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The costs of diagnosing breast-related conditions at a large, public hospital in Johannesburg, South Africa

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Abstract

Background: Breast cancer is the most common cancer among women in South Africa. Offering comprehensive breast care services requires careful planning; yet, there is limited literature on the costs of providing services in low-resource settings. We aimed to estimate the average costs per procedure and patient for the diagnosis of breast conditions in South Africa, including the impact of shifting to lower-cost imaging options.

Methods: We used a retrospective clinical cohort study conducted at an outpatient clinic in Johannesburg in 2013-2014 to establish a hypothetical, 12-month population of clinic patients and diagnostic service statistics. We estimated costs via micro-costing from the provider perspective. An Excel-based model was used to explore the financial impact of shifts from mammography to ultrasound.

Results: An estimated 3,867 individuals attended the clinic over 12 months. The average cost per initial consultation/examination was (USD 2015) $10.14. Mammography cost $59.96 and ultrasound $21.11 per patient. Cyto-histological procedures were most costly (stereotactic core needle biopsy (CNB) - $330.05, ultrasound-guided CNB - $279.42, fine needle aspiration - $101.00). The average cost per patient was $115.96. Hypothetically shifting from mammography to ultrasound only marginally lowered average per patient costs due to the high cost of the mammogram machine.

Conclusion: Holistic, accessible services are important for continuity of care and reducing delay to treatment initiation. Some have suggested use of ultrasound for imaging in low-resource settings, but our research shows that facility-level cost savings occur only when mammography is completely eliminated, suggesting the need for cost-efficient placement and use of technologies.

Introduction

Breast cancer is one of the largest causes of cancer-related deaths in sub-Saharan Africa [1]. Structural barriers, such as limited access to services, contribute to poor outcomes [2]. Also, patients often present late, and certain treatments, such as surgery or mastectomy, may not be acceptable to all patient groups [2,3].

Breast cancer statistics in sub-Saharan Africa also mask the much larger burden of breast-related conditions. In developed countries, the ratio of breast cancer diagnoses to women routinely screened is roughly five per 100 [4], and 80 percent of masses are found to be due to benign conditions [5]. Similar outcomes are seen in developing country settings, such as Nigeria and Uganda, where routine screening may be less likely [6].

In South Africa, where there is no national-level, routine screening program, breast cancer is the most common cancer among women. The age-standardised breast cancer incidence rate among women is 31.43 per 100,000 [7]. More than half of all women diagnosed with breast cancer in the public sector present with late-stage (i.e. stage 3 or 4) disease [8], and over 3,800 women die from breast cancer annually, comprising 15% of all cancer deaths among women [1]. South Africa's breast cancer statistics are likely also a large underestimate of the burden of breast disease in the country. A recent, retrospective study at an outpatient clinic in Johannesburg showed that among 363 men and women who presented with a complaint, cancer was diagnosed in 52 (14.3%), and the remaining individuals (approximately 85%) presented with non-malignant problems [9]. The outpatient clinic in the study, which allowed clients to present without a referral, provided a comprehensive service, ranging from initial physical examinations to cancer surgery and reconstructive surgery. For diagnosis, the clinic offered the gold standard, i.e. 'triple assessment'. This comprised clinical examination, imaging (via mammography and/or ultrasound), and cyto-histological testing [10,11]. This kind of holistic, accessible service is important for continuity of care and reducing delay to treatment initiation, which contributes to poor outcomes for cancer patients [12,13], but unfortunately comprehensive, integrated breast care is uncommon in low-resource settings [14]. Replicating this kind of service in other resource-limited settings – both within and outside of South Africa – would require careful consideration of the costs of providing care and how to best ensure equitable access.

There is limited literature on the costs of comprehensive, breast condition diagnosis and management. Often the breast-related cost literature focuses on mammograms and the cost-effectiveness of various screening intervals for asymptomatic women in high resource settings. This literature is difficult to apply in low- and middle-income settings, where population-level screening programs are less common and where screening with mammography in particular may be prohibitively expensive or simply not available [15,16].

In this study, we investigated the costs of offering breast care diagnostic services at an outpatient clinic in a large, urban, public hospital in Johannesburg, South Africa. We also aimed to explore the financial impact of using lower-cost imaging options (i.e. ultrasound instead of mammography) to provide guidance for policy makers in low-resource settings where routine screening with mammography may be unaffordable.

Materials and Methods

Service statistics

We derived service-related data for this economic evaluation from a retrospective file review conducted from August 2013 to June 2014 at a large, urban, outpatient clinic operating within a public hospital in Johannesburg, South Africa. The file review documented breast-related complaints and diagnoses for a sample of people attending the clinic [9]. Ethics approval for the retrospective study and this cost evaluation was obtained from the Human Research Ethics Committee at the University of the Witwatersrand and the hospital where the outpatient clinic is located.

A detailed description of the retrospective file review has been published separately [9]. In summary, clinic patients were eligible for selection into the sample for the retrospective study if they: attended the clinic for a first visit between 1 April 2011 and 30 June 2012; were age 18 or older at the time of their visit; and had a file available for review at the clinic during sampling. Research staff used clinic registers to identify and select eligible participants for enrollment. Selection was done using a systematic, random sample (i.e. a randomly selected first participant and a set selection interval thereafter) until the desired sample of 400 participants was reached.

For each selected/enrolled patient, the trained study team members used a standardized questionnaire to transcribe information from the patients' files regarding procedures conducted at the initial clinic visit and a uniform follow up period of 12 months after the initial visit.

For this analysis, we extrapolated the proportions of patients who had the various diagnostic procedures in the retrospective study to a hypothetical 12-month clinic population. Generally the initial consultation (including physical examination) and other diagnostics were performed at the first visit, and then the patient had a "follow-up diagnostic visit," which was where a health care worker would assemble the results of all the diagnostic procedures, make a final diagnosis, and present the information to the patient. Unfortunately follow-up visits were not routinely recorded in the patients' files. Based on conversations with staff at the facility, who indicated that some patients do not return and some have more than one follow-up visit, we have conservatively assumed that all patients returned for one follow-up visit.

Costs

We estimated the costs of diagnosing breast-related conditions, including cancer, at the study facility from the health service perspective. Procedures included were the initial medical consultation, mammography, ultrasound of the breast, ultrasound-guided core needle biopsy, stereotactic core needle biopsy, fine needle aspiration, and the follow-up diagnostic visit. We did not include the costs of treatment activities, such as surgery, chemotherapy or radiation; training costs; or patients' costs.

From February to July 2015, we estimated costs per procedure or activity using micro-costing, determining all required resources and resource volumes and then multiplying by resource costs. We included personnel, consumables, laboratory tests, equipment and some overhead costs, as described in Table 1.

We collected resource usage (i.e. time, number of items, number of uses, etc.) for the inputs in Table 1 through a combination of time and motion observations and discussions with staff at the facility and South Africa's National Health Laboratory Service (NHLS). Time and motion observations were conducted, where possible, for 20 to 40 patient interactions per diagnostic procedure type. Wherever possible, we determined the unit costs for consumables, laboratory tests and equipment using clinic records and publicly available sources [17,18]. Staff costs were calculated using public sector salary scales [19]. We followed generally recommended methods [20] to annualize capital costs (i.e. furniture and equipment) using a discount rate of 3% and depreciation periods recommended by the South Africa Revenue Service [21]. For the mammogram and ultrasound machines we used depreciation periods as provided in the purchase quotations (i.e. eight and six years respectively) in the base case scenario. All costs were collected in South African Rand (R) and inflated to 2015 prices (where necessary) using the IMF's World Economic Outlook database [22]. We present the costs in 2015 US dollars (USD) using an average exchange rate for 2015 of 12.77 Rands per dollar [23].

In some instances, different staff types (e.g. nurses, doctors, specialists) shared certain workloads. Where different levels of staff could perform a task, we chose the lowest cadre of staff (at a mid-career salary level) in our base case scenario.

Table 1. Cost inputs for breast diagnostic procedures performed at a large, outpatient clinic in Johannesburg, South Africa

Cost type	Inputs per procedure
Direct costs*	
Personnel	
Initial examination and follow-up	Staff nurse, medical officer**
Mammogram and ultrasound	Medical specialist, radiographer
Biopsies and FNA	Medical specialist, radiographer
Consumables	
All procedures	Medical consumables (gloves, hand sanitiser, paper toweling, needles, gauze, etc.), office supplies, etc.
Lab tests	
Biopsies and FNA	Sampling materials and cyto-histology charges from NHLS
Equipment	
Initial examination and follow-up	Consultation furniture
Ultrasound, FNA, Biopsy-UG	Ultrasound machine, biopsy instrument, furniture
Mammogram	Mammogram machine, biopsy instrument, furniture
Biopsy-S	Mammography machine, stereotactic biopsy add-on, furniture
Indirect costs***	
Shared personnel	
All procedures	Receptionist, security guard, quality control meeting time
Shared equipment	
All procedures	Shared computers, waiting room furniture
Infrastructure/overhead	
All procedures	Rent and utilities for dedicated and shared spaces (waiting rooms, reception, etc.)

Initial examination = Initial consultation with physical examination, Follow up = Follow-up diagnostic visit; FNA = Fine needle aspiration; Biopsy – UG = Ultrasound-guided core needle biopsy; Biopsy – S = Stereotactic core needle biopsy, NHLS = National Health Laboratory Service

* These are incremental costs – i.e. required per service, and they include both fixed and variable costs.

**The model included costs for a mid-career medical officer/doctor. If more junior doctors are employed, a specialist may also be required for support.

***These include overhead (rent, utilities, etc.) plus shared furniture and staffing not often defined as "overhead." Also, these costs are fixed costs only; the total cost of these items does not change with service volume.

Analysis

We captured the cost data and conducted the analysis using a model built for this study in Excel (Microsoft Corporation, 2010). The model consisted of several interlinked spreadsheets, utilising basic formulas and VBA (Visual Basic for Applications) programming language to produce the desired outcomes. A snapshot of the model contents are provide in Supplemental file: Workbook snapshot.

The analysis was conducted in two phases. First, we estimated the total cost for diagnostics and the average cost per patient seen in the retrospective study population and a hypothetical 12-month population at the clinic. We based the calculation of fixed costs (equipment, shared personnel, infrastructure/overhead) on the total expected volume of patients. Thus, for costs representing the retrospective study population, we spread the fixed costs across the study population only. For the hypothetical 12-month population, fixed costs are spread across the full patient volume for the 12 months.

We conducted univariate and multivariate sensitivity analysis to explore the impact of variation in our cost inputs on the total and average costs at the facility. Univariate sensitivity analysis involves adjusting each input parameter of interest consecutively; whereas multivariate sensitivity analysis involves adjusting more than two parameters simultaneously. The parameters varied in the analysis included: the time required for staff and the total costs for consumables and equipment per diagnostic procedure. We allowed for ±25% variation in all of these parameters. In addition, we varied depreciation periods for the mammography and ultrasound machines by ± 25%, and explored the impact of a 5% discount rate.

To illustrate the impact on costs of varying mammographic service volume, we decreased the proportion of patients at the clinic who have mammography and stereotactic biopsy (which requires a mammography machine) in increments of 25%. As usage decreased, we reduced the variable costs, but fixed costs remained static and were spread across the smaller number of patients receiving mammography. Because triple assessment diagnosis requires an imaging service, however; we did not eliminate imaging altogether. In our model, as we reduced use of mammography we shifted patients to ultrasound services. In the retrospective file review study, some women had both mammography and ultrasound [9]. For those women, we eliminated the mammogram cost rather than converting it to an additional ultrasound cost. When mammography services were eliminated, we removed all the mammography equipment and infrastructure costs completely. We present the cost per patient and per mammography and ultrasound for this hypothetical example where dependency is shifted to ultrasound for imaging.

We consulted the CHEERS checklist during the drafting of this manuscript.

Results

As documented in the retrospective study [9], 4,834 patients (606 (12.5%) male, 4,142 (85.7%) female, 86 (1.8%) gender unknown) visited the clinic during the 15-month sampling period (i.e. April 2011 to June 2012) (data not shown). Based on these figures, we estimated that 3,867 patients would attend the clinic in a hypothetical 12-month period (Table 2).

Table 2 presents information regarding the total numbers and proportions of patients who required the various diagnostic procedures at the clinic. In total, 363 files (9 (2.5%) male; 354 (97.5%) female) were selected for inclusion in the retrospective study [9]. All patients had the initial consultation with an examination, and roughly half (52%) had an ultrasound procedure. Mammography was performed for 41% of the patients seen. Cyto-histological procedures were less common.

Table 2. Services obtained in South African breast care clinic by study population* and hypothetical full clinic patient population

Procedure	Services obtained by study sample, 15-month period (n=363)	Services obtained by hypothetical, full clinic population, 12-month period (n=3,867)	Average number of services rendered per month, full clinic population (n=3,867)
Initial consultation**	363 (100%)	3,867 (100%)	322
Mammography	149 (41%)	1,585 (41%)	132
Ultrasound	189 (52%)	2,011 (52%)	168
Biopsy – UG	58 (16%)	619 (16%)	52
Biopsy – S	15 (4%)	155 (4%)	13
FNA	4 (1%)	39 (1%)	3
Fo.up diagnostic visit	363 (100%)	3,867 (100%)	322

F.up = Follow up; FNA = Fine needle aspiration; Biopsy – UG = Ultrasound-guided core needle biopsy; Biopsy – S = Stereotactic core needle biopsy

* Includes all procedures conducted for diagnostic purposes at initial visit to clinic and within the subsequent 12 months in the retrospective study [9].

** The initiation consultation included a clinical breast examination.

The average costs per procedure, considering a hypothetical 12-month period of service delivery at the facility, are provided in Table 3. The initial consultation with clinical breast examination and the follow-up visit were the least costly diagnostics. Personnel costs were the largest component of these costs. Considering the imaging procedures, which were considerably more costly because of expensive equipment, mammography was more costly than ultrasound. The histological procedures were the most costly diagnostic procedures because of personnel costs and laboratory charges.

Table 3. Average costs per procedure considering a 12-month time period and patient population (n=3,867) (base case (range*)) (USD 2015)

	Initial consultation**	Mammography	Ultrasound	Biopsy – UG	Biopsy – S	Fine needle aspiration	Follow-up diagnostic visit
Direct costs							
Personnel	5.97 (4.73-7.20)	18.14 (13.61-22.68)	12.93 (10.54-15.33)	38.59 (29.06-48.12)	55.54 (41.78-69.31)	20.74 (18.32-23.75)	7.13 (5.38-8.89)
Consumables	0.14 (0.10-0.17)	0.11 (0.09-0.14)	0.19 (0.15-0.24)	22.79 (17.10-28.49)	22.75 (17.06-28.44)	1.41 (1.06-1.77)	0.11 (0.09-0.14)
Labs	N/A	N/A	N/A	213.67 (160.25-267.09)	213.67 (160.25-267.09)	70.87 (53.15-88.58)	N/A
Equipment	0.26 (0.20-0.35)	36.22 (22.43-61.94)	2.54 (1.64-4.09)	2.54 (1.64-4.09)	36.22 (22.43-61.94)	2.54 (1.64-4.09)	0.26 (0.20-0.35)
Total direct costs	**6.37 (5.03-7.72)**	**54.48 (36.12-84.76)**	**15.67 (12.32-19.66)**	**277.59 (208.05-347.79)**	**328.18 (241.52-426.77)**	**95.56 (73.58-118.18)**	**7.51 (5.66-9.39)**
Indirect costs	3.77 (3.72-3.82)	5.49 (5.46-5.52)	5.44 (5.42-5.46)	1.83 (1.82-1.84)	1.87 (1.85-1.90)	5.44 (5.42-5.46)	3.77 (3.72-3.82)
Total costs	**10.14 (8.76-11.54)**	**59.96 (41.58-90.27)**	**21.11 (17.75-25.12)**	**279.42 (209.87-349.63)**	**330.05 (243.37-428.66)**	**101.00 (79.00-123.65)**	**11.29 (9.38-13.21)**

Biopsy – UG = Ultrasound-guided core needle biopsy; Biopsy – S = Stereotactic core needle biopsy; N/A = Not applicable
* From sensitivity analysis
** The initiation consultation included a clinical breast examination.

Table 4 provides the total cost for diagnosing breast conditions in the study clinic – for the study population and for all patients in a hypothetical 12-month period. The total costs of diagnosing breast conditions in the study population was $379,874 and the average cost per study patient seen was $1,046. Considering the hypothetical 12-month clinic population, the total cost of diagnosing patients was $448,423, and the average cost per patient seen was $116. The proportion of total costs spent on mammograms and stereotactic biopsies for the 12-month population was 34.3% (22.6% mammogram costs and 11.7% stereotactic biopsy costs).

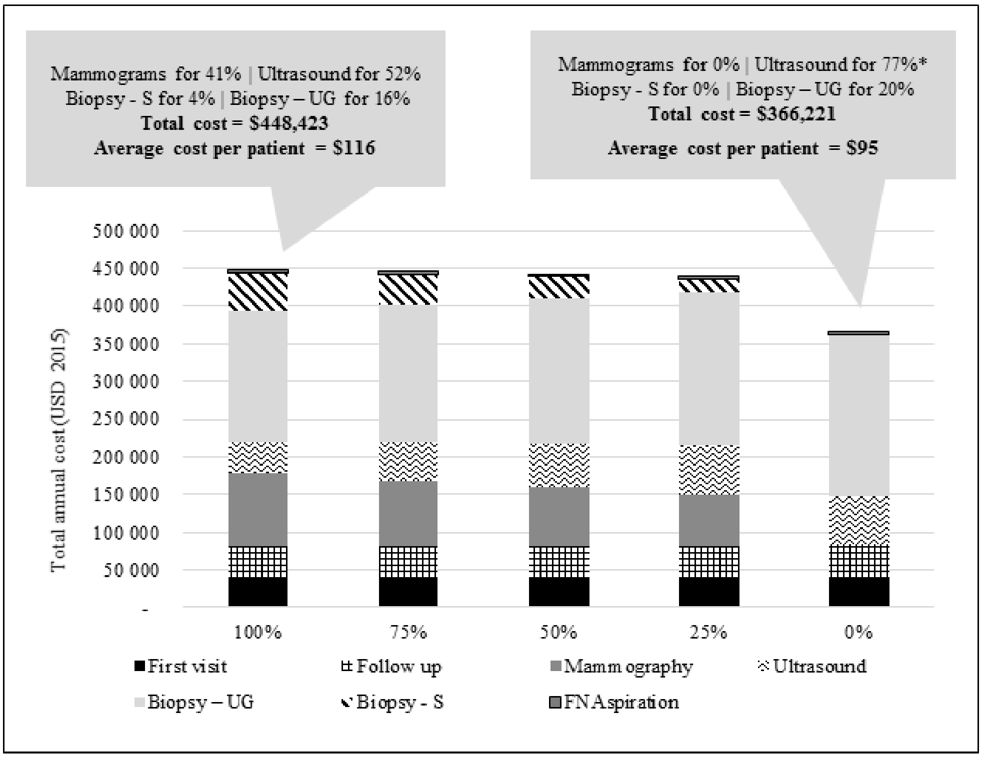
Table 4. Total and average per patient costs for breast-related diagnosis in outpatient clinic in Johannesburg, South Africa (study population* and hypothetical full-clinic population) (USD 2014)

	Cost (Range) or %**
Study population (n=363)	
Total cost	379,874.57 (285,368.44-497,018.98)
Average total cost per patient	1,046.49 (786.14-1,369.20)
Hypothetical 12-month population (n=3,867)	
Total cost	448,423.46 (342,471.74-577,013.46)
Average total cost per patient	115.96 (88.56-149.21)
Proportion of total costs spent on mammogram & stereotactic biopsy services	34.3%

*Retrospective study population [8]
** The range represents the plausible ranges based on sensitivity analysis.

Figure 1 illustrates the change in total costs, the cost per mammogram and ultrasound, and the cost per patient seen at the clinic as usage of mammography-based services is shifted to ultrasound-based services. The furthest left column represents mammography machine usage as documented in the retrospective study. As mammography is reduced, ultrasound usage is increased. In the rightmost column, mammography is no longer used at the clinic. Due to the high, fixed cost of the mammogram machine, total costs remain roughly the same until mammography services are eliminated completely. The cost per mammogram done, however, increases almost three-fold to $168.48 per patient as the service volume decreases to 25% of the current volume.

Figure 1. Reductions in total cost for hypothetical 12-month population at the breast clinic as dependency on mammograms and stereotactic biopsies are incrementally phased out (USD 2014)



F.up = Follow up; FNA = Fine needle aspiration; Biopsy – UG = Ultrasound-guided core needle biopsy; Biopsy – S = Stereotactic core needle biopsy
NB: The initiation consultation included an examination.
*This is the proportion of women who received any imaging (ultrasound or mammography) in the retrospective study [8].

Discussion

In this analysis, which is one of few to report on the costs of breast diagnostic services in a low-resource setting, cyto-histological assessments were the most expensive components of triple assessment for diagnosis of breast disease, including cancer. Personnel costs were strong drivers of the costs for consultations. Equipment costs comprised the majority of the imaging costs, and personnel costs *and* laboratory charges were drivers of the cyto-histological costs. For all procedures, service volume was critical in determining the average cost per patient. The costs of equipment and infrastructure decreased (per patient) as patient volume increased due to the large contribution of fixed costs to the total costs in the clinic. For example, for mammography specifically, equipment and infrastructural costs were 73.4% of the total procedural cost.

In this setting, the base case cost estimates for mammography services were higher than the estimated costs of ultrasound – when used for imaging and guiding biopsies. However, our sensitivity analysis produced overlapping cost ranges for the two services, meaning that their costs could be equivocal under certain conditions. Using the base case cost estimates for both procedures and assuming a theoretical environment where mammography use was shifted to ultrasound, we estimated that any cost savings from such a shift would be minimal until use of the mammography machine is stopped altogether.

Because of its use for multiple applications, ultrasound may be more accessible than mammography in low-resource settings [28], and, in fact, arguments have been made for use of ultrasound exclusively in such locations. Sensitivity of ultrasound for diagnosis of breast cancer has been estimated at 98.4% [24] and, because the technology is dependent on the technician conducting the assessment, both sensitivity and specificity may improve with practice [25]. For women with dense breasts ultrasound may be more sensitive than mammography [25,26], and for late stage disease diagnosed in settings with limited access to radiation and breast conserving surgery, access to mammography does not change management or improve patient outcomes [26,27].

Despite these clinical and logistical arguments for use of ultrasound, however, mammography does remain an important diagnostic and screening tool. Ultrasound has been shown to be a poor tool for diagnosis of calcification in the breast, which is indicative of pre-invasive cancer [29]. Also, stereotactic core needle biopsies, which require a mammography machine, generally cannot be replaced by ultrasound-guided core needle biopsies due to the presence of micro-calcifications undetectable with ultrasound imaging. Our simple illustration of the impact of low service volumes on average cost per mammogram suggests that policymakers in South Africa and other resource-limited settings, should plan for an equitable geographic distribution of both mammography and ultrasound machines (and the radiologists and/or technicians required to operate them) and strong referral pathways that allow for maximum utilization of the technologies.

There are limitations to this research. The clinical study from which the service statistics are drawn was retrospective, and there were challenges with data quality when assessing the services provided. The clinical and cost data are derived from one facility only; however, very few facilities offering comprehensive breast care diagnostic services exist in the country. Further, performing micro-costing in a complex environment was challenging. To address this, we used sensitivity analysis to assess variations in our assumptions. Finally, we assumed that the ultrasound machine was used for breast care only. In other settings, it may be used for many purposes, most particularly antenatal care, thus reducing the cost per use.

Despite limitations, this analysis provides a much needed contribution to the literature regarding the costs of a comprehensive approach for the diagnosis of breast conditions. To our knowledge, the data presented here are the first cost estimates for breast-related diagnosis in Sub-Saharan Africa. The analysis also provides guidance to service providers regarding the components of each diagnostic procedure that are most likely to affect the total cost.

Breast cancer is a major public health concern in South Africa and in many similar low- and middle-income countries globally. Making diagnostic services more accessible is critical for improved health outcomes. Services are already free or provided at low cost to men and women in the public sector in South Africa, but offering comprehensive diagnostic services is also important for ensuring that patients receive treatment if required in a timely fashion. Careful consideration of the financial implications of increasing access to all services in all settings is required, as some services such as mammography are extremely costly per person if utilization is low. Careful planning for maximum utilization of expensive machinery and considering lower cost alternatives for some locations could contribute to increased access to services for women in low-resource settings.

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Declarations of interest

None

References

[1] International Agency for Research on Cancer, GLOBOCAN 2012: Estimated Cancer Incidence, Mortality and Prevalence Worldwide in 2012, (2012). http://globocan.iarc.fr/Pages/fact_sheets_population.aspx (accessed May 19, 2016).

[2] T.P. Kingham, O.I. Alatise, V. Vanderpuye, C. Casper, F.A. Abantanga, T.B. Kamara, O.I. Olopade, M. Habeebu, F.B. Abdulkareem, L. Denny, Treatment of cancer in sub-Saharan Africa, Lancet Oncol. 14 (2013) e158–e167. doi:10.1016/S1470-2045(12)70472-2.

[3] S. Rayne, K. Schnippel, C. Firnhaber, K. Wright, D. Kruger, C.-A. Benn, Fear of Treatments Surpasses Demographic and Socioeconomic Factors in Affecting Patients With Breast Cancer in Urban South Africa, JGO. Online 22 (2016). doi:10.1200/JGO.2015.002691.

[4] S. Potter, S. Govindarajulu, M. Shere, F. Braddon, G. Curran, R. Greenwood, A.K. Sahu, S.J. Cawthorn, Referral patterns, cancer diagnoses, and waiting times after introduction of two week wait rule for breast cancer: prospective cohort study., BMJ. 335 (2007) 288. doi:10.1136/bmj.39258.688553.55.

[5] A. Ruston, Risk, anxiety and defensive action: general practitioner's referral decisions for women presenting with breast problems, Health. Risk Soc. 6 (2004) 25–38.

doi:10.1080/1369857042000193066.

[6] C. Okoth, M. Galukande, J. Jombwe, D. Wamala, Benign proliferative breast diseases among female patients at a sub-Saharan Africa tertiary hospital: a cross sectional study., BMC Surg. 13 (2013) 9. doi:10.1186/1471-2482-13-9.

[7] National Health Laboratory Service, National Cancer Registry: Summary statistics 2011, Johannesburg, 2011.

[8] C. Dickens, M. Joffe, J. Jacobson, F. Venter, J. Schüz, H. Cubasch, V. Mccormack, Stage at breast cancer diagnosis and distance from diagnostic hospital in a periurban setting: A South African public hospital case series of over 1,000 women, Int J Cancer. 135 (2014) 2173–2182. doi:10.1002/ijc.28861.

[9] S. Rayne, N. Lince-Deroche, C. Hendrickson, K. Shearer, F. Moyo, P. Michelow, G. Rubin, C. Benn, C. Firnhaber, Characterizing breast conditions at an open-access breast clinic in South Africa: a model that is more than cancer care for a resource-limited setting, BMC Health Serv. Res. 17 (2017) 63. doi:10.1186/s12913-016-1959-4.

[10] M. Nigam, B. Nigam, Triple Assessment of Breast – Gold Standard in Mass Screening for Breast Cancer Diagnosis, Iosr-Jdms. 7 (2013) 1–7. doi:10.9790/0853-0730107.

[11] R. Wilson, D. Asbury, J. Cooke, M. Michell, J. Patnick, Clinical Guidelines for Breast Cancer Screening Assessment, 2010. www.gov.uk/government/uploads/system/uploads/attachment_data/file/465528/nhsbsp49_June2010.pdf.

[12] E. Otieno, J. Micheni, S. Kimende, K. Mutai, Provider delay in the diagnosis and initiation of definitive treatment for breast cancer patients, East Afr. Med. J. 87 (2010) 143–146. doi:10.4314/eamj.v87i4.62201.

[13] J.M. McLaughlin, R.T. Anderson, A.K. Ferketich, E.E. Seiber, R. Balkrishnan, E.D. Paskett, Effect on Survival of Longer Intervals Between Confirmed Diagnosis and Treatment Initiation

Among Low-Income Women With Breast Cancer, J. Clin. Oncol. 30 (2012) 4493–4500. doi:10.1200/JCO.2012.39.7695.

[14] J. Harford, E. Azavedo, M. Fischietto, Guideline implementation for breast healthcare in low- and middle-income countries: Breast healthcare program resource allocation, Cancer. 113 (2008) 2282–2296. doi:10.1002/cncr.23841.

[15] M. Galukande, E. Kiguli-Malwadde, Rethinking breast cancer screening strategies in resource-limited settings., Afr. Health Sci. 10 (2010) 89–92. http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2895786&tool=pmcentrez&rendertype=abstract.

[16] B.O. Anderson, R. Shyyan, A. Eniu, R. a Smith, C.-H. Yip, N.S. Bese, L.W.C. Chow, S. Masood, S.D. Ramsey, R.W. Carlson, Breast cancer in limited-resource countries: an overview of the Breast Health Global Initiative 2005 guidelines., Breast J. 12 Suppl 1 (2006) S3-15. doi:10.1111/j.1075-122X.2006.00199.x.

[17] Department of Health-Republic of South Africa, Single Exit Price Documents, (2015). http://www.health.gov.za/index.php/single-exit-price-documents (accessed January 1, 2015).

[18] National Health Laboratory Service, State Pricing List: 2014-2015, Johannesburg, South Africa, 2014.

[19] Department of Public Service and Administration: Republic of South Africa, Salary scales, with translation keys, for employees on salary levels 1 to 12 and those employees covered by Occupation Specific Dispensations (OSDs), (2015). http://www.dpsa.gov.za/dpsa2g/r_documents.asp.

[20] M.F. Drummond, M.J. Sculpher, K. Claxton, G.L. Stoddart, G.W. Torrance, Methods for Economic Evaluation of Health Care Programmes, Fourth, Oxford University Press, Oxford, 2015.

[21] South African Revenue Service, Income Tax Act No. 58 of 1962. Binding General Ruling

(Income Tax): No. 7, Wear-and-tear or depreciation allowance, South Africa, 2012.

[22] International Monetary Fund, Consumer Price Index, World Econ. Outlook Database. (n.d.). https://www.imf.org/external/pubs/ft/weo/2014/02/weodata/index.aspx (accessed April 9, 2015).

[23] Oanda, Historical exchange rate USD-ZAR, 1/1/2014-31/12/2014, (2016). www.oanda.com.

[24] A.T. Stavros, D. Thickman, C.L. Rapp, M.A. Dennis, S.H. Parker, G.A. Sisney, Solid breast nodules: use of sonography to distinguish between benign and malignant lesions., Radiology. 196 (1995). doi:http://dx.doi.org.ezproxy.uct.ac.za/10.1148/radiology.196.1.7784555.

[25] J. Weigert, S. Steenbergen, The Connecticut experiments second year: Ultrasound in the screening of women with dense breasts, Breast J. 21 (2015) 175–180. doi:10.1111/tbj.12386.

[26] J. Okello, H. Kisembo, S. Bugeza, M. Galukande, Breast cancer detection using sonography in women with mammographically dense breasts., BMC Med. Imaging. 14 (2014) 41. doi:10.1186/s12880-014-0041-0.

[27] R. Shyyan, S. Masood, R. a Badwe, K.M. Errico, L. Liberman, V. Ozmen, H. Stalsberg, H. Vargas, L. Vass, Breast Health Global Initiative - Breast cancer in limited-resource countries: diagnosis and pathology., Breast J. 12 (2006) S27-37. doi:10.1111/j.1075-122X.2006.00201.x.

[28] R.S. Groen, J.J. Leow, V. Sadasivam, A.L. Kushner, Review: indications for ultrasound use in low- and middle-income countries, Trop. Med. Int. Heal. 16 (2011) 1525–1535. doi:10.1111/j.1365-3156.2011.02868.x.

[29] X.Y. Tang, T. Yamashita, M. Hara, N. Kumaki, Y. Tokuda, S. Masuda, Histopathological characteristics of breast ductal carcinoma in situ and association with imaging findings, Breast Cancer. 23 (2016) 491–498. doi:10.1007/s12282-015-0592-0.