipment, and supplies. The cost of each resource is then calculated from the product of two estimates: (a) capacity cost rate: the cost of providing the resource per minute, and (b) probability-weighted time: the actual time per patient (in minutes) spent using the resource during the care cycle. The total cost of the care cycle per patient is then calculated by summing up the total costs of all the resources used in the care process, and the total indirect costs associated with providing the service. Indirect costs include costs that cannot be directly tied to an individual patient; these include utilities, operational costs, telecommunications, etc. (Sharan et al., 2016, McBain et al, 2016).

1.4.3.2 Application of TDABC

TDABC has been used by several settings including companies and health care institutions (Alves et al., 2018). The TDBAC methodology has several advantages over other costing methods that make it a valuable tool for costing and quality improvement in healthcare delivery. First, the costs obtained using TDABC are based on practical capacity – actual productivity of resources taking into consideration downtime for service interruptions, maintenance, days off, etc. Contrarily, traditional costing methods use theoretical capacity – productivity assuming full efficiency of resources with no downtime. Using practical capacity gives a more realistic representation of capacity, and therefore estimates more accurate cost of resources. For example, using TDABC, Lewis Goetz, a manufacturing company, discovered that one plant was operating at only 27% practical capacity, which drove reallocation of resources, allowing for expansion of their production without acquiring more resources (Kaplan & Anderson, 2004). Similarly, an ophthalmology department in Turkey used TDABC to discover over 66% of unused human resource capacity in their care process. This discovery led to integration of polyclinic services with angiography and laser services using the same human resource and space to save costs (Kurt et al., 2019). Similar applications of TDABC can be used in other health care settings, especially in low resource settings, to upscale or integrate health services such as cancer screening programs into existing health systems without substantial investment in additional resources.

Secondly, following a process map, the costs obtained by TDABC are assigned to specific resources, and to specific steps in the care cycle. This reveals inefficiencies in the health care process and identifies underutilized resource capabilities or redundant activities that could be driving up the cost of services. For instance, a TDABC study comparing similar antenatal services in two facilities in Haiti discovered that the use of specialized staff to perform clinical activities that could have been performed by lower cadre staff unnecessarily drove up the cost of personnel in one of the facilities. This led to discussions about task shifting to less costly staff and reallocation of the specialized staff to other departments where their specific skills were required (McBain., 2016). Therefore, TDABC can be a valuable tool to guide optimization of resources, which is vital to maximizing value in healthcare delivery, especially in low resource settings where demand for a variety of services is high, but funding for acquiring additional resources is limited.

TDABC is increasingly being used for costing in healthcare, but literature is still limited. Systematic reviews of studies done to estimate the costs of healthcare using TDABC methodology found that TDABC implementation is still low, with most publications after 2013; this is partly because the costing method was only recently developed in 2004 (Alves et al., 2018, Keel et al., 2017, Kurt et al., 2019). The reviews found that majority of TDABC studies in healthcare are conducted in the hospital setting, and mostly in the surgical field. The authors also found that most TDABC studies in healthcare aimed to inform reimbursement policies and support operational improvements to maximize profitability and increase value. In the field of oncology, only eight TDABC studies were found; six of which were on cancer treatment programs, and none on cancer screening and prevention programs. Only two of the oncology studies were on breast cancer, and none were from sub-Saharan Africa (Alves et al., 2018, Keel et al., 2017, Kurt et al., 2019). These findings suggest that while the application of TDABC methodology is increasing, there is still limited evidence of its application in breast cancer screening and early detection programs, especially in LMICs. From our knowledge, our study will be the first of its kind in Rwanda and in Sub-Saharan Africa.

1.5 Breast Cancer in Rwanda

1.5.1 Incidence, prevalence, and mortality of breast cancer in Rwanda

Rwanda is a landlocked country in East Africa that the World Bank classifies as a low-income country (*Countries | Data*, n.d.). Rwanda has a population of 12 million people with a life expectancy of 67 years, and more than 90 percent of the population is covered by national community health insurance. Rwanda's health system is led by the Ministry of Health (MOH) which regulates and controls all health-related interventions with the main objective of improving the health of the population. The health system has five different levels (community health, health posts, health centers, district hospitals and referral hospitals) where health services are provided by different providers such as public, faith-based, private-for-profit, and non-governmental organization (USAID, 2018; Farmer et al., 2013).

The country is undergoing an epidemiological transition, with the increasing burden of noncommunicable diseases accounting for 35 percent of the DALYs (Kalra, 2018). Committed to reducing mortality and morbidity associated with noncommunicable diseases, Rwanda has integrated the national strategic plan on noncommunicable diseases into its health system, with the main objectives of preventing and controlling noncommunicable diseases (Binagwaho, 2012). However, as the number of new cases of cancer was becoming alarming, a national cancer control plan was also launched by the Ministry of Health in 2018 (Rubagumya et al., 2020).

Breast cancer is the most frequently diagnosed malignant tumor in Rwanda, accounting for 14% of all new cancer cases in 2020 (Global Cancer Observatory, 2020). In Rwanda, most breast cancer patients are diagnosed at late stage with more than 46% of patients having stage III and 31% having stage IV at the time of diagnosis (Pace et al., 2016). This is a result of delays in diagnosis experienced by patients with breast cancer symptoms. Pace et al (2016) found a total median for both patient and system delays of 15 months. The authors found that lower levels of education and visits to the traditional healer first were associated with longer patient delays, and that more than five times patient visits to the health facility before diagnosis was associated with system delays (Pace et al., 2015).

1.5.2 Breast Cancer programs in Rwanda.

1.5.2.1 Butaro Cancer Center of Excellence (BCCOE).

Butaro Cancer Center of Excellence (BCCOE) is located at Butaro Hospital in the northern province of Rwanda in a rural district, Burera. The center was established in 2012 through a partnership between Partners in Health, Dana-Farber Cancer Institute and Rwanda's Ministry of Health. BCCOE is the first public facility in the country equipped with a dedicated clinic, ward, laboratory, and staff to provide the full spectrum of cancer care at a large-scale including diagnosis, chemotherapy, surgery, palliative care, etc. These services are provided at a subsidized fee with contribution from community-based health insurance and partners. BCCOE treats over 1700 patients a year, which is the highest volume of cancer patients in the country (Revolutionary Cancer Care in Rwanda, 2012). Breast cancer is the most common malignancy diagnosed and treated at BCCOE (Pace et al., 2015). Results from a study at BCCOE demonstrated that an increased likelihood of advanced stage diagnosis of breast cancer was attributed to long delays both before presentation at health facilities, and between first presentation and ultimate diagnosis of breast cancer (Pace et al., 2019). As a result of these results, an early detection program intervention, the Breast Cancer Early Detection Program (BCED) was developed and piloted in Burera district to address those delays.

1.5.2.2 Breast Cancer Early Detection Program (BCED)

Breast Cancer Early Detection (BCED) pilot program was developed and piloted in Burera, a rural district in the northern province of Rwanda to facilitate early diagnosis of breast cancer in symptomatic patients. The pilot program was started in 2015 with an aim to evaluate the clinical and health system impact of the program, to identify the most effective and feasible roles for health care personnel from each health care system level, and to inform national policy on the integration of the BCED program into the Rwandan Health care system (Dusengimana et al., 2018).

The pilot BCED program was implemented in two phases covering a total of 12 health centers (HC) in Burera district; phase one started in April 2015 covering seven randomly selected health centers, while phase two started in November 2015 covering five additional HCs. The program involved a one-day training of community health workers (CHWs) in breast cancer awareness, self-breast examination and patient education. Additionally, all nurses at the 12 HCs received a one-week training in clinical breast examination (CBE) and management of breast concerns. District hospital level health workers were also trained in CBE with additional training in diagnostic breast ultrasound evaluation of palpable masses. The BCED program was accessed through weekly breast clinics at HCs and Butaro hospital, and patients with a positive CBE or breast ultrasound were sent to BCCOE for further diagnosis and treatment. To support clinical decision-making, simple algorithms were developed, and on-going mentorship was instituted, with a trained nurse-midwife making visits to each intervention health center 2-4 times/ month to supervise breast clinics and support the trained clinicians.

Results from the pilot phase of the intervention showed improved knowledge and skills among healthcare personnel on breast cancer diagnosis and management, an increased number of symptomatic patients presenting at HCs, and an increased number of biopsies, benign disease, and early-stage diagnosis rates (Pace et al., 2019). These results showed a promising intervention in early breast cancer diagnosis in Rwanda. The Rwanda Ministry of Health and Rwanda Biomedical Centre have been expanding these efforts to other districts. (Pace et al., 2019). To inform continued scale-up, more research is needed to understand the impact of the intervention on other health services and the health system costs associated with implementing it. The aim of this study is to assess the health system costs of phase one of the BCED program in Burera district.

Furthermore, there is limited literature on costing of breast cancer control programs in LMICs (Zelle et al., 2013). A systematic review on economic analysis of breast cancer control in LMICs by Zelle et al (2013) found that only five out of 24 economic analysis studies were from Africa: Ghana, Nigeria, Morocco, Egypt and Cameroon. Costing studies from the five African countries were of poor availability and poor quality. This gap in literature about cost of breast cancer programs in LMICs is an obstacle to effective implementation of breast cancer programs (Zelle et al, 2013). This study will add to this limited existing costing literature in LMICs.

CHAPTER 3: METHODOLOGY

3.1 Setting

The study was conducted in seven health centers and Butaro Hospital in Burera district. Burera is a rural district located in the northern province of Rwanda with a population of 336,455. About 24% of women in Burera are illiterate, and 82.3% are employed, with over 87.3% in the agricultural sector; 97.3% of women in Burera are covered by the Rwanda Community-based Health Insurance, Mutuelle de santé (Republic of Rwanda, 2020, pp. 1–3). Burera has 19 health centers providing primary health care that serve communities with similar socioeconomic and ethnic background. Secondary health care in Burera is provided at Butaro district hospital which also houses the Butaro Cancer Center of Excellence (BCCOE). BCCOE is a cancer referral center that provides cancer diagnostic and treatment services for patients from all over Rwanda.

3.2 Study design and data collection procedures

3.2.1 Study design

The study design is a cross-sectional economic analysis from the health system perspective using direct observation and secondary data review. The BCED program was rolled out in two phases – to seven health centers in phase one (*Appendix 4*), and then to an additional five health centers in the phase two. For this analysis we examined costs and health service utilization associated with the phase one of rollout from April 2015 to April 2017.

3.2.2 Data collection procedures

Following the TDABC method, a process map was iteratively developed via direct observation and staff discussion to understand the BCED process and to identify resources such as personnel, location, equipment, drugs, and indirect costs needed for BCED program activities. The cost of each resource was then derived by multiplying the cost of providing the resource per minute - capacity cost rate (CCR) - by the time of involvement of the resource in the BCED activity (probability- weighted time). The total cost per patient visit was then obtained from the total cost of all resources utilized by the patient throughout the process map.

From Human Resource records (HR), data on personnel's salaries, fringe benefits and working hours were used to derive the cost of providing personnel per minute. From finance records, data on cost of purchasing equipment, consumables, drugs, and cost of construction was used to derive the cost of providing these resources per minute. From annual budget and expenditure reports, data on annual indirect cost was obtained. From patient registry and electronic database, the data on total number of patients seen at health facilities was obtained. From BCED program patient database, data on dosage and frequency of prescribed medications was derived. From observation and time recording, the duration of involvement of each resource was obtained.

In addition to the running cost of the BCED program obtained using the TDABC method, data on start-up costs was obtained from BCED program coordinator records, to calculate the total cost of the BCED program from initiation to execution.

The details and data sources for each resource used to calculate the total cost of each activity of the BCED process are summarized in table 1.

Table 1: Summary of cost data categories and data sources

Category	Details	Data source
Personnel	Personnel cadre, working hours, salary, fringe benefits Duration of involvement in BCED activity	Human resource (HR) records. Duration of involvement from direct observation and timing by data collectors.
Equipment Space Electricity	List of all equipment and furniture Unit price of equipment Duration of involvement in BCED activity Useful life years Total area of space (in sq meter) Cost of construction of one square meter space Duration of involvement in BCED activity Useful life years Total cost of electricity	List of equipment compiled through observation by data collectors. Prices from previous TDABC study[1] and finance records of Butaro Hospital and PIH Duration of involvement from direct observation and timing by data collectors. Useful life years from literature[2] Measurement of the space by data collectors. Construction costs from local engineer and Butaro hospital finance records. Duration of involvement from direct observation and timing by data collectors. Useful life years from literature[2] Annual costs from finance records.
Drugs (Medication)	Dosage and frequency of drug prescription Unit cost of medication	Drug frequency of prescription was extracted from patient database, dosages from BCED staff interviews. Unit cost was obtained from previous TDABC study[1] and local pharmacy.
Consumables	List of all consumables Unit price of consumables	List of consumables compiled through observation by data collectors. Unit cost of consumables from previous TDABC study[1] and finance records of Butaro Hospital and Partners in Health.
Machines	List of lab machines Price of lab machines	List of machines compiled through observation by data collectors. Price of laboratory machines from TDABC study[1]

[1] TDABC costing studies conducted in Rwanda (Ruhumuriza et al., 2018 & Odhiambo et al., 2019).

[2] American Hospital Association, 1998

	Price of Ultrasound machine Duration of involvement in BCED activity	Ultrasound price from purchase invoice (BCED program records) Duration of involvement from timing by data collectors, staff interviews
Indirect costs	Cleaning supplies, office supplies, maintenance, telecommunication, transport, utilities Total number of patients seen at health facilities	Annual budget and expenditure reports from finance records Total patient numbers from patient registry and electronic patient database
Start-up cost	• Training costs: include one-week training of 126 nurses, one-day training of 1005 community health workers, and one-day training of a group of BCCOE clinicians as trainers. • Allowances and salaries: salaries for full-time BCED program coordinator and breast health mentor, allowances for consultants running weekly BCED clinics. • Purchase of equipment: training models, computers, files and filing cabinets, registers etc). • Operations costs: airtime, transport for mentors, meetings logistics e.g meals, venue, etc).	BCED program coordinator records.

3.2.3 Data collection tools

a) A time-motion data collection tool *(Appendix 2)* was used to record the duration time of involvement in each activity of the BCED program.
b) A data collection tool *(Appendix 3)* with multiple entry points was used to collect data on four main areas: human resources, equipment, indirect cost, and location. The tool was adopted from a similar TDABC costing study conducted in Rwanda (Ruhumuriza et al., 2018).

3.2.4 Data collectors

The two primary researchers who are master's students from University of Global Health Equity collected all the data. They were trained on TDABC methodology by a Partners in Health staff who conducted previous studies using the same methodology.

3.3 Data management and analysis

3.3.1 Data management

Data from the two data collection tools and the BCED patient database were aggregated into a TDABC calculation excel sheet (Ms Excel version 2105), which was pre-designed with costing analysis formulas. The excel sheet was adapted from previous TDABC studies (Ruhumuriza et al., 2018, Odhiambo et al., 2019). All data was stored on password protected laptops.

3.3.2 Costing analysis

Costing analysis was then conducted using the TDABC calculation excel sheet to obtain the allocated cost of each resource as below:

a) Allocated cost of personnel.

$$personnel\ probability\ weighted\ time = observed\ time \times probability\ of\ involvement$$

Where observed time was the average of the recorded time that personnel spent with a patient. Probability of involvement was the probability that the personnel was involved in the activity.

$$personnel\ \ CCR\left(\$ / min\right) = \frac{annual\ salary + fringe\ benefits\left(\$\right)}{annual\ availability\ \ of\ personnel\left(mins\right)}$$

Where annual salaries and benefits are the gross salaries and benefits of personnel involved in the BCED program. Annual availability of personnel is the time in minutes that the personnel is available to partake in BCED program activities. In this study, breast cancer screening clinics operate one day a week throughout the year. Assuming a 9-hour working day, the availability time was calculated as 9 hours * 60 minutes * 52 weeks which was computed to 20800 minutes a year.

$$allocated\ cost\ of\ personnel = personnel\ CCR\ x\ personnel\ probability\ weighted\ time$$

b) Allocated cost of space

$$space\ probability\ weighted\ time = observed\ time \times probability\ of\ involvement$$

Where observed time was the average of the recorded time that the patient utilized the space. Probability of involvement was the probability that the patient utilized that space.

$$space\ CCR = \frac{cost\ of\ construction\left(\$\ / \ldots\right.}{Useful \ldots}$$

Where cost of construction was the cost of constructing one m^2 space using durable local materials. The total area of space was the actual measurement of the space used by the patient in each activity. The useful years were number of years the building was expected to be fully functional. In this study, we used 30 useful years for buildings (American Hospital Association, 1998). Annual availability of space is the time in minutes that the space is available for use for BCED program activities. In this study, breast cancer screening clinics operate one day a week throughout the year. Assuming a 9-hour working day, the availability time was calculated as 9 hours * 60 minutes * 52 weeks which was computed to 20800 minutes a year.

$$Allocated\ cost\ of\ space = space\ CCR \times space\ probability\ weighted\ time$$

c) Allocated cost of equipment (furniture and machine)

$$equipment\ probability\ weighted - time = observed\ time \times probability\ of\ involvement$$

Where observed time was the average of the recorded time that the patient utilized the equipment. Probability of involvement was the probability that the equipment was utilized for a BCED activity.

$$equipment\ CCR\left(\$ / min\right) = \frac{Cost\ of\ equipment\left(\$\right)}{Useful\ years\left(mins\right)} / annual\ availability\ of\ equipmemt\left(mins\right)$$

Where cost of equipment was the unit price of purchasing the equipment. The useful years were number of years the equipment was expected to be fully functional. In this study, we used 15 useful years for furniture, between three to five years for electronics (American Hospital Association, 1998). Annual availability of equipment is the time in minutes that the equipment is available for use for BCED program activities. In this study, breast cancer screening clinics operate one day a week throughout the year. Assuming a 9-hour working day, the availability time was calculated as 9 hours * 60 minutes * 52 weeks = 20800 minutes a year.

$$allocated\ cost\ of\ equipment = equipment\ CCR \times equipment\ probability\ weighted\ time$$

d) Cost of consumables (medical supplies and drugs)

$$Cost\ of\ consumables\ (\$ / patient) = cost\ of\ consumables\ (\$\ per\ unit) \times units\ used\ per\ patient$$

Where cost of consumables is the price of purchasing one unit of that consumable. The number of units used per patient was obtained from drug prescription and staff interviews. The probability of involvement is the probability of a particular consumable being utilized by patient. In this study, the probability of involvement was obtained from staff interviews and calculation based on previous patient records.

$$allocated\ cost\ of\ consumables = Cost\ of\ consumables \times probability\ of\ involvement$$

e) Indirect costs

$$Indirect\ costs\ (\$ / patient) = \frac{annual\ indirect\ costs}{total\ number\ ofoutpatients}$$

Where the annual indirect costs were the total indirect costs of a health facility. In this study, we used an average of two annual indirect costs as our study period spanned over two years: 2015-2016 and 2016-2017. Referencing previous TDABC studies in similar settings, we assumed outpatient service utilized only 10% of annual indirect cost (Ruhumuriza et al; 2018 & Odhiambo et al., 2019). The total number of outpatients were used in this study because the BCED program is an outpatient service.

3.3.3 Data analysis.

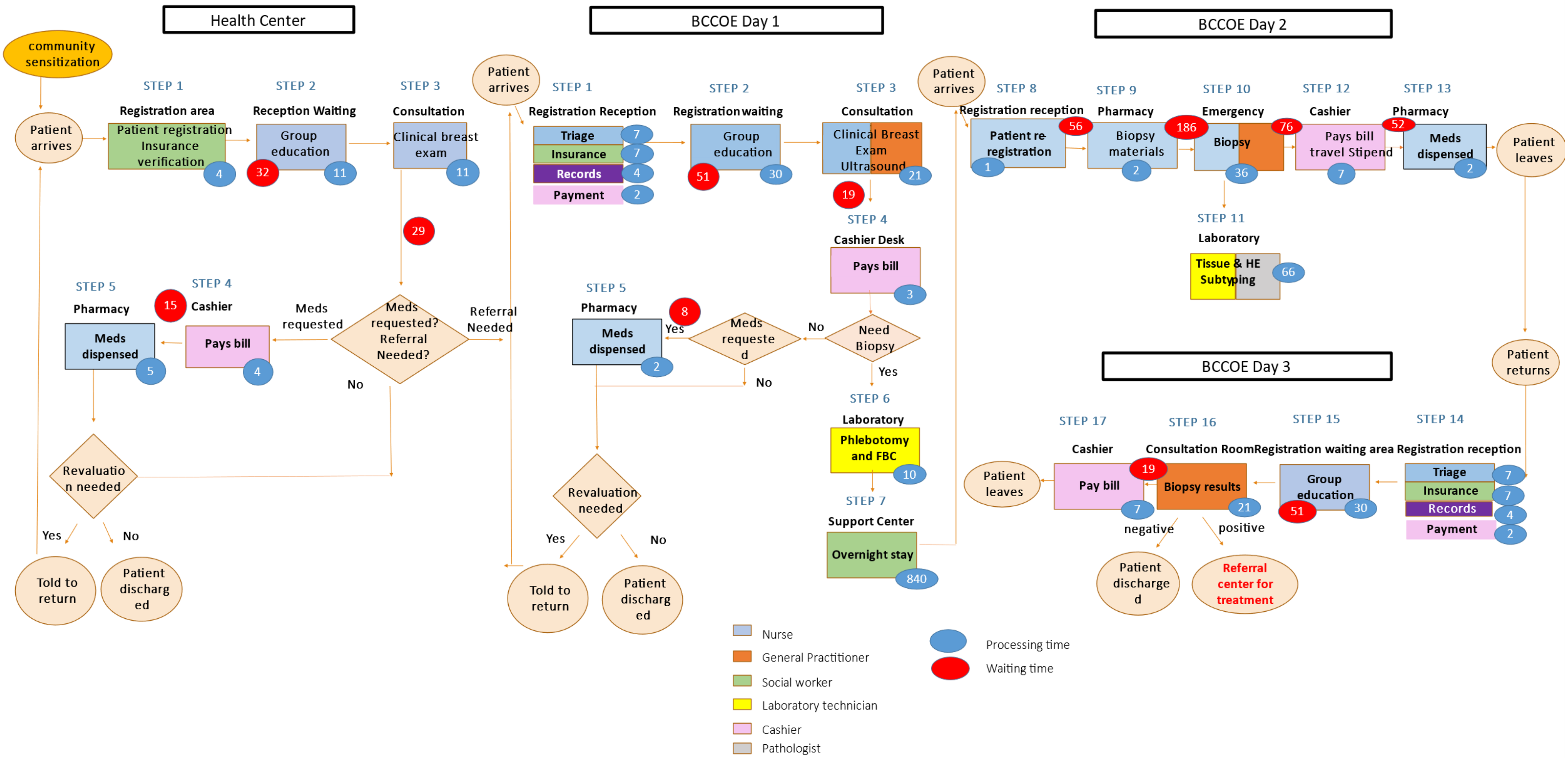
Descriptive statistics were used to summarize the volume of patients' visits, cost of resources at each health facility and the total cost of phase one of the BCED program between April 2015 and April 2017. For each health facility, the median cost of each resource utilized and its percentage contribution to the total cost of the BCED activities were summarized. At BCCOE level, the diagnostic tests done, cases of breast cancer diagnosed, and the cost of each activity were summarized.

3.4 Ethical approval

The study was approved by the Rwanda National Ethics Committee (IRB 00001497). We also received approval from health facilities leadership for data collection.

CHAPTER 4: RESULTS.

4.1 Figure 1 BCED process map



BCED process map

Figure 1 shows a process map for patients going through the BCED process at health center and BCCOE level. The process starts with sensitization by trained community health workers at the community level. Symptomatic patients visit a health center for clinical breast examination, and those who need further evaluation are referred to BCCOE.

In the process map, boxes show activities, arrows show direction of events, diamonds show decision point, and circles show start and endpoints of care cycle. Blue ovals show processing time, and red ovals show the waiting time between activities.

4.2 Summary of BCED program start-up cost

The BCED program start-up costs were summarized in table 2. They were grouped into four categories: training, allowances, purchases, and operation costs as described in Table 1. The total of start-up costs was $107,185.49 with the highest cost-driver being allowances at $46,705.11 (44%). Allowances included salaries for full time BCED program coordinator and breast health mentor, and top-up allowances for clinical consultants who were involved in the weekly BCED clinics at the BCCOE. The lowest cost driver was purchases at $8,196.68 (8%) which included procurement of training models, paper-based filling system and computers.

Table 2: BCED program start-up costs

Item	2015-2016	2016-2017	Total in RWF	Total in USD	(%)
Training	22,343,300	670,700	23,014,000	29,620.57	28%
Allowance	13,764,000	22,524,000	36,288,000	46,705.11	44%
Purchase	6,368,490	0	6,368,490	8,196.68	8%
Operation	9,093,200	8,515,150	17,608,350	22,663.14	21%
Total	**51,568,990**	**31,709,850**	**83,278,840**	**107,185.49**	

4.3 Summary of BCED program patient visits

The total number of patients' visits during the study period were summarized in table 3. Out of 1220 total patients' visits, 1010 (83%) were health centers visits, while 210 (17%) were referrals to BCCOE. Among health centers, Kirambo had the highest patient volume of 171 (14%) and Nyamugali the lowest of 108 (8%).

Table 3: Number of patient visits in the BCED program from April 2015 to April 2017

			N (%)
Sample			1220
BCCOE			210 (17%)
Health Center	Kinoni	129 (11%)	1010 (83%)
	Kirambo	171 (14%)	
	Kivuye	134 (11%)	
	Ntaruka	160 (13%)	
	Nyamugali	102 (8%)	
	Rugarama	152 (12%)	
	Rusasa	162 (13%)	

4.4 Cost of BCED program at health center and BCCOE

The allocated costs per visit of each resource in the BCED program at each health facility were summarized in table 4. In health center, the median of the total allocated costs per patient visit for all resources was $3.27 with an IQR of [2.12-3.37]. The highest cost driver was personnel with a median cost of $1.60 (49%) and IQR of [1.05-2.06]. This was followed by drugs with a median cost of $0.83 (25%) and IQR [0.71-0.93] and location with median cost at $0.39 (12%) and IQR of [0.27-0.54]. The lowest cost driver was indirect cost with median cost at $0.10 (3%) and IQR of [0.08-0.11].

In BCCOE, the total allocated cost per patient for all resources was $58.03. The main cost driver was consumables at $27.29 (46.3%), followed by personnel at $14.30 (24.3%) and the least cost driver was drugs at $0.83 (1.4%).

Table 4: allocated cost per patient of resources used in health facilities

	Cost in USD (%)						
Facility	personnel	location	drugs	indirect costs	consumables	machines	total ($)
Kirambo	1.22 (49%)	0.27 (11%)	0.93 (37%)	0.07 (3%)	0	0	2.49
Kivuye	2.06 (63%)	0.39 (12%)	0.72 (22%)	0.10 (3%)	0	0	3.27
Nyamugali	2.18 (65%)	0.39 (12%)	0.71 (21%)	0.10 (3%)	0	0	3.37
Rugarama	1.76 (53%)	0.54 (16%)	0.90 (27%)	0.10 (3%)	0	0	3.29
Rusasa	1.05 (54%)	0.27 (14%)	0.50 (26%)	0.11 (6%)	0	0	1.93
Kinoni	1.60 (42%)	0.64 (17%)	1.12 (30%)	0.42 (11%)	0	0	3.78
Ntaruka	0.98 (46%)	0.23 (11%)	0.83 (39%)	0.08 (4%)	0	0	2.12
Median (HCs) Inter-quartile range	1.60 (49%) [1.05-2.06]	0.39 (12%) [0.27-0.54]	0.83 (25%) [0.71-0.93]	0.10 (3%) [0.08-0.11]	0 -	0 -	3.27 [2.12-3.37]
BCCOE	14.30 (24.3%)	12.60 (21.4%)	0.83 (1.4%)	1.90 (3.2%)	27.29 (46.3%)	2.01 (3.4%)	58.93

The number of patients who received laboratory diagnostics and ultrasound services were summarized in table 5. Out of the 210 patients' visits, 80 (38%) got a breast ultrasound, 65 (31%) got breast biopsy diagnostics and 10 patients got a breast cancer diagnosis.

Table 5: breast cancer diagnostics at BCCOE; April 2015 to April 2017

	N (%)
Breast biopsy	65 (31%)
Breast ultrasound	80 (38%)
Breast cancer diagnosis	10 (5%)
Total	210

The cost of the BCED program services at BCCOE per patient visit were summarized in table 6. Pathology services were the highest cost driver at $37.11 (63.0%); this cost includes ultrasound guided core-needle biopsy sample collection, biopsy sample processing, and subtyping using Immunohistochemistry (IHC). The cost of other diagnostics was $ 4.49 (7.6%) for clinical breast exam (CBE) + ultrasound and $ 0.25 (0.4%) for full blood count tests (FBC).

Other routine services (patient registration, cashier, pharmacy) accounted for $11.95 (20.3%), while indirect costs (utilities, maintenance & repairs, communication, transport) were $1.90 (3.2%). The total cost of the BCED program at BCCOE also includes $3.16 (5.4%) for support center services (room, furniture, and support center personnel) for patients that needed overnight accommodation while waiting for biopsy.

Table 6: Cost of BCED program activities at BCCOE

		Cost in USD (%)
Total cost		58.93
Activities	Pathology (biopsy)	37.11 (63.0%)
	FBC	0.25 (0.4%)
	CBE + Ultrasound	4.49 (7.6%)
	support center	3.16 (5.4%)
	other services	11.95 (20.3%)
	indirect costs	1.90 (3.2%)

4.5 Total cost of phase-one of the BCED program

The total cost of the BCED program between April 2015 to April 2017 were summarized in table7. The total cost of BCED program was $122,863.49 including running costs (*Table 4)* and program start-up costs *(Table 2*).

Table 7: Total cost of BCED program from April 2015- April 2017

	Total allocated cost per patient visit	Total number of patients	Total cost (%)
Health center level	$3.27	1010	$3,302.7 (2.69%)
BCCOE level	$58.93	210	$12,375.3 (10.07%)
Start-up costs			$107,185.49 (87.24%)
Total			$122,863.49

CHAPTER 5: DISCUSSION.

5.1 Discussion

The aim of this study was to calculate the total cost of the BCED program from April 2015-April 2017 and compare the cost of resources among the seven phase-one health centers and BCCOE.

5.1.1 Total cost of BCED program

The total cost of the BCED program was $122,8632.49 with 87.24 % ($107,185.49) attached to the start-up costs (*Table 7*). Of the start-up costs, allowances were the highest cost-driver at $46,705.11 (44%). Over 50% of allowances went to full time program coordinator and clinical breast health mentor salaries and fringe benefits. These personnel were necessary for continuous stakeholder engagement, coordinated integration and quality assurance of BCED services.

The training cost was the second cost driver at $29,620.57 (28%) which included one-day training of 1005 community health workers (CHWs) for community sensitization, one-week training of 126 nurses on didactic, practical skills and breast cancer early diagnostic algorithms. A one-day training was also held for a group of BCCOE clinicians as trainers (Pace et al., 2018). Investment in these start-up trainings is necessary in the task-sharing model of the BCED program where health center nurses examine and manage initial breast concerns and make appropriate referrals for further management. Studies have shown that training and provision of algorithms for screening are important factors in determining the success of task-sharing intervention (Joshi et al., 2014). Our results also showed that the start-up costs decreased by over 40% in the second year. This is because purchases were one-time investments, majority of trainings and initial stakeholder engagement activities happened in the first year. Even though the start-up costs contributed 87.24% of the BCED program costs, they were important for implementing and ensuring continuous operation of the BCED program. The total investment of $122,863.49 resulted in diagnosis of 10 breast cancers among patients served by the phase one health centers in Burera district, between April 2015 to April 2017 (*Table 5*). There was a higher incidence of early-stage diagnoses in intervention versus control health centers suggesting a downstaging benefit of the intervention (Pace et al., 2019). Further studies assessing cost-effectiveness of the BCED program are recommended.

5.1.2 Cost of resources across seven health centers and BCCOE

The median cost per patient visit across the seven health centers was $3.27 with personnel as the main cost driver (*Table 4)***.** A study by Manzi et al (2018) costing an integrated childhood illness outpatient program at a rural health center in Rwanda found similar results; the cost per correctly diagnosed children was $2.95, with personnel as the main cost driver. The low cost of the BCED program at health center level can be attributed to integration of clinical breast exam (CBE) into already existing outpatient services; patients utilized the same resources and followed the same process map as other outpatients. Therefore, besides additional training costs for the personnel performing CBEs, there was no additional capital investment associated with CBE screening at health-center levels. The $3.27 cost per patient visit is therefore mostly an incremental cost on already existing outpatient services. Similar results were found by Bindoria et al (2014) who found that integrating HIV screening into ANC services at health centers in India resulted in substantially lower project costs since major resources like infrastructure and human resources were already covered within the existing ANC program. Additionally, with an integrated program there is a cost efficiency in terms of overhead costs as they are allotted across multiple services. For instance, Vodicka et al (2017) found that an integrated cervical cancer screening into existing HIV services had lower overhead costs of $1.94 per screening compared to a standalone program where the overhead cost was $9.07. Therefore, in a resource-limited setting, an integrated program allows better resource utilization of scarce personnel and facilities than a standalone or non-integrated program (Hyle et al., 2014). Further studies to assess the impact of BCED program integration into existing outpatient services and the cost effectiveness of the program would be valuable.

At the BCCOE level, the total allocated cost per patient visit was $58.93, which is much higher than the health center ($3.27) (*Table 4)*. At health center level, services were limited to clinical breast examination, while at BCCOE, additional services included ultrasound screening, laboratory investigation, and biopsies. This level of care requires higher cadres and number of personnel, more advanced equipment, more space, and consumables. The highest cost driver of resources used at BCCOE was consumables accounting for 46.3 % of the total cost. Most of the consumables' cost was attached to the pathology services which, in turn, became the main cost driver (63.0%) of BCED activities at BCCOE level *(Table 6)*. The high cost of consumables could be partly attributed to the fact that Rwanda heavily relies on imports for its pharmaceutical supplies (Uwizeyimana et al., 2021). Therefore, investment in local pharmaceutical production would reduce the cost of consumables.

The shortage of pathologists is a limiting factor to the access of pathology services. Although, the cost of pathologist was more than 50% of the total cost of personnel at BCCOE, the personnel cost was the second cost driver of resources. This result suggested the cost of a pathologist was not a limiting factor, but their shortage affected the frequency of diagnostic services and limited scheduling. Similarly, a study conducted in 2018 found the limiting factor to the access to laparotomy services was not the cost, but the shortage of surgeons (Ruhumuriza et al., 2018). Pathologist shortage at BCCOE was similar across the rest of Rwanda as most pathology services were being delivered by expatriates at the time, and the only other four public pathology laboratories were all located in Kigali (Rubagumya et al., 2020). Similar shortages in pathology services have been reported in other sub-Saharan countries as a challenge to cancer care (Adesina et al; 2013).

The shortage of pathologist and other oncology personnel led to limited scheduling at the oncology clinic which led to a lengthy process map of 3 visits at BCCOE. Patients' only option was the once-a-week consultation services on Mondays and biopsy services on Tuesdays. The lengthy process map increased costs to the health system in two ways. First, it created a need for support services (overnight housing, food, and transport allowances) for vulnerable patients who had to travel long distances back and forth to BCCOE. During the study period, these support services increased the cost per patient visit by at least $3.16 *(Table 6)*. Second, the cost of other support activities (registration, cashier, insurance verification), which accounted for 20.3% of the total cost per patient visit are compounded over the three-visits. Besides the above additional cost to the health system, multiple visits could have financial implications to the patients, and possibly impact utilization of the BCED services. Additionally, studies show that health system-factors such as travel burden due to long distances from diagnostic and treatment centers, and high numbers of referrals needed before definitive diagnosis may result into more advanced stage of tumor diagnosis (Espina et al; 2017, Ambroggi et al; 2015).

Comparatively, the cost of other preliminary diagnostics including CBE with ultrasound and FBC was only 8% of the total *(Table 6*). Therefore, to shorten the process map, we recommend that the CBE screening with ultrasound and FBC should be decentralized to the district hospital level. Referrals to BCCOE can be restricted to only patients who require pathology services and cancer treatment. Decentralization of these services to more accessible district hospitals would provide options for patients to access preliminary diagnostic services closer to their homes, which would also reduce their travel burden to BCCOE, and the need for additional support services from the health system. Similar recommendations for decentralization of preliminary diagnostics to secondary levels of care were made in a breast cancer management symposium in Rwanda (Murthy et al., 2015) and by World Health Organization (WHO, 2017).

This decentralization is possible because the ANC guidelines in Rwanda includes capacity for FBC tests and point-of-care ultrasound as part of ANC services at the gynecology and obstetrics outpatient department at district hospital level (Rwanda Biomedical Center, 2020). Therefore, similar to the set-up in health centers, integration of these BCED activities into district level ANC services would be possible at a lower cost using existing infrastructure. Additionally, studies in Rwanda (L. Pace et al; 2018 & Shah et al., 2009) and Uganda (Matovu et al et; 2016) have demonstrated successful implementation of various ultrasound services at primary and secondary level health facilities with in-service training of general practitioners and nurses. The trained staff acquired strong diagnostic skills leading to timely patient referrals for further cancer diagnostics and treatment. Similar models can be scaled up and harnessed for the integration of BCED program activities at district hospitals, which would bring diagnostic services closer to the communities and reduce the cost to the patient and the health system.

However, integrating the BCED program into existing outpatient services is not without drawbacks. During the study, we observed patients waited over one hour between BCED activities, especially at registration, pharmacy, and cashier departments (*Figure 1*). Similar findings of long waiting times at these departments were reported at Kigali University teaching hospital in Rwanda (Thaoussi, 2016), and Mulago hospital in Uganda (Musinguzi, 2013). From our observation, none of the health centers had waiting rooms, so patients waited in open spaces with occasional availability of benches. From a financial perspective, since they did not take up additional personnel, equipment, or infrastructural resources, the health system costs did not increase. However, these long waiting times could add cost to patients, and potentially impact utilization of the BCED program. Further studies on the impact of BCED program integration on existing antenatal services from patient's perspective as well as assessing its cost-effectiveness would be beneficial.

Using a TDABC approach provided useful insight that would not have been possible with other costing methods. With TDABC, we were able to obtain more accurate costs of BCED services by obtaining costs per resource at a patient level. This enabled us to identify the cause of cost variation between health centers providing the same screening services. We found that the Nyamugali health center had a higher personnel cost because all activities were conducted by the highest cadre of personnel, while the other health centers used mixed levels of personnel cadres. The variations in salary and fringe benefits between different personnel cadres caused a higher overall personnel cost in the health center, even though the same screening service was provided. A similar TDABC study in Haiti showed a significantly higher cost of initial antenatal care visits in the health facility that used high-paid specialists to provide basic routine care (McBain et al, 2016). Given that all personnel cadres went through the same CBE training; using the lowest cadre of personnel can help reduce the cost. Further studies to investigate the quality of services provided by different cadres are also recommended. Our results also found that a higher cost of drugs in Kinoni (*Table 4*) was explained by different prescription practices. While most health centers prescribed only cloxacillin and ibuprofen to most of their patients, Kinoni added paracetamol to over 10% of their patients' prescriptions. A TDABC study in Haiti also showed significant variation in multivitamins prescriptions between two health facilities which was attributed to stockouts (McBain et al., 2018).

Furthermore, using TDABC, we were able to identify opportunities to reduce cost by sharing space. Our results showed that, the cost of location was highest *(Table 4)* in Kinoni health center because each activity used a separate room. Comparatively, Ntaruka health center where shared spaces were used for related activities such as patient registration, insurance verification, and cashier payment was able to bring the cost of location to the lowest ($0.23).

TDABC approach requires the development of process map. Apart from enabling us to attach cost to specific activities, the process mapping helped identified the inefficiencies in the flow of services. Thus, allowing us to provide recommendations such as redesigning the work process through decentralization of preliminary diagnostics services (CBE+ ultrasound and FBC) to district hospitals. Previous study had shown such process reengineering could save operating cost. Results from a TDABC study in Boston Children's department of plastics and oral surgery, showed that process redesign of placing children with normal airway risk in a step-down monitoring unit instead of the ICU after a cleft palate surgery decreased the total 18-month cost of care by 8% without compromising patient outcomes (Kaplan et al, 2014). Despite the strengths of the TDABC approach, it was a time-intensive process. We recommend costing this intervention using other traditional costing methods to compare the results with our findings to assess the value of investing in TDABC.

5.2 Challenges

Our study has shown the utility of using a TDABC approach to cost a breast cancer early detection program in a rural low-resource setting. However, we experienced two main challenges during the study implementation. First, the retrospective nature of some of our data particularly those from finance departments was challenging to access in some facilities. Change in accountants and data systems from paper-based to electronic systems over the study period created gaps in the available data at the time of data collection. Second, our data collection required measuring the service time of patients at different service stations. This was a time-consuming process as there were long waiting times between services, in addition to only limited number of data collectors, and the spread out of service locations across the facility. To address these challenges, we recommend having a data collector at each service station and strengthening data management system in health facilities to minimize gaps in data.

5.3 Limitations

Our study had several limitations; first the costing method relied on assumptions to calculate the total cost of the BCED program (*Appendix 1).* However, these assumptions were minimized by verifying through interviews with personnel involved in the program and using local guidelines. In future work, sensitivity analyses will be conducted to examine how our findings change in response to altering these assumptions. Second, observation and timing of patients were done in June 2021 while the costing period was April 2015 to April 2017. Therefore, there is a possibility of slight process time variations between these two periods. However, observed times were validated through BCED staff interviews to minimize this variation. Third, our study was conducted on patients from Burera district which has a unique set-up in that the BCCOE referral center is housed at the district hospital. Therefore, the results of this study might not be generalizable to patients from other districts that would need to go to their affiliated district hospital before referral to the BCCOE. Lastly, the generalizability of our findings might be restricted to Rwanda because of the Rwandan referral system that is based on the community health insurance. The unit cost of resources such as salary, equipment was also based on the Rwandan's rates. Despite the challenges and limitations, this study successfully identified the BCED program cost for the first 2 years of operation, that provides the baseline information for the scale-up of the program to other districts in Rwanda and other similar settings.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This study aimed at estimating the total cost of phase one of the BCED program between April 2015-April 2017 and compare the cost of resources across the different health facilities. Our findings showed that the total cost of phase one of BCED program over 2 years was $ 122,863.49. The median cost per patient visit at health center was $3.27 and was driven by personnel. Using lower cadres of personnel could lead to lower personnel cost in health centers. The cost per patient visit at BCCOE was $58.93 with consumables as the highest cost driver among resources and pathology service as the highest cost driver among activities. Using TDABC methodology, we identified inefficiencies in the care process at BCCOE level due to multiple patient visits. Our findings can be used to inform scale-up of the BCED program to other regions/districts. The following recommendations can be considered to maximize the value of the BCED program.

6.2 Summary of recommendation

From our study findings, we have the several recommendations. First, at health center level we recommend the use of the lowest personnel cadre for BCED activity and use of shared spaces for related activities. Second, we recommend decentralization of low-cost services such as CBE with ultrasound and FBC test to district level, and referral to BCCOE level for only patients that need advanced pathology services and treatment. Lastly, further studies on the impact of integration of BCED activities into existing outpatient services at health center level, the cost of the BCED program from the patient's perspective, and cost-effectiveness analyses would provide more comprehensive information on the impact of the BCED program.

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Appendix 1: Summary of assumptions

General

- For the conversion rate of RWF to USD, the average conversion rate of the three years (2015, 2016, 2017) was used to get 1 USD:776.96 $
- Only resources consumed by more than 10% of patients were included in the costing analysis, based on what was done in similar TDABC studies [3]

Personnel

- Work time was assumed to be 9hrs/per day for five days a week for all personnel based on Rwanda National guidelines for Human resource, and information from the Human resource officer at Butaro Hospital
- Total days off were assumed to be 183 days off per year for all personnel; this includes weekends, vacation days, sick days, bereavement days and academic days). This was based on Rwanda National guidelines for Human resource, and information from the Human resource officer at Butaro Hospital
- Lunch breaks were assumed to be 60 minutes for all staff based on information from staff and Human Resource officer at Butaro hospital

Equipment

- For the conversion rate of 2011 RWF equipment prices to 2015 RWF prices, a conversion rate of 1.232 was used. [4]
- Availability time for all equipment was assumed to be only once a week (9/hrs a day) because the breast cancer clinic and the pathology services are available five days a week

Location

- Availability time for all spaces was assumed to be 9 hrs/1 day a week because the breast cancer clinic and pathology services are available five days a week

[3] Ruhumuriza et al., 2018 & Odhiambo et al., 2019, McBain et al., 2016
[4] https://www.worlddata.info/africa/rwanda/inflation-rates.php

- For health centers, electricity costs were added to indirect costs, not as part of location because information on total footage of the facility was not available
- For BCCOE, the laboratory spaces were assumed to consume 25% of total electricity costs based on what was done in similar TDABC studies at Butaro hospital[5]

Drugs

- Only medications prescribed for more than 10% of patients were included in the costing analysis, based on similar TDABC studies [1]

Indirect cost

- It was assumed that outpatients utilize 90% of indirect costs, while inpatients utilize only 10%; based on previous TDABC studies done in Rwanda[3]
- For health centers where data could not be found for indirect costs of the study period, costs from the most recent years were used

[5] Ruhumuriza et al., 2018 & Odhiambo et al., 2019.

Appendix 2: Time motion data collection tool

BCED TDABC costing

Time motion data collection tool

Date			Health facility	
Activity			Data collector	
Patient no.	Start time	End time	Waiting time?	Notes
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				

Time reported by personnel ……………………………………………………….

Appendix 3: Health facilities data collection tool

Name of Health center: **Date:**

1. Human resources				
Cadre of staff	Activity	Salary (Net)	Benefits/allowances Housing, meals, etc.	Other costs related to human resources

2. Health Service Delivery					
2.1 Vehicles	**Purchases of new: cars, ambulances, motorcycles, bicycles, etc.**			**Year**	**Cost**
2.2 Buildings	**New construction, renovation, etc.**				
Building 1	Total square meters surface areas (m^2)	Year of construction	Price at time of construction	Footage of room used for BCED	Renovation Year and Price
Building 2	Total square meters surface areas (m^2)	Year of construction	Price at time of construction /materials used	Footage of room used for BCED	Renovation Year and Price

2.3 Furniture	**Item**	**No**	**Room location**	**Year**	**Cost (RWF)**

2.4 Indirect costs	**Year**	**Cost**	**Notes**
Water			
Electricity			
Office supplies (printing, copying)			
Telecommunication (phone and internet)			
Cleaning supplies			
Transportation (cars and fuel)			
Fuel – generator			

3. Maintenance and operations (total value of recurring items)			
Item	**Description**	**Year**	**Cost**
3.1 Maintenance	Costs of maintaining vehicles, buildings, furniture, equipment, etc.		
3.2 Insurance	Insurance for vehicles, buildings, furniture, equipment, public, etc.		
3.3 Rental	Clinic/office space, meeting/training rooms, equipment rental, etc.		
3.4 Patient costs	Food, transport reimbursement, incentives (such as payments for taking medicine or returning for re-checks), cash transfers, etc.		

3.5 Other costs of maintenance & operations			

4. Health Information	**Item**	**Year**	**Cost**
4.1 Equipment	Computers, phones, servers, printers, scanners, satellite dishes, etc.		
4.2 Software	Acquisition, maintenance (excluding HR costs listed above), etc.		
4.3 Other costs related to health information			
COMMENTS:	*Please write down any comments about the data (for example, if certain sections did not have records, or any other factors that may have affected the quality of the data).*		

Appendix 4: List of seven phase one health centers

No	Name of HC
1	Kinoni
2	Kivuye
3	Kirambo
4	Ntaruka
5	Nyamugali
6	Rugarama
7	Rusasa