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Surveying and Mapping Breast Cancer Services in Ghana: A Cross-Sectional Pilot Study in the Eastern Region

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ABSTRACT

Objectives

Define the services available for the care of breast cancer at hospitals in the Eastern Region of Ghana, identify areas of the region with limited access to care through geospatial mapping, and test a novel survey instrument in anticipation of a nationwide scale up of the study.

Design

A cross-sectional, facility-based survey study.

Setting

This study was conducted at 33 of the 34 hospitals in the Eastern Region of Ghana.

Participants

The 33 hospitals surveyed represented 97% of all hospitals in the region. This includes private, government, quasi-government, and faith-based organization owned hospitals.

Results

82% of the hospitals surveyed provide basic screening services, 33% provide pathologic diagnosis, and 9% provide those services in addition to basic surgical care. Fifty-three percent, 64%, and 78% of the population live within 10 km, 25 km, and 45 km of screening, diagnostic, and treatment services respectively. Limited chemotherapy is available at 2 hospitals, endocrine therapy at 1 hospital, and radiotherapy is not available. Ninety-four percent of hospitals employ a general practitioner, 55% a radiology technician, and 39% a surgeon. Oncology specialists, pathology personnel, and a plastic surgeon are only available in 1 hospital in the Eastern Region.

Conclusions

Although 82% of hospitals provide screening, only half the population lives within reasonable distance of these services. Few hospitals offer diagnosis and surgical services, but 64% and 78% of the population live within a reasonable distance of these hospitals. Geospatial analysis suggests two priorities to cost-effectively expand breast cancer services: 1) increase the number of health facilities providing screening services and 2) centralize basic imaging, pathologic, and surgical services at targeted hospitals.

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Strengths and limitations of this study

- This study accomplished a comprehensive assessment of breast cancer care available at 33 out of 34 hospitals in the Eastern Region of Ghana.
- Through geospatial analyses, areas of the region with limited access to services were identified and recommendations for expanding services with limited resources were able to be developed.
- Our study only evaluates geographic access to care and does not address other significant barriers in accessing care including transportation challenges, financial barriers, patient factors, facility capacity thresholds, and cultural factors.
- Only hospitals were surveyed for this study, so other health facilities that may provide some limited breast cancer screening or care services were not captured in this study.

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Competing Interests Statement

There are no conflicts of interest or competing interests to disclose. There are no financial relationships with any organizations that might have an interest in the submitted work in the previous three years and no other relationships or activities that could appear to have influenced the submitted work.

Data Sharing Statement

Data detailing services available at diagnostic centers and non-governmental organization health facilities as well as information on cervical cancer cervices provided at the surveyed hospitals is available and was not included in this manuscript. For inquiries regarding the data please contact Dr. Edward Sutherland at sutherlandmd@yahoo.com. For inquiries regarding the survey tool and possible use in another country, please contact sutherlandmd@yahoo.com or rayrprice@comcast.net.

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Introduction

Breast cancer is the most common cancer and the leading cause of cancer-related death for women in Ghana.[1] Incidence of breast cancer is lower in sub-Saharan Africa (SSA) compared to North America, but current estimates suggest the incidence is increasing.[2] Outcomes vary widely across the continent, but 5-year survival is estimated to be around 35% for women in western SSA compared to the greater than 80% 5-year survival seen in high-income countries.[3–5] Some early stage breast cancers may be treated with surgery alone, but advanced disease requires complex multidisciplinary care. Given that 77% of black women in SSA have advanced disease (stage III or IV) at presentation,[6] expanding services that allow for early diagnosis of breast cancer, improving access to basic diagnostic and surgical treatment, and developing sites with more comprehensive care should be prioritized.

In 2011, Ghana's Ministry of Health (MOH) published the "National Strategy for Cancer Control in Ghana 2012-2016." This document outlines goals to improve early diagnosis of breast cancer through breast awareness, breast self-exam, and clinical breast exam (CBE). It also details targets for the expansion of cancer related equipment, infrastructure, and services at the various levels of health facilities across the country.[7] In this study, we aimed to delineate the current resources available for breast cancer care in the Eastern Region of Ghana and map these services to identify populations without geographic access to care. In addition, we aimed to test the survey instrument and administration process in anticipation of a nationwide scale up of this study. The MOH can use the information obtained from this project to evaluate progress towards the stated targets in their National Strategy and help direct resource implementation to improve access to care.

Methods

A cross-sectional, facility-based survey was performed from March 2020 to May 2020 in Ghana's Eastern Region. This region was chosen for the pilot because the senior principal investigator (PI) for the project and our partners in the Ghana Health Service (GHS) live and work in the region. This provided our team with familiarity of the region and ensured the research assistants (RAs) would be geographically close to the senior PI if questions or concerns arose. The Eastern Region covers 8% of Ghana's landmass, is home to almost 3 million people, and is about 55% rural.[8] Targeted facilities included all hospitals in the region because hospitals are expected to provide the majority of care for breast cancer. Lists of hospitals in the region were obtained from databases of the Health Facilities Regulatory Agency and from the GHS. A total of 34 hospitals were identified, and 33 agreed to participate.

Survey Design

The objective of the survey is to provide an assessment of a hospital's capacity to provide breast cancer care. The general framework for the survey is based on the World Health Organization's (WHO) Situational Analysis Tool for assessing emergency and essential surgical care and the Surgeons OverSeas (SOS) Personnel, Infrastructure, Procedure, Equipment, and Supplies (PIPES) tool for assessing surgical infrastructure.[9-10] Experts in breast cancer surgery, oncology, and global surgery reviewed the tool

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and made key modifications. The final version was developed through expert consensus and input from local and international partners. The data entry form used by RAs in the field and a guide with expanded information on each question is available in supplemental materials (please note the full survey also includes assessment of cervical cancer services which is not reported in this article).

Survey Structure

General information about each hospital including address, GPS coordinates, facility type, and ownership was collected. Additional sections identifying the nature and quantity of personnel, imaging services, screening and diagnostic capacity, procedure and treatment options, surveillance, and follow up were also queried. Respondents were asked if a service is available at their facility (yes/no). "Yes" responses were specified as being always available (defined as greater than 80% of the time) or not always available. A sub-survey with additional questions about mammograms including number performed per month, patient cost, and who reviews the imaging was completed if a facility reported having a mammogram machine.

The personnel section surveyed how many healthcare providers involved with breast cancer care are employed at each hospital. Medical doctors (MDs) included general medical practitioners, general and plastic surgeons, obstetricians and gynecologists (ob/gyns) as well as radiology, pathology, oncology, and radiation oncology specialists and consultants. Ob/gyns were included in the survey because they often perform CBE. Non-MD trained providers included radiology and pathology technicians, physician assistants (PAs), and social workers. Social workers were included because they are often involved with palliative care and patient counseling.

Survey Administration

Four RAs familiar with the local geography were recruited via The Ensign College of Public Health (ECOPH) in Kpong, Ghana, located in the Eastern Region. The RAs participated in a week-long training course based at ECOPH. Training included didactic and field work components. The didactic portion detailed the study purpose and design and included an introductory clinical course on breast cancer and oncology basics. The field work component included proctored visits to local hospitals with gradually increased autonomy with survey administration. To promote consistency of the survey administration methods, all four RAs participated together in the initial portions of the study prior to traveling to their individually designated areas within the Eastern Region.

Both paper and electronic copies of the survey were distributed to all hospital directors prior to site visits by the RAs. The survey was administered through a structured interview with key administrative personnel, the most knowledgeable clinical specialist (eg, Medical Director, Hospital Superintendent, etc.) of each facility, or the lead breast cancer specialist. If a question was encountered that the respondent did not know, the appropriate person within the hospital was contacted.

Hospital stratification

In order to present the data in a meaningful manner, we developed a system to stratify hospitals based on the services they provide. The National Comprehensive Cancer Network's (NCCN) Framework for

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Resource Stratification of NCCN guidelines consists of three tiers: “Basic,” “Core,” and “Enhanced.” These tiers are intended to provide guidelines for appropriate care in a resource-limited environment.[11] Although these guidelines were not developed as a stratification system, their tiered structure provides an intuitive way to describe care available at each hospital. The three sets of guidelines for Invasive Breast Cancer and for Breast Cancer Screening and Diagnosis were closely reviewed by our researchers, and the services necessary to provide the care detailed in each guideline were listed and used as the basis for the stratification system (Table 1).[12-17] In order for a hospital to be categorized as a specific level, they need to offer all services for that level. In addition, the hospital has to offer the service greater than 80% of the time throughout the year, except as specified in Level 4.

We renamed the levels that reflect the NCCN “Basic,” “Core,” and “Enhanced” guidelines as Level 3, 2, and 1 respectively. The resources required to provide guideline-concordant care in a “Basic,” or Level 3 hospital, are more extensive than what is available in the Eastern Region of Ghana. Thus, to better differentiate hospitals that offer limited services, we developed three additional levels: Level 6 is defined as hospitals that provide basic screening and clinical diagnosis, Level 5 hospitals provide screening, clinical diagnosis, and pathologic diagnosis, and Level 4 hospitals provide screening, clinical and pathologic diagnosis, and basic surgical services (Table 1). Hospitals that did not fulfill criteria for any of the levels were labeled as “Other”. The “Other” category includes hospitals that perform no breast cancer care as well as hospitals that offer some services, but are missing important components of breast cancer care (for example, a hospital that has an ultrasound and x-ray machine, but does not perform CBE).

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Hospital Stratification

LEVEL 1 (NCCN Enhanced)

Screening and clinical diagnosis
-Clinical breast examination
-Mammography

Pathologic confirmation & Imaging
-Core needle biopsy
-Skin punch biopsy
-Pathological review (in house or external)
-ER/PR status testing (in house or external)
-HER2/neu status testing (in house or external)
-Ultrasound
-X Ray
-Mammography
-CT scan
-Bone scan
-Breast MRI
-Genetic counseling and genetic testing

Surgical treatment
-Lumpectomy
-Mastectomy
-Axillary dissection
-Sentinel lymph node biopsy
-Breast reconstruction
-Oophorectomy (or medical ovarian suppression)

Non-surgical treatment
-Chemotherapy
-Radiotherapy
-Endocrine therapy
-Trastuzumab
-Long term surveillance/follow up
-Supportive/palliative care

LEVEL 2 (NCCN Core)

Screening and clinical diagnosis
-Clinical breast examination

Pathologic confirmation & Imaging
-Core needle biopsy
-Pathological review (in house or external)
-ER/PR status testing (in house or external)
-Ultrasound
-X Ray
-Mammography

Surgical treatment
-Lumpectomy
-Mastectomy
-Axillary dissection
-Sentinel lymph node biopsy
-Oophorectomy (or medical ovarian suppression)

Non-surgical treatment
-Chemotherapy
-Radiotherapy
-Endocrine therapy
-Long term surveillance/follow up
-Supportive/palliative care

LEVEL 3 (NCCN Basic)

Screening and clinical diagnosis
-Clinical breast examination

Pathologic confirmation & Imaging
-Excisional biopsy or incisional biopsy
-Pathological review (in house or external)
-ER/PR status testing (in house or external)
-Ultrasound
-X Ray
-Mammography

Surgical treatment
-Mastectomy
-Axillary dissection
-Oophorectomy (or medical ovarian suppression)

Non-surgical treatment
-Endocrine therapy
-Long term surveillance/follow up
-Supportive/palliative care

LEVEL 4

Screening and clinical diagnosis
-Clinical breast examination

Pathologic confirmation & Imaging
-Excisional biopsy, incisional biopsy, core needle biopsy, or fine needle aspiration cytology
-Pathological review (in house or external)
-Ultrasound
-X Ray

Surgical treatment
-Mastectomy (always or sometimes available)*
-Axillary dissection (always or sometimes available)*

LEVEL 5

Screening and clinical diagnosis
-Clinical breast examination

Pathologic confirmation & Imaging
-Excisional biopsy, incisional biopsy, core needle biopsy, or fine needle aspiration cytology
-Pathological review (in house or external)
-Ultrasound

LEVEL 6

Screening and clinical diagnosis
-Clinical breast examination

Table 1 Hospital Stratification. Detailed list of services required to be categorized under each hospital level. A hospital must have ALL listed services to be categorized under a specific level. These services must be available >80% of the time throughout the year unless otherwise specified. Level 6 represents a hospital with the fewest breast cancer services.
*"Sometimes available" includes hospitals that reported offering a service, but it is only available <80% of the time throughout the year.

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Mapping of available services

Geographic Information Systems (GIS) technology was employed to derive the proximity of service availability and proportion of the population within a specified distance of key services. Each hospital location was geospatially visualized utilizing Esri ArcGIS Pro software (2020 Version 2.6) and proximity buffers extending outward in 5 kilometer (km) increments were generated. A 2018 LandScan population density raster from the Oak Ridge National Laboratory (Oak Ridge, TN), which depicts the dispersal of individuals throughout the region was used, and a zonal statistics tool was deployed to obtain population numbers contained within each of the 5 km proximity buffers. The results of the spatial analysis returned values for populations within each of the specified distances while presenting a visual representation of the data.

Hypothetical targeted resource allocation

To observe the impact of a hypothetical targeted resource allocation, an additional spatial and population analysis was performed. The goal of this analysis was to evaluate access to breast cancer care after a modest addition of services at targeted hospitals. This hypothetical targeted resource allocation included two conditions aimed at modeling cost-effective expansion of care: 1) All hospitals were modeled to provide CBE. Under this assumption all hospitals are at least Level 6. 2) Hospitals that were missing only a single service in order to increase their level within the stratification system were modeled as if they provided that service. For example, a Level 6 hospital that only required addition of ultrasound services in order to be categorized as Level 5 was modeled as a Level 5 hospital.

Reasonable travel distance

For the spatial and population analyses, reasonable travel distances were established as 10 km, 25 km, and 45 km for screening, pathologic diagnosis, and surgical care respectively. The Lancet Commission on Global Surgery (LcoGS) describes access for essential surgery as being within two hours of a facility performing care.[18] Given the numerous aspects of cancer care however, this threshold is not easily transferable, and there are no established thresholds that describe geographic access to cancer care. A Ghanaian study found that patients greater than 10 km from a health facility were less likely to utilize laboratory screening services, so 10 km was established as our screening threshold.[19] In South Africa, women who lived greater than 20 km from a diagnostic hospital were more likely to have advanced disease at time of breast cancer diagnosis, so we established 25 km as our diagnosis threshold.[20] For surgical management, we established 45 km as our distance threshold to keep travel time typically less than 1 hour. This is based on a Ghanaian study that found greater than 80% of respondents reported they would rarely or irregularly utilize available health services if travel time was one hour or greater.[21]

Data analysis

Descriptive statistics are presented as frequency and percentages. The hospital that was not surveyed was removed from the dataset and analysis was only run on the 33 hospitals with completed surveys. Analysis was performed using R software version 3.6.2 (R Core Team, 2019).

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Patient and Public Involvement

The GHS through the Eastern Regional Health Directorate has been involved with the entirety of this study from the development of the study concept through implementation. Results have been presented to the GHS's Eastern Regional leadership, including a discussion of recommendations. These officials directly represent the public. Patients were not involved in this study.

Ethical Approval

The study was reviewed with and approved by the Ethical Review Committee of the GHS, and was shared with the Regional Health Directorate of the Eastern Region.

Results

Thirty-three out of the 34 hospitals in the Eastern Region were surveyed. The single hospital not surveyed was due to lack of response. Surveyed hospitals included one regional hospital, one municipal hospital, 20 district hospitals, and 11 hospitals with no special designation. Sixteen of the hospitals were owned by the state, nine were privately owned, six were owned by faith-based organizations, and two were quasi-government (hospitals with partial funding from the government).

A total of 350 healthcare workers involved with breast cancer care were reported across the 33 hospitals. Of these healthcare workers, 182 (56.2%) were MDs and 32 (97.0%) of the hospitals employ at least one MD. The 182 MDs included 130 (71.4%) general practitioners without a specialty, 20 (11.0%) general surgeons, 24 (13.2%) obstetricians and gynecologists, three (1.6%) radiology specialists, two (1.1%) oncology specialists, one (0.5%) pathology specialist, one (0.5%) pathology consultant, and one (0.5%) plastic surgeon. General practitioners were employed at 29 (87.9%) hospitals, general surgeons at 13 (39.4%) hospitals, and ob/gyns at 17 (51.5%). The second largest group of healthcare workers were PAs with a total of 112 in the region across 32 (97.0%) hospitals. Twenty-seven radiology technicians, three pathology technicians, and 26 social workers were also reported in the surveys. The 30 total radiology personnel (27 technicians and three specialists) were employed at 14 (42.4%) hospitals and the five pathology personnel (three technicians, one specialist, and one consultant) were all employed by the same hospital.

Breast cancer screening is mainly performed via CBE, and this was always available at 27 (81.8%) of the hospitals. None of the surveyed facilities had a mammogram machine. Ultrasound was available in 25 (75%) facilities, and x-ray machines were available in 19 (57%) facilities. One hospital (3.0%) had a CT scanner, while MRI machines and PET scans were not available in the region.

For the pathologic diagnosis of breast cancer, excisional biopsy was offered at 18 hospitals (54.5%). Five of these sites also performed fine needle aspiration and core needle biopsy and one additional hospital offered core needle biopsy only. Thirty (90.9%) hospitals use an external lab for pathology, and seven (21.2%) of these also had in house pathology services. Two (6.1%) hospitals utilized in house pathology services only. Only one (3.0%) hospital in the region had the capacity to perform immunohistochemistry to test for estrogen receptor (ER), progesterone receptor (PR), and human epidermal growth factor receptor 2 (HER2) status.

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Thirteen hospitals (39.4%) provided surgery for the treatment of breast cancer. Six of these hospitals reported performing both mastectomy and wide local excision, and the other seven provided wide local excision only. Four of the hospitals that perform both mastectomy and wide local excision also perform axillary surgery, but no facilities perform sentinel lymph node biopsy.

Two hospitals (6.1%) offer chemotherapy for breast cancer. One of them offers CAF (cyclophosphamide, doxorubicin, and fluorouracil) and the other provides CMF (cyclophosphamide, methotrexate, fluorouracil) chemotherapy. One of these hospitals (3.0%) offers endocrine therapy with tamoxifen. Radiotherapy was not available in any of the surveyed hospitals. Palliative care was available at ten hospitals (30.3%).

When the hospital level stratification was applied, three hospitals were classified as Level 4, eight were categorized as Level 5, and 16 were classified as Level 6 (Figure 1 and Table 2). No facilities in the Eastern region could provide the full spectrum of care detailed in the NCCN Framework for Resource Stratification (Levels 1, 2, and 3). The three facilities that offer the most breast cancer services require the addition of mammogram, endocrine therapy, and testing for ER/PR status in order to provide Level 3 (NCCN Basic) care.[12]

	Number of Hospitals	Number of Hospitals after Hypothetical Targeted Resource Allocation
Level 1 (NCCN Enhanced)	0	0
Level 2 (NCCN Core)	0	0
Level 3 (NCCN Basic)	0	0
Level 4 (screening + path diagnosis + surgery)	3	6
Level 5 (screening + path diagnosis)	8	9
Level 6 (screening)	16	18
Other	6	0

Table 2 Number of hospitals in each stratification before and after hypothetical targeted resource allocation. The hypothetical targeted resource allocation included the following two conditions: 1) All hospitals were modeled to provide CBE. Under this assumption all hospitals are at least Level 6. 2) Hospitals that were missing only a single service in order to increase their level within the stratification system were modeled as if they provided that service.

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The spatial analysis using LandScan population data found that 52% of the population in the Eastern Region lives within 10 km of a hospital that provides breast cancer screening with CBE (Figure 2A), 64% of the population lives within 25 km of pathologic diagnosis services (Figure 2B), and 78% of the population lives within 45 km of basic surgical care (Figure 2C). Assessment of the hypothetical targeted resource allocation previously detailed was then performed. Implementing the first condition of the hypothetical resource allocation, modeling all hospitals to provide CBE, would increase the population living within 10 km of basic screening from 52% to 60% (Figure 3A). This model impacts six hospitals that reported they do not perform or only sometimes perform CBE. Four of these hospitals would be upgraded to a Level 6, one would be upgraded to Level 5, and one would be upgraded to Level 4 with the addition of CBE only. For the second condition of the hypothetical resource allocation, one hospital was identified that required the addition of an ultrasound machine to be upgraded to Level 5 and two hospitals could be upgraded to Level 4 with the addition of an x-ray machine and breast biopsy, respectively (Table 2). If these services were added, the proportion of the population in the Eastern Region within 25 km of a hospital that provides both screening and pathologic diagnostic services would increase to 74% (from 64%) (Figure 3B). The population within 45 km of a hospital that provides screening, pathologic diagnosis, and basic surgical care would increase to 81% (from 78%) (Figure 3C).

Discussion

The WHO provides a stepwise framework to guide the development of a National Cancer Control Program. The first step involves an in-depth situational analysis to identify where gaps in care exist.[22] Breast cancer is the most common cancer in Ghana,[1] and its incidence is increasing across SSA,[2,23] so analyzing breast cancer services and access to care is increasingly important. While enumerating various services might be straightforward, measuring true access is complex. Existing frameworks to measure access to care recognize numerous factors as important including socio-cultural, demographic, geographic, psychological, and organizational factors.[24] Previous research in Ghana has identified many patient level factors including lack of knowledge about the disease, fear of treatment, financial concerns, religious and social factors, and preference for care from traditional healers as reasons for delays in accessing care or incomplete treatment.[25–27] In contrast, system level and geographic factors have not been well studied. In addition, since publication of the "National Strategy for Cancer Control in Ghana: 2012-2016," which outlined goals for equipment and infrastructure at various hospitals, no follow up studies have been conducted.[7] Our survey of 33 hospitals provides a detailed situational analysis of personnel and services available for breast cancer care in the Eastern Region of Ghana.

Geographic considerations in access to care are a key element in describing capacity. Several recent studies have demonstrated the impact that distance from care has on breast cancer presentation in SSA. The African Breast Cancer Disparities in Outcomes Cohort Study identified that distance to a diagnostic health facility was independently associated with a delay in diagnosis of greater than 3 months and late diagnosis (Stage III/IV) for women with breast cancer in Namibia, Uganda, and Zambia.[28] In Ethiopia, rural residence and a distance greater than 5 km from a cancer referral center were associated with a delay greater than three months between onset of symptoms and medical consultation.[29] Lastly, a diagnostic hospital in South Africa identified that their patients who lived farther from the hospital were

more likely to have late stage (Stage III/IV) breast cancer at time of diagnosis.[20] By including spatial analyses, we are able to geographically describe the current service availability, identify areas most in need of enhanced care, and quantify the impact that various capacity improvements can have on population level access.

The first step of the care pathway for breast cancer involves screening and early clinical diagnosis, which the WHO describes as the "cornerstone of breast cancer control" owing to the impact that stage at diagnosis has on outcomes.[30] This is illustrated in a 2016 study of over 1,000 Ghanaian women with breast cancer, which found cumulative five-year survival rates of 91.94%, 59.93%, 33.95%, and 15.09% for stage 0 and I, II, III, and IV disease, respectively.[31] In our survey, we identified that no hospitals offer mammography. CBE is offered at 82% of the surveyed hospitals, but only about 50% of the population in the Eastern Region lives within 10 km of a Level 4, 5, or 6 hospital. If all hospitals started offering CBE, still only 60% of the population would be within 10 km of care. Given the limited access to screening and the fact that the majority of women in SSA present with late-stage disease,[6] guidance from the Breast Health Global Initiative suggests a focus on expansion of early detection services with CBE, rather than screening programs with mammography, should be prioritized.[32] Availability of CBE at non-hospital community level health facilities, which are more abundant and widespread than hospitals, is critical to expand services to reach a greater proportion of the population.

The next step of care, pathologic diagnosis, has been scarcely published about in Ghana. Estimates from a survey conducted by the International Academy of Pathology demonstrated limited access to pathology services in Ghana with only 30 pathologists in the entire country (1.1 per million population).[33] Our study reiterated the sparse availability of pathology services in Ghana with only one-third of hospitals meeting requirements for a Level 4 or 5 designation. We have identified the few hospitals offering in-house or send out pathology services and with GIS analysis found that 64% of the population in the Eastern Region lives within 25 km of a Level 4 or 5 hospital. Nine hospitals reported always or sometimes offering in-house pathologic review of breast biopsies, but only one of these hospitals employs formally trained pathology personnel. In addition, none of the facilities offering in-house services test for ER, PR, or HER2 status, which is crucial in guiding appropriate therapies for breast cancer.[34] Many hospitals surveyed send pathology to other laboratories for evaluation, but this also has limitations. Wait times of 2 weeks to 1 month for results were most frequently reported. Only one hospital uses an outside laboratory that performs ER/PR and HER2 testing. Development of surgical pathology services is time consuming and requires significant investment in equipment and education as demonstrated by the decade-long effort to develop pathology services at a teaching hospital in Kumasi, Ghana.[35] Because of this, further development of centralized pathology services with an emphasis on streamlining send out services should be prioritized as Ghana continues the long-term investment of increasing the pathology workforce.

The final step in breast cancer care, treatment, requires several medical specialties and treatment modalities. Four hospitals surveyed provide basic surgical care with mastectomy and axillary dissection and two hospitals offer mastectomy only. Availability of non-surgical therapies are more restricted, with limited chemotherapy available at two hospitals, endocrine therapy at one hospital, and no radiotherapy services in the region. Although only three hospitals are categorized as Level 4,

representing that they perform screening, pathologic diagnosis, and basic surgical care, a large share of the population (78%) lives within 45 km of one of those facilities. Further study needs to be done in SSA and Ghana to evaluate "how far is too far" in regards to cancer treatment accessibility, especially for services such as chemotherapy and radiation therapy that require extended periods of treatment with multiple trips to the hospital. Until that information is available, we believe that centralizing care by expanding non-surgical services at hospitals already categorized as Level 4 is a reasonable strategy to expand services. This would help to centralize care for patients in one hospital, potentially minimizing travel-related barriers and expenses.

The complex and interdisciplinary nature of cancer care makes reporting results of a situational analysis challenging. Presentation of data in a concise and actionable manner for use by the MOH and NGOs is crucial. This study takes the NCCN tiered guidelines as a starting point to define appropriate care across a spectrum of resource levels. The stratification makes it easy to identify what resources should be added next to expand care at a single facility. When applying this stratification system to hospitals in the Eastern Region, we identified that no hospitals had the resources to provide the care outlined in the NCCN "Basic" guidelines for low-resource areas.[12, 15] The lack of mammography services prevents all hospitals in the region from providing full care concurrent with the "Basic" guidelines, and lack of ER/PR testing is also a significant barrier.[12-14] By defining three additional "levels," we were able to better describe the services available across the region. The GIS analysis added additional value to the survey results by determining the proportion of the population within a set distance from care. This type of analysis can be further utilized to evaluate the impact that potential resource allocation would have on the population, allowing for a more cost-effective and impactful expansion of care.

Limitations

There are a few limitations to address in this study. First, although it is modeled on PIPES and the WHO situational analysis tools, our novel survey tool is not validated. The importance of expanding tools that enumerate surgical services lies in the multidisciplinary nature of cancer care, which extends well beyond surgical treatment. Second, this analysis only assesses geographic access to services using an Euclidean "straight line" distance from care, rather than actual travel time. Our study does not evaluate other significant barriers to care including transportation challenges, financial barriers, patient factors such as breast cancer awareness, facility capacity thresholds, and cultural factors. This means that our population analysis likely overestimates the proportion of the population with access to breast cancer care. Third, only hospitals were surveyed, so there may be non-hospital health facilities and local healthcare workers offering select services that were not captured by our assessment. Because of the limited availability of resources observed in the included hospitals however, we believe it is unlikely these non-hospital facilities provide cancer services that would significantly change our estimations. In addition, one hospital declined to participate in the survey. This was a small hospital that would not be expected to provide comprehensive breast cancer services. In addition, it is geographically close to other hospitals that were surveyed, so is unlikely to have impacted our population analysis. Fourth, many hospitals employ locum doctors who work at more than one hospital. This may have inflated the absolute numbers of providers reported, but does not impact the number of hospitals that employ

specific providers. Lastly, as this study was confined to the Eastern Region, there may be facilities just beyond the borders in another region that provide care. This would skew the spatial analysis for areas along the border since individuals are able to access care in any region. We anticipate that the possibility of para-regional access will be more clearly elucidated in the ongoing nationwide expansion of this survey.

Conclusions

This study accomplishes an in-depth situational analysis of available breast cancer care in the Eastern Region of Ghana using a novel facility-based survey tool. Screening is performed with CBE due to the absence of mammography machines. Basic surgical care is available across the region, but chemotherapy is limited and radiotherapy is not available. By stratifying each hospital and performing GIS analysis to identify areas most in need of services, the results of the survey can be used by the MOH to target cost-effective and guideline-concordant resource allocation to improve breast cancer care in Ghana. Based on the results of the study, we suggest two priorities in the Eastern Region: 1) expansion of screening and early diagnosis services with CBE by ensuring it is available at all hospitals, and leveraging providers at non-hospital health facilities to provide CBE, and 2) centralize treatment (surgery, chemotherapy, and radiotherapy services) to select hospitals to help streamline patient care until resources are available to expand services in more hospitals across the region.

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Author Contribution Statement

All authors discussed the results of the project, critically revised the manuscript, and approved the final version. In addition, the following authors had additional responsibilities: M.K.M. designed and organized the project, oversaw data collection, and wrote the manuscript with M.E.M. and F.L-V. M.E.M. and F.L-V. analyzed and interpreted the data and wrote the manuscript with M.K.M. O.S. was involved with project design. A.B-N. and I.O. assisted with organization and design of the project and provided local support. J.S. assisted with analyzing the data, performed the geospatial analysis, and created the maps. A.K. was the lead research assistant and helped to coordinate local data collection efforts. R.R.P. and E.K.S. designed, organized, and oversaw the entirety of the project and are senior investigators.

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We would like to acknowledge Dr. Florence Dedey and Dr. Grace Ayensu-Danquah for their support throughout this project.

Figure Legends

Table 1 Hospital Stratification. Detailed list of services required to be categorized under each hospital level. A hospital must have ALL listed services to be categorized under a specific level. These services must be available >80% of the time throughout the year unless otherwise specified. Level 6 represents a hospital with the fewest breast cancer services.

*"Sometimes available" includes hospitals that reported offering a service, but it is only available <80% of the time throughout the year.

Table 2 Number of hospitals in each stratification before and after hypothetical targeted resource allocation. The hypothetical targeted resource allocation included the following two conditions: 1) All hospitals were modeled to provide CBE. Under this assumption all hospitals are at least Level 6. 2) Hospitals that were missing only a single service in order to increase their level within the stratification system were modeled as if they provided that service.

Figure 1 Map depicting the stratification level and location of hospitals in the Eastern Region of Ghana. Black lines depict borders for districts within the Eastern Region.

Figure 2 Proximity maps depicting the stratification level and location of hospitals in the Eastern Region of Ghana. Each concentric circle depicts a 5km distance from the corresponding hospital. A) Hospitals providing screening services (Levels 1-6). B) Hospitals providing diagnostic services (Levels 1-5). C) Hospitals providing surgical management (Levels 1-4).

Figure 3 Proximity maps depicting the stratification level and location of hospitals in the Eastern Region of Ghana after hypothetical targeted resource allocation. Each concentric circle depicts a 5km distance from the corresponding hospital. A) Hospitals hypothetically providing screening services (Levels 1-6). B) Hospitals hypothetically providing diagnostic services (Levels 1-5). C) Hospitals hypothetically providing surgical management (Levels 1-4).

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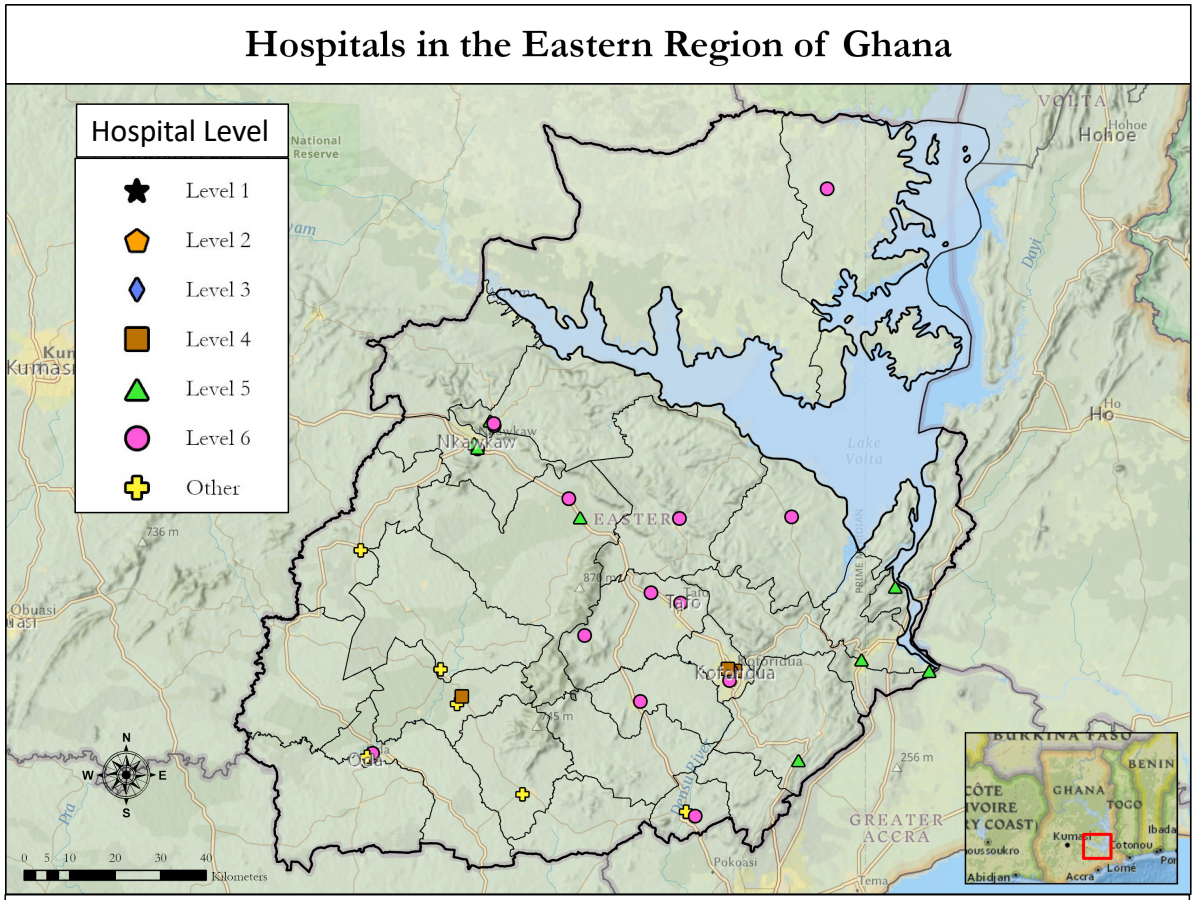

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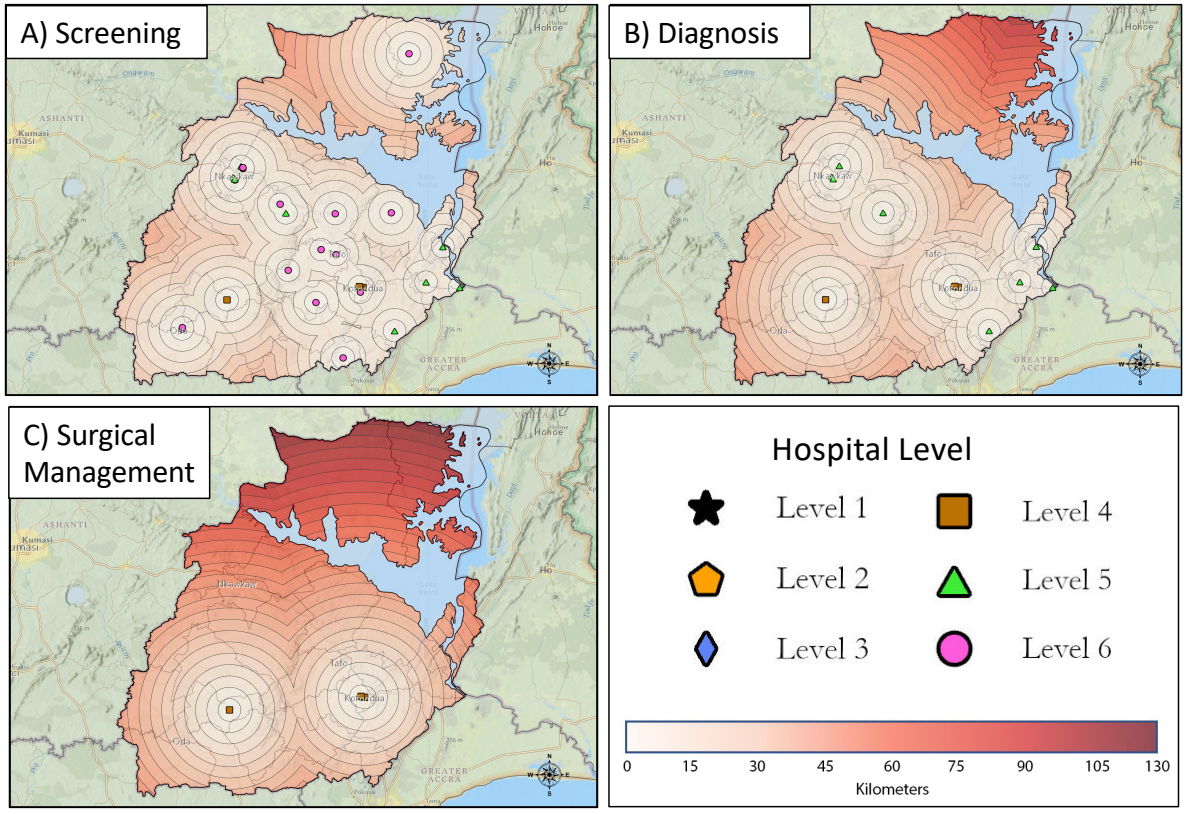

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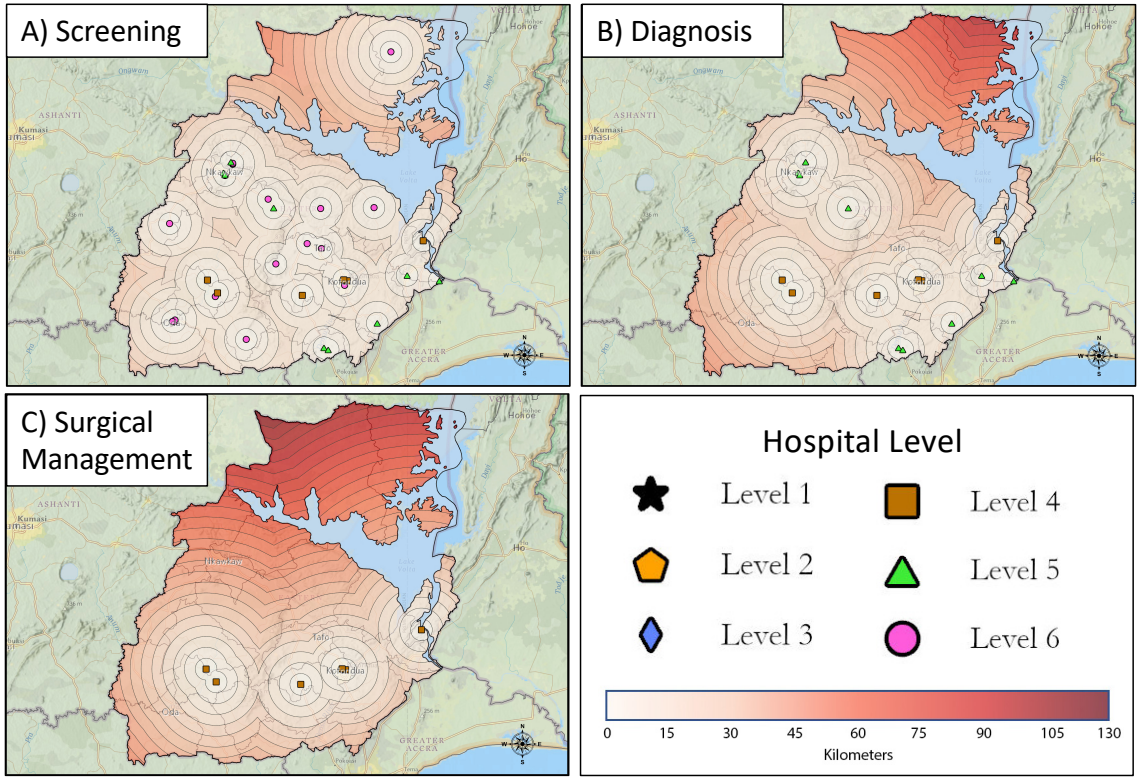

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Breast PIPES Data Entry

Section A – 1: Basic Information		**Section B – 1: Onsite Imaging**	**B – 1**
1. Region: 2. District: 3. Date: 4. Name: 5. Respondent Phone: 6. Title: 7. Facility: 8. Address: 9. GPS Lat: _____ Long: _____ 10. Facility Phone: 11. Facility Email: 12. RA: 13. RA Phone:		All [Y/N] + Availability [1/0] Example: Y/1, Y/0 or N 1. CBE 2. Mammogram 3. US 4. XR 5. MRI 6. CT 7. PET 8. Genetics	 1. ____ 2. ____ 3. ____ 4. ____ 5. ____ 6. ____ 7. ____ 8. ____
Section A – 2: Facility Information	**A – 2**	**Section B – 2: Mammogram Sub Survey**	**B – 2**
1. Facility Type (1-6): 1 = Teaching 2 = Regional 3 = Metropolitan 4 = Municipal 5 = District 6 = Hospital 2. Facility Ownership (1-5): 1 = Government 2 = Quasi government 3 = Private 4 = CAHG 5 = Other faith based, *indicate* 3. Breast clinic [Y/N]: 4. Cervical clinic [Y/N]:	1. _____ 2._____ 3._____ 4._____	1. Keep records [Y/N]: 2. Number records (1-4): 3. Free to patient (Y/N): 4. If no, cost (1=<100 2=100-500 3=>500): 5. Insurance covered (Y/N) 6. Which (1=NHIS or 2=Private, list): 7. 100% by NHIS (Y/N) 8. Who interprets (1=Outside facility 2 = in house non rad 3 = in house cons rad 4 = in house spec rads 5 = other, list): 9. External review? (1 = Ghana 2 = Outside GH): 10. External facility name: 11. Time for results (1-3)	1. ____ 2. ____ 3. ____ 4. ____ 5. ____ 6. _____ 7. ____ 8. _____ 9. ____ 10.____ 11.____
Section A – 3: Personnel Number If none, indicate with "0". 1. MD surgeon: _____ 2. MD Ob/Gyn _____ 3. MD Gyn/Onc: _____ 4. MD plastic surgeon: _____ 5. Radiologist: ___T ___S ___C 6. Pathologist: ___T ___S ___C 7. Oncologist: ___S ___C 8. Rad Onc: ___S ___C 9. Physician Assistant: _____ 10. Social worker: _____		**Section B – 3: Pap and HPV** All [Y/N] + Availability [1/0] Ex: Y/1, Y/0 or N 1. Pap 2. HPV 3. HPV 16/18 4. HPV (1=provider 2=patient) 5. HPV vaccine	**B – 3** 1. ____ 2. ____ 3. ____ 4. ____ 5. ____

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C – 1: Breast Procedures	**C – 1**	**D – 1: Chemotherapy**	**D – 1**
1. Biopsy FNA [Y1, Y0 or N] 2. Biopsy Core Needle [Y1, Y0 or N] 3. Excisional Bx [Y1, Y0 or N] 4. In house review [Y1, Y0 or N] 5. External review [Y1, Y0 or N] 6. If ext, name and country: 7. Result time (1-3) 8. Stain for immuno [Y1, Y0 or N] 9. ER stain [Y1, Y0 or N] 10. PR stain [Y1, Y0 or N] 11. HER2 [Y1, Y0 or N]	1. ____ 2.____ 3.____ 4.____ 5.____ 6. _____ 7.____ 8.____ 9.____ 10.____ 11.____	1. Chemo [Y1, Y0 or N] 2. 1=For Breast, 2=Cervical, 3=Both 3. Which agents (1-10) 4. Combinations used: 5. Endocrine [Y1, Y0 or N] 6. Which agents? (1 – 7)	1. ____ 2.____ 3.____ 4. write _____ 5.____ 6._____
C – 2: Staging	**C – 2**	**D – 2: Radiation**	**D – 2**
1. Staging [Y1, Y0 or N] 2. If yes, how? (1 = CE only, 2 = CE + imaging) 4. Imaging for staging (1-5, list all) (1=XR 2=CT 3=US 4=MRI 5=PET) 5. Pathological staging? [Y1, Y0 or N]	1.____ 2.____ 3.____ 4._____ 5.____	1. Offer radiation? [Y1, Y0 or N] 2. If no, refer? [Y/N] 3. Where? 4. Type of radiation? (1=external beam 2=brachy 3=other, write)	1.____ 2.____ 3._____ 4.____
C – 3: Breast Surgery	**C – 3**	**D – 3: Follow Up**	**D – 3**
1. Breast surgery [Y1, Y0 or N] 2a.WLE/Lump [Y1, Y0 or N] 2b.Mastectomy [Y1, Y0 or N] 2c.Ax Surg [Y1, Y0 or N] 3.If yes Ax, SLN map? [Y1, Y0 or N] 3a.Dye 3b.Radio 4.Reconstruction? [Y1, Y0 or N] 5.Which (1=expander/implant 2=rotation flap 3=free flap)	1. _____ 2a._____ 2b._____ 2c._____ 3._____ 3a._____ 3b_____ 4._____ 5._____	1. Long term F/U (Y/N) 2. How F/U (1-4) 1=phone 2=home 3=clinic 4=other 3. Registry 4. Cancer outreach 5. Counseling 6. Palliative care?	1._____ 2._____ 3._____ 4._____ 5._____ 6._____
C – 4: Cervical Procedures	**C – 4**	**Notes**	Chemo Numbers 1. Cyclophosphamide 2. Doxorubicin (Adriamycin) 3. 5 FU 4. Methotrexate 5. Epirubicin 6. Doxetaxel 7. Paclitaxel 8. Carboplatin 9. Cisplatin 10. Others, list Endocrine Numbers 1. Tamoxifen 2. Anastrozole 3. Esemestane 4. Fulvestrant 5. Goserlin 6. Letrozole 7. Other
1. Gynecologic surgery [Y1, Y0 or N] 2. Which (1=simple hyst 2 = rad hyst 3 = trachelectomy) 3. For cervical cancer? Y/N 4. VIA 5. VILI 6. Colp: 7. Cryo: 8. Cervical bx: 9. LEEP: 10. Cold knife cone: 11. Other	1. ____ 2.____ 3. ____ 4.____ 5.____ 6.____ 7.____ 8.____ 9.____ 10.___ 11._____		

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Breast and Cervical PIPES (BCP) Question Guide and Data Dictionary

Yes/No answers should be recorded as Y or N
Available/Not Always Available should be indicated by 1 (Available) or 0 (Not always available) after the Y or N.
For example, a mammogram that exists but is not always available should be indicated as Y/0.
If there is no mammogram at all, it should be indicated as N.

Section A – 1: Contact information.

1. Region name 2. District Name 3. Date 4. Respondent Name 5. Respondent Phone 6. His/Her Title 7. Name of Facility 8. Facility Address 9. GPS coordinates 10. Facility Phone 11.Research Assistant Name 12. RA Phone.

Section A – 2 Facility Information

1. Facility Type, write number.
    a. 1 = Teaching
    b. 2 = Regional
    c. 3 = Metropolitan
    d. 4 = Municipal
    e. 5 = District
    f. 6 = Hospital
2. Facility Ownership, write number.
    a. 1 = Government
    b. 2 = Quasi government
    c. 3 = Private
    d. 4 = CAHG
    e. 5 = Other faith based, *indicate*
3. Breast clinic: Does your facility have a breast clinic? Indicate with Y/N
4. Cervical clinic: Does your facility have cervical clinic? Y/N

Section A – 3: Personnel

For this section indicate the number of personnel as asked. For some specialties, note the number of technicians (T), specialists (S), and consultants (C).

Section B – 1: Imaging Capacity

Ask if they have the listed diagnostic modalities by indicating Y/N, followed by nearly always available (1) or not always available (0).

Example 1: MRI always available = Y-1.
Example 2: XRay not always available = Y-0
Example 3: No CT scan = N

Section B – 2 Mammogram Sub Survey

1. Do they keep records? Y/N
2. Number of mammograms per month that the facility performs
    a. 1 = 1-10
    b. 2 = 11-30
    c. 3 = 31-100
    d. 4 = >100
3. Free? Y/N
4. If no, how much does it cost?

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    a. 1 = <100 GHC
    b. 2 = 100-500 GHC
    c. 3 = >500 GHC
5. 100% insurance covered? Y/N
6. Which insurance? 1 = NHIS 2 = Private, write
7. Do you conduct in house read of mammogram? Y/N
8. Who interprets mammograms? List all applicable
    a. 1=Outside facility
    b. 2=In house non radiologist (such as the surgeon)
    c. 3=In house consultant radiologist
    d. 4=In house specialist radiologist
    e. 5=Other, please list.
9. If interpretation is at an external facility, indicate 1 or 2.
    a. 1=Within Ghana
    b. 2=Outside of Ghana
10. If outside of Ghana, write the name of the facility and the name of the country.
11. How long does it take for the patient to receive their results?
    a. 1=<2 weeks
    b. 2=2 weeks-1 month
    c. 3=>1month

Section B – 3 PAP and HPV

Yes/No answers should be recorded as Y or N
Available/Not Always Available should be indicated by 1 (Available) or 0 (Not always available) after the Y or N.
For example, Pap smear that exists but is not always available should be indicated as Y/0.
If there is no Pap smear at all, it should be indicated as N.

1. Does the facility offer Pap smears
2. HPV testing
3. Do the facility test for 16/18 specifically
4. Offer HPV vaccine
5. Who performs the HPV swab?
    a. 1=Provider performed
    b. 2=Patient performed

Section C – 1 Breast Diagnostic Procedures

Yes/No answers should be recorded as Y or N
Available/Not Always Available should be indicated by 1 (Available) or 0 (Not always available) after the Y or N.
For example, FNA that exists but is not always available should be indicated as Y/0.
If there is no FNA at all, it should be indicated as N.

Does your facility perform the following:

1. Biopsy FNA
2. Biopsy core needle
3. Excisional biopsy
4. In house review of pathology results?
5. External review of pathology results?
6. If external, write the name and country.
7. How long does it take the patient to receive the results of the pathology report? Indicate using 1,2 or 3.

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    a. 1=<1 month
    b. 2=1-2 months
    c. 3=>2 months
8. Does your facility stain for immunohistochemistry?
9. If yes, does it stain for Estrogen Receptor (ER) and is it always available?
10. Progesterone Receptor (PR) and always available?
11. HER2 neu and always available?

Section C – 2 Staging

1. Does your facility perform staging for breast and cervical cancer? Y/N
2. If yes, how is it performed
    a. 1=With clinical exam (CE) only?
    b. 2=Imaging + CE?
    c. 3=Pathological staging?
3. If imaging is used, indicate which modalities (can list more than 1).
    a. 1=XR
    b. 2=CT
    c. 3=US
    d. 4=MRI
    e. 5=PET

Section C – 3 Breast Surgery

1. Does your center perform surgery for breast cancer? Indicate Y/N and if always available (1/0).
2. If yes do you offer the following? Y/N and note the availability (1/0)
    a. 1=Wide Local Excision (WLE)/Lumpectomy
    b. 2=Mastectomy
    c. 3=Axillary surgery
3. If yes to axillary surgery, does your center perform sentinel lymph node mapping?
    a. 1=with dye (such as isosulphan blue or Patent blue V [PBV])
    b. 2=with radioactive isotope
4. Does your center offer reconstructive surgery for breast cancer? Y/N + 1/0
5. If yes, list which methods (list all applicable).
    a. 1=Tissue Expander
    b. 2=Rotational flap
    c. 3=Free flap

Section C – 4 Cervical Surgery and Procedures

Indicate Y/N and if always available (1/0)

1. Does your center offer surgery for cervical cancer?
2. If yes, what kind of surgery/
    a. 1=Simple hysterectomy
    b. 2=Radical hysterectomy
    c. 3=Trachelectomy
3. Does your center offer Visual Inspection with Acetic Acid (VIA)?
4. Visual Inspection with Lugol's Iodine VILI?
5. Colposocopy?
6. Cryotherapy?
7. Cervical biopsy?

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8. LEEP?
9. Cold Knife Cone?
10. Other, write.

Section D -1 Chemotherapy and Endocrine Therapy

1. Does your center offer chemotherapy? Y/N + 1/0
2. If yes, does it offer it for the following? Number plus availability using 1/0.
    a. 1=Breast cancer only
    b. 2=Cervical cancer
    c. 3=Both breast cancer and cervical cancer
3. Which agents do you have? List all applicable
    a. 1=Cyclophosphamide
    b. 2=Doxorubicin (Adriamycin)
    c. 3=5FU
    d. 4=Methotrexate
    e. 5=Epirubicin
    f. 6=Docetaxel
    g. 7=Paclitaxel
    h. 8=Carboplatin
    i. 9=Cisplatin
    j. 10=Other, please specify
4. What combinations does your center use (such as CAF). Please write.
5. Does your center use endocrine therapy? Y/N + 1/0
6. If yes, which agents? List all applicable.
    a. 1=Tamoxifen
    b. 2=Anastrozole
    c. 3=Esemestane
    d. 4=Fulvestrant
    e. 5=Goserelin
    f. 6=Letrozole
    g. 7=Other

Section D – 2 Radiation Therapy

1. Does your center offer radiation? Indicate with Y/N and availability with 1/0.
2. If yes what kind(s)?
    a. 1=External beam
    b. 2=Brachytherapy
    c. 3=Other, list

Section D – 3 Follow Up

1. Does your center offer follow up with patients?
2. How do you conduct follow up?
    a. 1 = Phone
    b. 2 = Home visit
    c. 3 = Clinical visit
    d. 4 = Other, write
3. Does your facility maintain a cancer registry?
4. Does your facility perform cancer outreach?
5. Does your facility provide counseling?
6. Does your facility offer palliative care services?

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

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Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Surveying and Mapping Breast Cancer Services in Ghana: A Cross-Sectional Pilot Study in the Eastern Region

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ABSTRACT

Objectives

Define the services available for the care of breast cancer at hospitals in the Eastern Region of Ghana, identify areas of the region with limited access to care through geospatial mapping, and test a novel survey instrument in anticipation of a nationwide scale up of the study.

Design

A cross-sectional, facility-based survey study.

Setting

This study was conducted at 33 of the 34 hospitals in the Eastern Region of Ghana from March 2020 to May 2020.

Participants

The 33 hospitals surveyed represented 97% of all hospitals in the region. This included private, government, quasi-government, and faith-based organization owned hospitals.

Results

Sixteen hospitals (82%) surveyed provided basic screening services, 11 (33%) provided pathologic diagnosis, and 3 (9%) provided those services in addition to basic surgical care. Fifty-three percent, 64%, and 78% of the population lived within 10 km, 25 km, and 45 km of screening, diagnostic, and treatment services respectively. Limited chemotherapy was available at 2 hospitals (6%), endocrine therapy at 1 hospital (3%), and radiotherapy was not available. Twenty-nine hospitals (88%) employed a general practitioner and 13 (39%) employed a surgeon. Oncology specialists, pathology personnel, and a plastic surgeon were only available in 1 hospital (3%) in the Eastern Region.

Conclusions

Although 16 hospitals (82%) provided screening, only half the population lived within reasonable distance of these services. Few hospitals offered diagnosis and surgical services, but 64% and 78% of the population lived within a reasonable distance of these hospitals. Geospatial analysis suggested two priorities to cost-effectively expand breast cancer services: 1) increase the number of health facilities providing screening services and 2) centralize basic imaging, pathologic, and surgical services at targeted hospitals.

Keywords

Breast tumours < ONCOLOGY
Breast imaging < RADIOLOGY & IMAGING
Breast surgery < SURGERY
Organisation of health services <HEALTH SERVICES ADMINISTRATION & MANAGEMENT
Surgical pathology < PATHOLOGY

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Strengths and limitations of this study

- This study accomplished a comprehensive assessment of breast cancer care available at 33 out of 34 hospitals in the Eastern Region of Ghana.
- Through geospatial analyses, areas of the region with limited access to services were identified and recommendations for expanding services with limited resources were able to be developed.
- Our study only evaluated geographic access to care and did not address other significant barriers in accessing care including transportation challenges, financial barriers, patient factors, facility capacity thresholds, and cultural factors.
- Only hospitals were surveyed for this study, so other health facilities that may provide some limited breast cancer screening or care services were not captured in this study.

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Competing Interests Statement

There are no conflicts of interest or competing interests to disclose. There are no financial relationships with any organizations that might have an interest in the submitted work in the previous three years and no other relationships or activities that could appear to have influenced the submitted work.

Data Sharing Statement

Data detailing services available at diagnostic centers and non-governmental organization health facilities as well as information on cervical cancer services provided at the surveyed hospitals is available and was not included in this manuscript. For inquiries regarding the data please contact Dr. Edward Sutherland at sutherlandmd@yahoo.com. For inquiries regarding the survey tool and possible use in another country, please contact sutherlandmd@yahoo.com or rayrprice@comcast.net.

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Introduction

Breast cancer is the most common cancer and the leading cause of cancer-related death for women in Ghana, with 4,482 cases and 2,055 deaths attributed to breast cancer in 2020.[1] Incidence of breast cancer is lower in sub-Saharan Africa (SSA) compared to North America, but current estimates suggest the incidence is increasing.[2] Outcomes vary widely across the continent, but 5-year survival is estimated to be around 35% for women in western SSA compared to the greater than 80% 5-year survival seen in high-income countries.[3–5] Some early stage breast cancers may be treated with surgery alone, but advanced disease requires complex multidisciplinary care. Given that 77% of black women in SSA have advanced disease (stage III or IV) at presentation,[6] expanding services that allow for early diagnosis of breast cancer, improving access to basic diagnostic and surgical treatment, and developing sites with more comprehensive care should be prioritized. The Global Breast Cancer Initiative, launched by the World Health Organization (WHO) in 2021, acknowledges these priorities to improve equitable access to breast cancer care across the globe.[7]

Ghana is a lower-middle income country located in West Africa with 16 regions and a population of around 31 million.[8-10] The gross national income per capita is $2,230 United States dollars, which ranks 147th out of 194 countries with data reported by The World Bank.[9,11] Around half of Ghanaians pay for their healthcare out of pocket despite the presence of the National Health Insurance Scheme, which only 38% of the population is enrolled in.[12,13] Management of breast cancer in Ghana is guided by The Ministry of Health's (MOH) "Standard Treatment Guidelines." These guidelines recommend clinical breast examination (CBE) every 3 years for women younger than 40 years old and annually after the age of 40. Mammography is also recommended every 2 years for women 40 years and older. The remainder of the guidelines are broad and emphasize the need for personalization of treatment based on patient and tumor factors. Surgery, chemotherapy, immunotherapy, radiotherapy, hormonal therapy, and palliative care are all listed as treatment options that should be considered.[14] There are no formal specifications detailing what different health facilities should provide in regards to breast cancer care, but the most comprehensive care is expected at tertiary teaching hospitals followed by regional hospitals, municipal hospitals, then district hospitals.[15]

In 2011, Ghana's MOH published the "National Strategy for Cancer Control in Ghana 2012-2016." This document outlines goals to improve early diagnosis of breast cancer through breast awareness, breast self-exam, and CBE. It also details targets for the expansion of cancer related equipment, infrastructure, and services at the various levels of health facilities across the country.[16] In this study, we aimed to delineate the current resources available for breast cancer care in the Eastern Region of Ghana and map these services to identify populations without geographic access to care. In addition, we aimed to test the survey instrument and administration process in anticipation of a nationwide scale up of this study. The MOH can use the information obtained from this project to evaluate progress towards the stated targets in their National Strategy and help direct resource implementation to improve access to care.

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Methods

Study Design and Setting

A cross-sectional, facility-based survey was performed from March 2020 to May 2020 in Ghana's Eastern Region. This region was chosen for the pilot because the senior principal investigator (PI) for the project and our partners in the Ghana Health Service (GHS) live and work in the region. This provided our team with familiarity of the region and ensured the research assistants (RAs) would be geographically close to the senior PI if questions or concerns arose. The Eastern Region covers 8% of Ghana's landmass, is home to almost 3 million people, and is about 55% rural.[17]

Inclusion Criteria

Targeted facilities included all hospitals in the region because hospitals are expected to provide the majority of care for breast cancer. Lists of hospitals in the region were obtained from databases of the Health Facilities Regulatory Agency (HeFRA) and from the GHS. A total of 34 hospitals were identified, and 33 agreed to participate.

Exclusion Criteria

Health facilities that were not designated as hospitals by HeFRA and GHS were not included in this study. Health facilities not surveyed included: community-based health planning and services (CHPS facilities), health centers, clinics and polyclinics.

Survey Design

The objective of the survey was to provide an assessment of a hospital's capacity to provide breast cancer care. The general framework for the survey was based on the WHO's Situational Analysis Tool for assessing emergency and essential surgical care and the Surgeons OverSeas (SOS) Personnel, Infrastructure, Procedure, Equipment, and Supplies (PIPES) tool for assessing surgical infrastructure.[18,19] Experts in breast cancer surgery, oncology, and global surgery reviewed the tool and made key modifications. The final version was developed through expert consensus and input from local and international partners. The data entry form used by RAs in the field and a guide with expanded information on each question is available in supplemental materials (please note the full survey also included assessment of cervical cancer services which is not reported in this article).

Survey Structure

General information collected about each hospital included address, GPS coordinates, facility type, and ownership. Additional sections identifying the nature and quantity of personnel, imaging services, screening and diagnostic capacity, procedure and treatment options, surveillance, and follow up were also queried. Respondents were asked if a service is available at their facility (yes/no). "Yes" responses were specified as being always available (defined as greater than 80% of the time) or not always available. A sub-survey with additional questions about mammograms including number performed per month, patient cost, and who reviews the imaging was completed if a facility reported having a mammogram machine.

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The personnel section surveyed how many healthcare providers involved with breast cancer care were employed at each hospital. Medical doctors (MDs) included general medical practitioners, general and plastic surgeons, obstetricians and gynecologists (ob/gyns) as well as radiology, pathology, oncology, and radiation oncology specialists and consultants. Ob/gyns were included in the survey because they often perform CBE. Non-MD trained providers included radiology and pathology technicians, physician assistants (PAs), and social workers. Social workers were included because they are often involved with palliative care and patient counseling.

Survey Administration

Four RAs familiar with the local geography were recruited via The Ensign College of Public Health (ECOPH) in Kpong, Ghana, located in the Eastern Region. The RAs participated in a week-long training course based at ECOPH. Training included didactic and field work components. The didactic portion detailed the study purpose and design and included an introductory clinical course on breast cancer and oncology basics. The field work component included proctored visits to local hospitals with gradually increased autonomy with survey administration. To promote consistency of the survey administration methods, all 4 RAs participated together in the initial portions of the study prior to traveling to their individually designated areas within the Eastern Region.

Both paper and electronic copies of the survey were distributed to all hospital directors prior to site visits by the RAs. The survey was administered through a structured interview with key administrative personnel, the most knowledgeable clinical specialist (eg, Medical Director, Hospital Superintendent, etc.) of each facility, or the lead breast cancer specialist. If a question was encountered that the respondent did not know, the appropriate person within the hospital was contacted. The RA returned to the hospital for follow-up of any missing questions after the respondent had acquired the necessary information. The in-person survey administration and follow-up of missing sections contributed to complete survey responses by all participating hospitals.

Hospital stratification

In order to present the data in a meaningful manner, we developed a system to stratify hospitals based on the services they provided. The National Comprehensive Cancer Network's (NCCN) Framework for Resource Stratification of NCCN guidelines consists of 3 tiers: "Basic," "Core," and "Enhanced." These tiers are intended to provide guidelines for appropriate care in a resource-limited environment.[20] Although these guidelines were not developed as a stratification system, their tiered structure provides an intuitive way to describe care available at each hospital. The 3 sets of guidelines for Invasive Breast Cancer and for Breast Cancer Screening and Diagnosis were closely reviewed by our researchers, and the services necessary to provide the care detailed in each guideline were listed and used as the basis for the stratification system (Table 1).[21-26] In order for a hospital to be categorized as a specific level, they needed to offer all services for that level. In addition, the hospital had to offer the service greater than 80% of the time throughout the year, except as specified in Level 4.

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We renamed the levels that reflect the NCCN “Basic,” “Core,” and “Enhanced” guidelines as Level 3, 2, and 1 respectively. The resources required to provide guideline-concordant care in a “Basic,” or Level 3 hospital, were more extensive than what was available in the Eastern Region of Ghana. Thus, to better differentiate hospitals that offer limited services, we developed 3 additional levels: Level 6 is defined as hospitals that provided basic screening and clinical diagnosis, Level 5 hospitals provided screening, clinical diagnosis, and pathologic diagnosis, and Level 4 hospitals provided screening, clinical and pathologic diagnosis, and basic surgical services (Table 1). Hospitals that did not fulfill criteria for any of the levels were labeled as “Other”. The “Other” category included hospitals that perform no breast cancer care as well as hospitals that offered some services, but were missing important components of breast cancer care (for example, a hospital that had an ultrasound and x-ray machine, but did not perform CBE).

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Table 1 Hospital Stratification

LEVEL 1 (NCCN Enhanced)

Screening and clinical diagnosis
-Clinical breast examination
-Mammography

Pathologic confirmation & Imaging
-Core needle biopsy
-Skin punch biopsy
-Pathological review (in house or external)
-ER/PR status testing (in house or external)
-HER2/neu status testing (in house or external)
-Ultrasound
-X Ray
-Mammography
-CT scan
-Bone scan
-Breast MRI
-Genetic counseling and genetic testing

Surgical treatment
-Lumpectomy
-Mastectomy
-Axillary dissection
-Sentinel lymph node biopsy
-Breast reconstruction
-Oophorectomy (or medical ovarian suppression)

Non-surgical treatment
-Chemotherapy
-Radiotherapy
-Endocrine therapy
-Trastuzumab
-Long term surveillance/follow up
-Supportive/palliative care

LEVEL 2 (NCCN Core)

Screening and clinical diagnosis
-Clinical breast examination

Pathologic confirmation & Imaging
-Core needle biopsy
-Pathological review (in house or external)
-ER/PR status testing (in house or external)
-Ultrasound
-X Ray
-Mammography

Surgical treatment
-Lumpectomy
-Mastectomy
-Axillary dissection
-Sentinel lymph node biopsy
-Oophorectomy (or medical ovarian suppression)

Non-surgical treatment
-Chemotherapy
-Radiotherapy
-Endocrine therapy
-Long term surveillance/follow up
-Supportive/palliative care

LEVEL 3 (NCCN Basic)

Screening and clinical diagnosis
-Clinical breast examination

Pathologic confirmation & Imaging
-Excisional biopsy or incisional biopsy
-Pathological review (in house or external)
-ER/PR status testing (in house or external)
-Ultrasound
-X Ray
-Mammography

Surgical treatment
-Mastectomy
-Axillary dissection
-Oophorectomy (or medical ovarian suppression)

Non-surgical treatment
-Endocrine therapy
-Long term surveillance/follow up
-Supportive/palliative care

LEVEL 4

Screening and clinical diagnosis
-Clinical breast examination

Pathologic confirmation & Imaging
-Excisional biopsy, incisional biopsy, core needle biopsy, or fine needle aspiration cytology
-Pathological review (in house or external)
-Ultrasound
-X Ray

Surgical treatment
-Mastectomy (always or sometimes available)*
-Axillary dissection (always or sometimes available)*

LEVEL 5

Screening and clinical diagnosis
-Clinical breast examination

Pathologic confirmation & Imaging
-Excisional biopsy, incisional biopsy, core needle biopsy, or fine needle aspiration cytology
-Pathological review (in house or external)
-Ultrasound

LEVEL 6

Screening and clinical diagnosis
-Clinical breast examination

Detailed list of services required to be categorized under each hospital level. A hospital must have ALL listed services to be categorized under a specific level. These services must be available >80% of the time throughout the year unless otherwise specified. Level 6 represents a hospital with the fewest breast cancer services.
*"Sometimes available" includes hospitals that reported offering a service, but it is only available <80% of the time throughout the year.

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Mapping of available services

Geographic Information Systems (GIS) technology was employed to derive the proximity of service availability and proportion of the population within a specified distance of key services. Each hospital location was geospatially visualized utilizing Esri ArcGIS Pro software (2020 Version 2.6) and proximity buffers extending outward in 5 kilometer (km) increments were generated. A 2018 LandScan population density raster from the Oak Ridge National Laboratory (Oak Ridge, TN), which depicts the dispersal of individuals throughout the region was used, and a zonal statistics tool was deployed to obtain population numbers contained within each of the 5 km proximity buffers. The results of the spatial analysis returned values for populations within each of the specified distances while presenting a visual representation of the data.

Hypothetical targeted resource allocation

To observe the impact of a hypothetical targeted resource allocation, an additional spatial and population analysis was performed. The goal of this analysis was to evaluate access to breast cancer care after a modest addition of services at targeted hospitals. This hypothetical targeted resource allocation included 2 conditions aimed at modeling cost-effective expansion of care: 1) All hospitals were modeled to provide CBE. Under this assumption all hospitals are at least Level 6. 2) Hospitals that were missing only a single service in order to increase their level within the stratification system were modeled as if they provided that service. For example, a Level 6 hospital that only required the addition of ultrasound services in order to be categorized as Level 5 was modeled as a Level 5 hospital.

Reasonable travel distance

For the spatial and population analyses, reasonable travel distances were established as 10 km, 25 km, and 45 km for screening, pathologic diagnosis, and surgical care respectively. The Lancet Commission on Global Surgery (LcoGS) describes access for essential surgery as being within 2 hours of a facility performing care.[27] Given the numerous aspects of cancer care however, this threshold is not easily transferable, and there are no established thresholds that describe geographic access to cancer care. A Ghanaian study found that patients greater than 10 km from a health facility were less likely to utilize laboratory screening services, so 10 km was established as our screening threshold.[28] In South Africa, women who lived greater than 20 km from a diagnostic hospital were more likely to have advanced disease at time of breast cancer diagnosis, so we established 25 km as our diagnosis threshold.[29] For surgical management, we established 45 km as our distance threshold to keep travel time typically less than 1 hour. This is based on a Ghanaian study that found greater than 80% of respondents reported they would rarely or irregularly utilize available health services if travel time was 1 hour or greater.[30]

Data analysis

Descriptive statistics are presented as frequency and percentages. The hospital that was not surveyed was removed from the dataset and analysis was only run on the 33 hospitals with completed surveys. Analysis was performed using R software version 3.6.2 (R Core Team, 2019).

Patient and Public Involvement

The GHS through the Eastern Regional Health Directorate has been involved with the entirety of this study from the development of the study concept through implementation. Results were presented to the GHS's Eastern Regional leadership, including a discussion of recommendations. These officials directly represent the public. Patients were not involved in this study.

Ethical Approval

The study was reviewed and approved by the Ethical Review Committee of the Ghana Health Service, and was shared with the Regional Health Directorate of the Eastern Region. The protocol ID number is GHS-ERC 010/11/19.

Results

Thirty-three out of the 34 hospitals (97%) in the Eastern Region were surveyed. The single hospital not surveyed was due to lack of response. Surveyed hospitals included 1 regional hospital, 1 municipal hospital, 20 district hospitals, and 11 hospitals with no special designation. Sixteen of the hospitals were owned by the state, 9 were privately owned, 6 were owned by faith-based organizations, and 2 were quasi-government (hospitals with partial funding from the government).

A total of 350 healthcare workers involved with breast cancer care were reported across the 33 hospitals. Of these healthcare workers, 182 (56.2%) were MDs and 32 (97.0%) of the hospitals employed at least 1 MD. The 182 MDs included 130 (71.4%) general practitioners without a specialty, 20 (11.0%) general surgeons, 24 (13.2%) obstetricians and gynecologists, 3 (1.6%) radiology specialists, 2 (1.1%) oncology specialists, 1 (0.5%) pathology specialist, 1 (0.5%) pathology consultant, and 1 (0.5%) plastic surgeon. General practitioners were employed at 29 (87.9%) hospitals, general surgeons at 13 (39.4%) hospitals, and ob/gyns at 17 (51.5%). The second largest group of healthcare workers were PAs with a total of 112 in the region across 32 (97.0%) hospitals. Twenty-seven radiology technicians, 3 pathology technicians, and 26 social workers were also reported in the surveys. The 30 total radiology personnel (27 technicians and 3 specialists) were employed at 14 (42.4%) hospitals and the 5 pathology personnel (3 technicians, 1 specialist, and 1 consultant) were all employed by the same hospital.

Breast cancer screening was mainly performed via CBE, and this was always available at 27 (81.8%) of the hospitals. None of the surveyed facilities had a mammogram machine. Ultrasound was available in 25 (75%) facilities, and x-ray machines were available in 19 (57%) facilities. One hospital (3.0%) had a CT scanner, while MRI machines and PET scans were not available in the region.

For the pathologic diagnosis of breast cancer, excisional biopsy was offered at 18 hospitals (54.5%). Five of these sites also performed fine needle aspiration and core needle biopsy and 1 additional hospital offered core needle biopsy only. Thirty (90.9%) hospitals used an external lab for pathology, and 7 (21.2%) of these also had in house pathology services. Two (6.1%) hospitals utilized in house pathology services only. Only 1 (3.0%) hospital in the region had the capacity to perform immunohistochemistry to test for estrogen receptor (ER), progesterone receptor (PR), and human epidermal growth factor receptor 2 (HER2) status.

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Thirteen hospitals (39.4%) provided surgery for the treatment of breast cancer. Six of these hospitals reported performing both mastectomy and wide local excision, and the other 7 provided wide local excision only. Four of the hospitals that performed both mastectomy and wide local excision also performed axillary surgery, but no facilities performed sentinel lymph node biopsy.

Two hospitals (6.1%) offered chemotherapy for breast cancer. One of them offered CAF (cyclophosphamide, doxorubicin, and fluorouracil) and the other provided CMF (cyclophosphamide, methotrexate, fluorouracil) chemotherapy. One of these hospitals (3.0%) offered endocrine therapy with tamoxifen. Radiotherapy was not available in any of the surveyed hospitals. Palliative care was available at 10 hospitals (30.3%).

When the hospital level stratification was applied, 3 hospitals were classified as Level 4, 8 were categorized as Level 5, and 16 were classified as Level 6 (Figure 1 and Table 2). The regional hospital, which is the main referral center in the region was categorized as Level 4, but the municipal hospital was categorized as Other (Table 2). No facilities in the Eastern region could provide the full spectrum of care detailed in the NCCN Framework for Resource Stratification (Levels 1, 2, and 3). The 3 facilities that offered the most breast cancer services required the addition of mammogram, endocrine therapy, and testing for ER/PR status in order to provide Level 3 (NCCN Basic) care.[21]

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Table 2 **Number of hospitals by level at the time of survey and after hypothetical targeted resource allocation**

Hospital Level	Number of Hospitals at time of survey	Number of Hospitals after hypothetical targeted resource allocation
Level 1 (NCCN Enhanced)	**0**	**0**
Level 2 (NCCN Core)	**0**	**0**
Level 3 (NCCN Basic)	**0**	**0**
Level 4 (screening + path + surgery)	**3**	**6**
Hospital type	1 regional, 2 district	1 regional, 5 district
Hospital ownership	1 government, 2 CHAG	3 government, 2 CHAG, 1 quasi-gov
Level 5 (screening + path)	**8**	**9**
Hospital type	5 district, 3 general	5 district, 4 general
Hospital ownership	3 govt, 1 CHAG, 1 quasi-govt, 3 private	4 govt, 1 CHAG, 4 private
Level 6 (screening)	**16**	**18**
Hospital type	10 district, 6 general	10 district, 1 municipal, 7 general
Hospital ownership	8 govt, 3 CHAG, 5 private	9 govt, 3 CHAG, 1 quasi-govt, 5 private
Other	**6**	**0**
Hospital type	3 district, 1 municipal, 2 general	
Hospital ownership	4 govt, 1 quasi-govt, 1 private	

Number of hospitals in each level at the time of survey and after hypothetical targeted resource allocation.
The hypothetical targeted resource allocation included the following two conditions:
1) All hospitals were modeled to provide CBE. Under this assumption all hospitals are at least Level 6.
2) Hospitals that were missing only a single service in order to increase their level within the stratification system were modeled as if they provided that service.

Abbreviations as follows: government (govt), Christian Health Association of Ghana (CHAG), hospital with no special designation (general), quasi-government (quasi-govt)

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The spatial analysis using LandScan population data found that 52% of the population in the Eastern Region lived within 10 km of a hospital that provided breast cancer screening with CBE (Figure 2A), 64% of the population lived within 25 km of pathologic diagnosis services (Figure 2B), and 78% of the population lived within 45 km of basic surgical care (Figure 2C). Assessment of the hypothetical targeted resource allocation previously detailed was then performed. Implementing the first condition of the hypothetical resource allocation, modeling all hospitals to provide CBE, increased the population living within 10 km of basic screening from 52% to 60% (Figure 3A). This model impacted 6 hospitals that reported they did not perform or only sometimes performed CBE. Four of these hospitals would be upgraded to a Level 6, 1 would be upgraded to Level 5, and 1 would be upgraded to Level 4 with the addition of CBE only. For the second condition of the hypothetical resource allocation, 1 hospital was identified that required the addition of an ultrasound machine to be upgraded to Level 5 and 2 hospitals could be upgraded to Level 4 with the addition of an x-ray machine and breast biopsy, respectively (Table 2). If these services were added, the proportion of the population in the Eastern Region within 25 km of a hospital that provided both screening and pathologic diagnostic services would increase to 74% (from 64%) (Figure 3B). The population within 45 km of a hospital that provided screening, pathologic diagnosis, and basic surgical care would increase to 81% (from 78%) (Figure 3C).

Discussion

The WHO provides a stepwise framework to guide the development of a National Cancer Control Program. The first step involves an in-depth situational analysis to identify where gaps in care exist.[31] Breast cancer is the most common cancer in Ghana,[1] and its incidence is increasing across SSA,[2,32] so analyzing breast cancer services and access to care is increasingly important. While enumerating various services might be straightforward, measuring true access is complex. Existing frameworks to measure access to care recognize numerous factors as important including socio-cultural, demographic, geographic, psychological, and organizational factors.[33] Previous research in Ghana has identified many patient level factors including lack of knowledge about the disease, fear of treatment, financial concerns, religious and social factors, and preference for care from traditional healers as reasons for delays in accessing care or incomplete treatment.[34-36] In contrast, system level and geographic factors have not been well studied. In addition, since publication of the "National Strategy for Cancer Control in Ghana: 2012-2016," which outlined goals for equipment and infrastructure at various hospitals, no follow up studies have been conducted.[16] Our survey of 33 hospitals provides a detailed situational analysis of personnel and services available for breast cancer care in the Eastern Region of Ghana.

Geographic considerations in access to care are a key element in describing capacity. Several recent studies have demonstrated the impact that distance from care has on breast cancer presentation in SSA. The African Breast Cancer Disparities in Outcomes Cohort Study identified that distance to a diagnostic health facility was independently associated with a delay in diagnosis of greater than 3 months and late diagnosis (Stage III/IV) for women with breast cancer in Namibia, Uganda, and Zambia.[37] In Ethiopia, rural residence and a distance greater than 5 km from a cancer referral center were associated with a delay greater than three months between onset of symptoms and medical consultation.[38] Lastly, a diagnostic hospital in South Africa identified that their patients who lived farther from the hospital were

more likely to have late stage (Stage III/IV) breast cancer at time of diagnosis.[29] By including spatial analyses, we are able to geographically describe service availability, identify areas most in need of enhanced care, and quantify the impact that various capacity improvements can have on population level access.

The first step of the care pathway for breast cancer involves screening and early clinical diagnosis, which the WHO describes as the "cornerstone of breast cancer control" owing to the impact that stage at diagnosis has on outcomes.[39] This is illustrated in a 2016 study of over 1,000 Ghanaian women with breast cancer, which found cumulative 5-year survival rates of 91.94%, 59.93%, 33.95%, and 15.09% for stage 0 and I, II, III, and IV disease, respectively.[40] In our survey, we identified that no hospitals offered mammography. CBE was offered at 82% of the surveyed hospitals, but only about 50% of the population in the Eastern Region lived within 10 km of a Level 4, 5, or 6 hospital. If all hospitals started offering CBE, still only 60% of the population would be within 10 km of care. Given the limited access to screening and the fact that the majority of women in SSA present with late-stage disease,[6] guidance from the Breast Health Global Initiative suggests a focus on expansion of early detection services with CBE, rather than screening programs with mammography, should be prioritized.[41] Availability of CBE at non-hospital community level health facilities, which are more abundant and widespread than hospitals, is critical to expand services to reach a greater proportion of the population.

The next step of care is pathologic diagnosis. There are few publications about access to pathology services in Ghana. Estimates from a survey conducted by the International Academy of Pathology demonstrated limited access to pathology services in Ghana with only 30 pathologists in the entire country (1.1 per million population).[42] Our study reiterated the sparse availability of pathology services in Ghana with only one-third of hospitals meeting requirements for a Level 4 or 5 designation. We have identified a few hospitals offering in-house or send out pathology services and with GIS analysis found that 64% of the population in the Eastern Region lived within 25 km of a Level 4 or 5 hospital. Nine hospitals reported always or sometimes offering in-house pathologic review of breast biopsies, but only 1 of these hospitals employed formally trained pathology personnel. In addition, none of the facilities which offered in-house services tested for ER, PR, or HER2 status, which is crucial in guiding appropriate therapies for breast cancer.[43] Many hospitals surveyed send pathology to other laboratories for evaluation, but this also has limitations. Wait times of 2 weeks to 1 month for results were most frequently reported. Only 1 hospital used an outside laboratory that performs ER/PR and HER2 testing. Development of surgical pathology services is time consuming and requires significant investment in equipment and education as demonstrated by the decade-long effort to develop pathology services at a teaching hospital in Kumasi, Ghana.[44] Because of this, further development of centralized pathology services with an emphasis on streamlining send out services should be prioritized as Ghana continues the long-term investment of increasing the pathology workforce.

The final step in breast cancer care, treatment, requires several medical specialties and treatment modalities. Four hospitals surveyed provided basic surgical care with mastectomy and axillary dissection and 2 hospitals offered mastectomy only. All of these hospitals and 7 additional hospitals also offered wide local excision. Sentinel lymph node biopsy was not available in the region. Availability of non-surgical therapies were more restricted, with limited chemotherapy available at 2 hospitals, endocrine

therapy at 1 hospital, and no radiotherapy services in the region. Although only 3 hospitals were categorized as Level 4, representing that they performed screening, pathologic diagnosis, and basic surgical care, a large share of the population (78%) lived within 45 km of one of those facilities. Further study needs to be done in SSA and Ghana to evaluate "how far is too far" in regards to cancer treatment accessibility, especially for services such as chemotherapy and radiation therapy that require extended periods of treatment with multiple trips to the hospital. Until that information is available, we believe that centralizing care by expanding non-surgical services at hospitals already categorized as Level 4 is a reasonable strategy to expand services. This would help to centralize care for patients in 1 hospital, potentially minimizing travel-related barriers and expenses.

The complex and interdisciplinary nature of cancer care makes reporting results of a situational analysis challenging. Presentation of data in a concise and actionable manner for use by the MOH and NGOs is crucial. This study used the NCCN tiered guidelines as a starting point to define appropriate care across a spectrum of resource levels. The stratification made it easy to identify what resources should be added next to expand care at a single facility. When applying this stratification system to hospitals in the Eastern Region, we identified that no hospitals had the resources to provide the care outlined in the NCCN "Basic" guidelines for low-resource areas.[21, 24] The lack of mammography services prevented all hospitals in the region from providing full care concurrent with the "Basic" guidelines, and lack of ER/PR testing was also a significant barrier.[21-23] By defining 3 additional "levels," we were able to better describe the services available across the region. The GIS analysis added additional value to the survey results by determining the proportion of the population within a set distance from care. This analysis was utilized to evaluate the impact that potential resource allocation would have on the population, allowing for a more cost-effective and impactful expansion of care.

Limitations

There are a few limitations to address in this study. First, although it is modeled on PIPES and the WHO situational analysis tools, our novel survey tool has not been validated. The importance of expanding tools that enumerate surgical services lies in the multidisciplinary nature of cancer care, which extends well beyond surgical treatment. Second, this analysis only assessed geographic access to services using an Euclidean "straight line" distance from care, rather than actual travel time. Our study did not evaluate other significant barriers to care including transportation challenges, financial barriers, patient factors such as breast cancer awareness, facility capacity thresholds, and cultural factors. This means that our population analysis likely overestimated the proportion of the population with access to breast cancer care. Additionally, because of these other barriers in access to care, the proposed hypothetical targeted resource allocation may not lead to improved access or utilization of care if other factors are not addressed. Third, only hospitals were surveyed, so there may be non-hospital health facilities and local healthcare workers offering select services that were not captured by our assessment. Because of the limited availability of resources observed in the included hospitals however, we believe it is unlikely these non-hospital facilities provide cancer services that would significantly change our estimations. In addition, 1 hospital declined to participate in the survey. This was a small hospital that was not expected to provide comprehensive breast cancer services. In addition, it is geographically close to other hospitals

that were surveyed, so is unlikely to have impacted our population analysis. Fourth, many hospitals employed locum doctors who work at more than 1 hospital. This may have inflated the absolute numbers of providers reported, but does not impact the number of hospitals that employ specific providers. Lastly, as this study was confined to the Eastern Region, there may be facilities just beyond the borders in another region that provide care. This would skew the spatial analysis for areas along the border since individuals are able to access care in any region. We anticipate that the possibility of para-regional access will be more clearly elucidated in the ongoing nationwide expansion of this survey.

Conclusions

This study accomplished an in-depth situational analysis of available breast cancer care in the Eastern Region of Ghana using a novel facility-based survey tool. By stratifying each hospital and performing GIS analysis to identify areas most in need of services, the results of the survey can be used by the MOH to target cost-effective and guideline-concordant resource allocation to improve breast cancer care in Ghana. Based on the results of the study, we suggest 2 priorities in the Eastern Region: 1) expansion of screening and early diagnosis services with CBE by ensuring it is available at all hospitals, and leveraging providers at non-hospital health facilities to provide CBE, and 2) centralization of treatment (surgery, chemotherapy, and radiotherapy services) to select hospitals to help streamline patient care until resources are available to expand services in more hospitals across the region.

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Author Contribution Statement

All authors discussed the results of the project, critically revised the manuscript, and approved the final version, this was the primary role for authors S.M. and K.E.B. In addition, the following authors had additional responsibilities: M.K.M. designed and organized the project, oversaw data collection, and wrote the manuscript with M.E.M. and F.L-V. M.E.M. and F.L-V. analyzed and interpreted the data and wrote the manuscript with M.K.M. O.S. was involved with project design. A.B-N. and I.O. assisted with organization and design of the project and provided local support. J.S. assisted with analyzing the data, performed the geospatial analysis, and created the maps. J.N. and A.G. assisted with organization and management of the project. A.K. was the lead research assistant and helped to coordinate local data collection efforts. R.R.P. and E.K.S. designed, organized, and oversaw the entirety of the project and are senior investigators.

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Figure Legends

Table 1 Hospital Stratification. Detailed list of services required to be categorized under each hospital level. A hospital must have ALL listed services to be categorized under a specific level. These services must be available >80% of the time throughout the year unless otherwise specified. Level 6 represents a hospital with the fewest breast cancer services.

*"Sometimes available" includes hospitals that reported offering a service, but it is only available <80% of the time throughout the year.

Table 2 Number of hospitals in each level at the time of survey and after hypothetical targeted resource allocation. The hypothetical targeted resource allocation included the following two conditions: 1) All hospitals were modeled to provide CBE. Under this assumption all hospitals are at least Level 6. 2) Hospitals that were missing only a single service in order to increase their level within the stratification system were modeled as if they provided that service. Abbreviations as follows: government (govt), Christian Health Association of Ghana (CHAG), hospital with no special designation (general), quasi-government (quasi-govt)

Figure 1 Map depicting the stratification level and location of hospitals in the Eastern Region of Ghana. Black lines depict borders for districts within the Eastern Region.

Figure 2 Proximity maps depicting the stratification level and location of hospitals in the Eastern Region of Ghana. Each concentric circle depicts a 5km distance from the corresponding hospital. A) Hospitals providing screening services (Levels 1-6). B) Hospitals providing diagnostic services (Levels 1-5). C) Hospitals providing surgical management (Levels 1-4).

Figure 3 Proximity maps depicting the stratification level and location of hospitals in the Eastern Region of Ghana after hypothetical targeted resource allocation. Each concentric circle depicts a 5km distance from the corresponding hospital. A) Hospitals hypothetically providing screening services (Levels 1-6). B) Hospitals hypothetically providing diagnostic services (Levels 1-5). C) Hospitals hypothetically providing surgical management (Levels 1-4).

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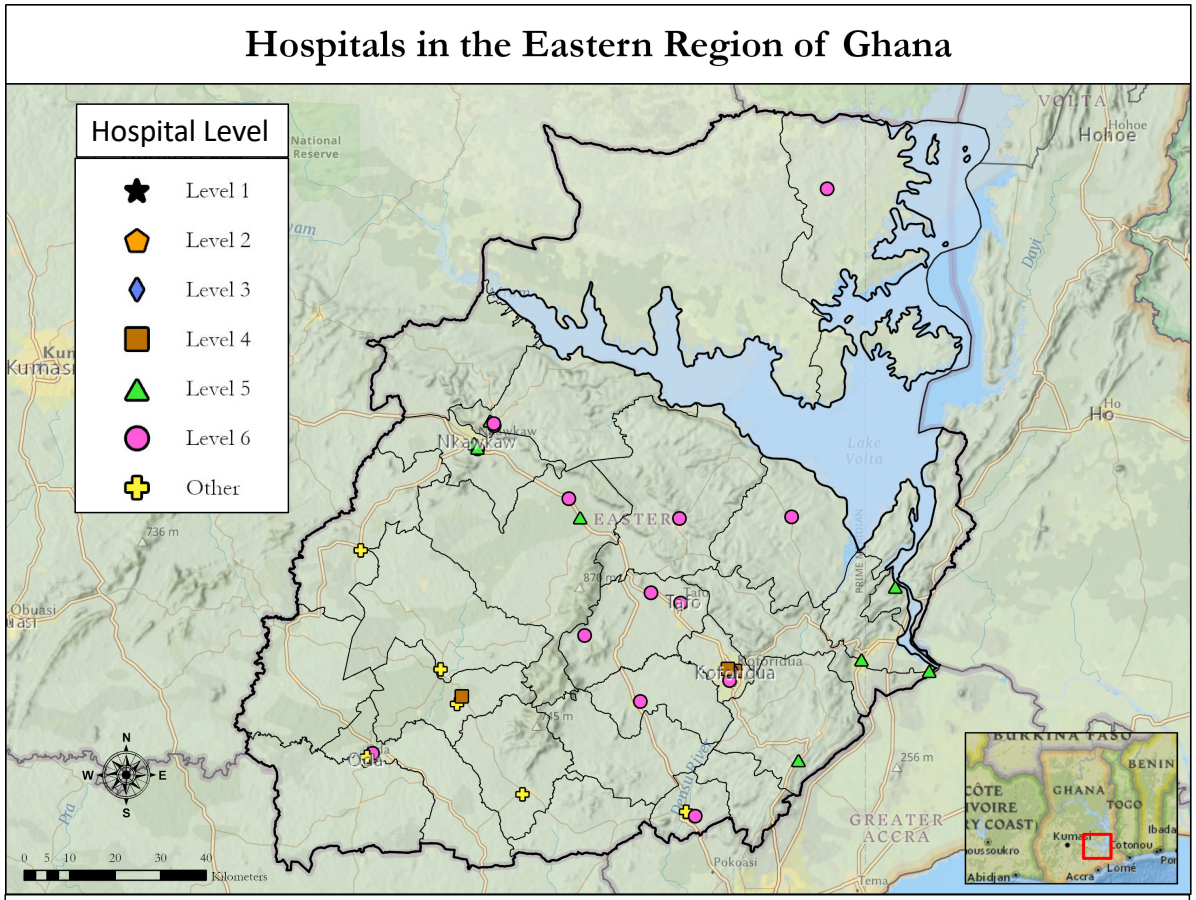
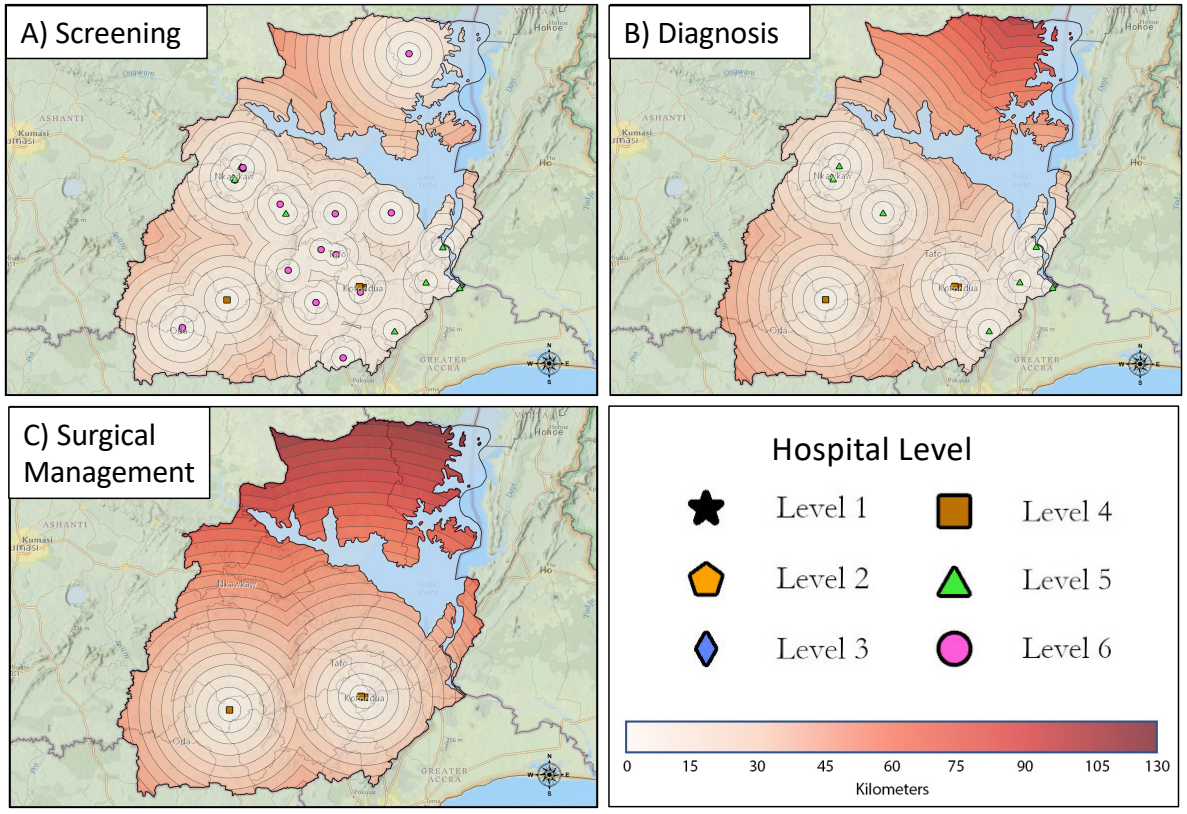


Figure 1 Map depicting the stratification level and location of hospitals in the Eastern Region of Ghana. Black lines depict borders for districts within the Eastern Region.



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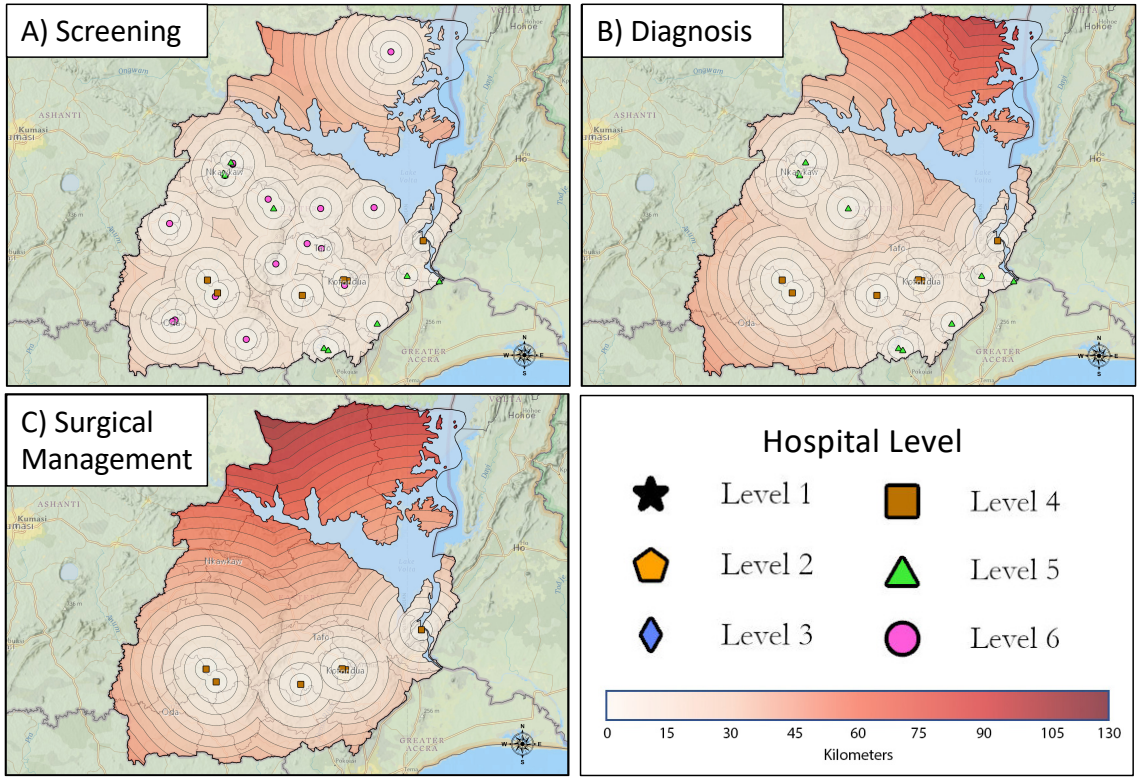

Figure 3 Proximity maps depicting the stratification level and location of hospitals in the Eastern Region of Ghana after hypothetical targeted resource allocation. Each concentric circle depicts a 5km distance from the corresponding hospital. A) Hospitals hypothetically providing screening services (Levels 1-6). B) Hospitals hypothetically providing diagnostic services (Levels 1-5). C) Hospitals hypothetically providing surgical management (Levels 1-4).

Breast PIPES Data Entry

Section A – 1: Basic Information		**Section B – 1: Onsite Imaging**	**B – 1**
1. Region: 2. District: 3. Date: 4. Name: 5. Respondent Phone: 6. Title: 7. Facility: 8. Address: 9. GPS Lat: _____ Long: _____ 10. Facility Phone: 11. Facility Email: 12. RA: 13. RA Phone:		All [Y/N] + Availability [1/0] Example: Y/1, Y/0 or N 1. CBE 2. Mammogram 3. US 4. XR 5. MRI 6. CT 7. PET 8. Genetics	 1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____
Section A – 2: Facility Information	**A – 2**	**Section B – 2: Mammogram Sub Survey**	**B – 2**
1. Facility Type (1-6): 1 = Teaching 2 = Regional 3 = Metropolitan 4 = Municipal 5 = District 6 = Hospital 2. Facility Ownership (1-5): 1 = Government 2 = Quasi government 3 = Private 4 = CAHG 5 = Other faith based, *indicate* 3. Breast clinic [Y/N]: 4. Cervical clinic [Y/N]:	1. _____ 2._____ 3._____ 4._____	1. Keep records [Y/N]: 2. Number records (1-4): 3. Free to patient (Y/N): 4. If no, cost (1=<100 2=100-500 3=>500): 5. Insurance covered (Y/N) 6. Which (1=NHIS or 2=Private, list): 7. 100% by NHIS (Y/N) 8. Who interprets (1=Outside facility 2 = in house non rad 3 = in house cons rad 4 = in house spec rads 5 = other, list): 9. External review? (1 = Ghana 2 = Outside GH): 10. External facility name: 11. Time for results (1-3)	1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____ 9. _____ 10._____ 11._____
Section A – 3: Personnel Number If none, indicate with "0". 1. MD surgeon: _____ 2. MD Ob/Gyn _____ 3. MD Gyn/Onc: _____ 4. MD plastic surgeon: _____ 5. Radiologist: ___T ___S ___C 6. Pathologist: ___T ___S ___C 7. Oncologist: ___S ___C 8. Rad Onc: ___S ___C 9. Physician Assistant: _____ 10. Social worker: _____		**Section B – 3: Pap and HPV** All [Y/N] + Availability [1/0] Ex: Y/1, Y/0 or N 1. Pap 2. HPV 3. HPV 16/18 4. HPV (1=provider 2=patient) 5. HPV vaccine	**B – 3** 1. _____ 2. _____ 3. _____ 4. _____ 5. _____	

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C – 1: Breast Procedures	**C – 1**	**D – 1: Chemotherapy**	**D – 1**
1. Biopsy FNA [Y1, Y0 or N] 2. Biopsy Core Needle [Y1, Y0 or N] 3. Excisional Bx [Y1, Y0 or N] 4. In house review [Y1, Y0 or N] 5. External review [Y1, Y0 or N] 6. If ext, name and country: 7. Result time (1-3) 8. Stain for immuno [Y1, Y0 or N] 9. ER stain [Y1, Y0 or N] 10. PR stain [Y1, Y0 or N] 11. HER2 [Y1, Y0 or N]	1. ____ 2.____ 3.____ 4.____ 5.____ 6. _____ 7.____ 8.____ 9.____ 10.____ 11.____	1. Chemo [Y1, Y0 or N] 2. 1=For Breast, 2=Cervical, 3=Both 3. Which agents (1-10) 4. Combinations used: 5. Endocrine [Y1, Y0 or N] 6. Which agents? (1 – 7)	1. ____ 2.____ 3.____ 4. write _____ 5.____ 6._____
C – 2: Staging	**C – 2**	**D – 2: Radiation**	**D – 2**
1. Staging [Y1, Y0 or N] 2. If yes, how? (1 = CE only, 2 = CE + imaging) 4. Imaging for staging (1-5, list all) (1=XR 2=CT 3=US 4=MRI 5=PET) 5. Pathological staging? [Y1, Y0 or N]	1.____ 2.____ 3.____ 4._____ 5.____	1. Offer radiation? [Y1, Y0 or N] 2. If no, refer? [Y/N] 3. Where? 4. Type of radiation? (1=external beam 2=brachy 3=other, write)	1.____ 2.____ 3._____ 4.____
C – 3: Breast Surgery	**C – 3**	**D – 3: Follow Up**	**D – 3**
1. Breast surgery [Y1, Y0 or N] 2a.WLE/Lump [Y1, Y0 or N] 2b.Mastectomy [Y1, Y0 or N] 2c.Ax Surg [Y1, Y0 or N] 3.If yes Ax, SLN map? [Y1, Y0 or N] 3a.Dye 3b.Radio 4.Reconstruction? [Y1, Y0 or N] 5.Which (1=expander/implant 2=rotation flap 3=free flap)	1. _____ 2a._____ 2b._____ 2c._____ 3._____ 3a._____ 3b_____ 4._____ 5._____	1. Long term F/U (Y/N) 2. How F/U (1-4) 1=phone 2=home 3=clinic 4=other 3. Registry 4. Cancer outreach 5. Counseling 6. Palliative care?	1._____ 2._____ 3._____ 4._____ 5._____ 6._____
C – 4: Cervical Procedures	**C – 4**	**Notes**	Chemo Numbers 1. Cyclophosphamide 2. Doxorubicin (Adriamycin) 3. 5 FU 4. Methotrexate 5. Epirubicin 6. Doxetaxel 7. Paclitaxel 8. Carboplatin 9. Cisplatin 10. Others, list Endocrine Numbers 1. Tamoxifen 2. Anastrozole 3. Esemestane 4. Fulvestrant 5. Goserlin 6. Letrozole 7. Other
1. Gynecologic surgery [Y1, Y0 or N] 2. Which (1=simple hyst 2 = rad hyst 3 = trachelectomy) 3. For cervical cancer? Y/N 4. VIA 5. VILI 6. Colp: 7. Cryo: 8. Cervical bx: 9. LEEP: 10. Cold knife cone: 11. Other	1. ____ 2.____ 3. ____ 4.____ 5.____ 6.____ 7.____ 8.____ 9.____ 10.___ 11._____		

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Breast and Cervical PIPES (BCP) Question Guide and Data Dictionary

Yes/No answers should be recorded as Y or N
Available/Not Always Available should be indicated by 1 (Available) or 0 (Not always available) after the Y or N.
For example, a mammogram that exists but is not always available should be indicated as Y/0.
If there is no mammogram at all, it should be indicated as N.

Section A – 1: Contact information.

1. Region name 2. District Name 3. Date 4. Respondent Name 5. Respondent Phone 6. His/Her Title 7. Name of Facility 8. Facility Address 9. GPS coordinates 10. Facility Phone 11.Research Assistant Name 12. RA Phone.

Section A – 2 Facility Information

1. Facility Type, write number.
    a. 1 = Teaching
    b. 2 = Regional
    c. 3 = Metropolitan
    d. 4 = Municipal
    e. 5 = District
    f. 6 = Hospital
2. Facility Ownership, write number.
    a. 1 = Government
    b. 2 = Quasi government
    c. 3 = Private
    d. 4 = CAHG
    e. 5 = Other faith based, *indicate*
3. Breast clinic: Does your facility have a breast clinic? Indicate with Y/N
4. Cervical clinic: Does your facility have cervical clinic? Y/N

Section A – 3: Personnel

For this section indicate the number of personnel as asked. For some specialties, note the number of technicians (T), specialists (S), and consultants (C).

Section B – 1: Imaging Capacity

Ask if they have the listed diagnostic modalities by indicating Y/N, followed by nearly always available (1) or not always available (0).

Example 1: MRI always available = Y-1.
Example 2: XRay not always available = Y-0
Example 3: No CT scan = N

Section B – 2 Mammogram Sub Survey

1. Do they keep records? Y/N
2. Number of mammograms per month that the facility performs
    a. 1 = 1-10
    b. 2 = 11-30
    c. 3 = 31-100
    d. 4 = >100
3. Free? Y/N
4. If no, how much does it cost?

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    a. 1 = <100 GHC
    b. 2 = 100-500 GHC
    c. 3 = >500 GHC
5. 100% insurance covered? Y/N
6. Which insurance? 1 = NHIS 2 = Private, write
7. Do you conduct in house read of mammogram? Y/N
8. Who interprets mammograms? List all applicable
    a. 1=Outside facility
    b. 2=In house non radiologist (such as the surgeon)
    c. 3=In house consultant radiologist
    d. 4=In house specialist radiologist
    e. 5=Other, please list.
9. If interpretation is at an external facility, indicate 1 or 2.
    a. 1=Within Ghana
    b. 2=Outside of Ghana
10. If outside of Ghana, write the name of the facility and the name of the country.
11. How long does it take for the patient to receive their results?
    a. 1=<2 weeks
    b. 2=2 weeks-1 month
    c. 3=>1month

Section B – 3 PAP and HPV

Yes/No answers should be recorded as Y or N
Available/Not Always Available should be indicated by 1 (Available) or 0 (Not always available) after the Y or N.
For example, Pap smear that exists but is not always available should be indicated as Y/0.
If there is no Pap smear at all, it should be indicated as N.

1. Does the facility offer Pap smears
2. HPV testing
3. Do the facility test for 16/18 specifically
4. Offer HPV vaccine
5. Who performs the HPV swab?
    a. 1=Provider performed
    b. 2=Patient performed

Section C – 1 Breast Diagnostic Procedures

Yes/No answers should be recorded as Y or N
Available/Not Always Available should be indicated by 1 (Available) or 0 (Not always available) after the Y or N.
For example, FNA that exists but is not always available should be indicated as Y/0.
If there is no FNA at all, it should be indicated as N.

Does your facility perform the following:

1. Biopsy FNA
2. Biopsy core needle
3. Excisional biopsy
4. In house review of pathology results?
5. External review of pathology results?
6. If external, write the name and country.
7. How long does it take the patient to receive the results of the pathology report? Indicate using 1,2 or 3.

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   a. 1=<1 month
   b. 2=1-2 months
   c. 3=>2 months
8. Does your facility stain for immunohistochemistry?
9. If yes, does it stain for Estrogen Receptor (ER) and is it always available?
10. Progesterone Receptor (PR) and always available?
11. HER2 neu and always available?

Section C – 2 Staging

1. Does your facility perform staging for breast and cervical cancer? Y/N
2. If yes, how is it performed
   a. 1=With clinical exam (CE) only?
   b. 2=Imaging + CE?
   c. 3=Pathological staging?
3. If imaging is used, indicate which modalities (can list more than 1).
   a. 1=XR
   b. 2=CT
   c. 3=US
   d. 4=MRI
   e. 5=PET

Section C – 3 Breast Surgery

1. Does your center perform surgery for breast cancer? Indicate Y/N and if always available (1/0).
2. If yes do you offer the following? Y/N and note the availability (1/0)
   a. 1=Wide Local Excision (WLE)/Lumpectomy
   b. 2=Mastectomy
   c. 3=Axillary surgery
3. If yes to axillary surgery, does your center perform sentinel lymph node mapping?
   a. 1=with dye (such as isosulphan blue or Patent blue V [PBV])
   b. 2=with radioactive isotope
4. Does your center offer reconstructive surgery for breast cancer? Y/N + 1/0
5. If yes, list which methods (list all applicable).
   a. 1=Tissue Expander
   b. 2=Rotational flap
   c. 3=Free flap

Section C – 4 Cervical Surgery and Procedures

Indicate Y/N and if always available (1/0)

1. Does your center offer surgery for cervical cancer?
2. If yes, what kind of surgery/
   a. 1=Simple hysterectomy
   b. 2=Radical hysterectomy
   c. 3=Trachelectomy
3. Does your center offer Visual Inspection with Acetic Acid (VIA)?
4. Visual Inspection with Lugol's Iodine VILI?
5. Colposocopy?
6. Cryotherapy?
7. Cervical biopsy?

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8. LEEP?
9. Cold Knife Cone?
10. Other, write.

Section D -1 Chemotherapy and Endocrine Therapy

1. Does your center offer chemotherapy? Y/N + 1/0
2. If yes, does it offer it for the following? Number plus availability using 1/0.
    a. 1=Breast cancer only
    b. 2=Cervical cancer
    c. 3=Both breast cancer and cervical cancer
3. Which agents do you have? List all applicable
    a. 1=Cyclophosphamide
    b. 2=Doxorubicin (Adriamycin)
    c. 3=5FU
    d. 4=Methotrexate
    e. 5=Epirubicin
    f. 6=Docetaxel
    g. 7=Paclitaxel
    h. 8=Carboplatin
    i. 9=Cisplatin
    j. 10=Other, please specify
4. What combinations does your center use (such as CAF). Please write.
5. Does your center use endocrine therapy? Y/N + 1/0
6. If yes, which agents? List all applicable.
    a. 1=Tamoxifen
    b. 2=Anastrozole
    c. 3=Esemestane
    d. 4=Fulvestrant
    e. 5=Goserelin
    f. 6=Letrozole
    g. 7=Other

Section D – 2 Radiation Therapy

1. Does your center offer radiation? Indicate with Y/N and availability with 1/0.
2. If yes what kind(s)?
    a. 1=External beam
    b. 2=Brachytherapy
    c. 3=Other, list

Section D – 3 Follow Up

1. Does your center offer follow up with patients?
2. How do you conduct follow up?
    a. 1 = Phone
    b. 2 = Home visit
    c. 3 = Clinical visit
    d. 4 = Other, write
3. Does your facility maintain a cancer registry?
4. Does your facility perform cancer outreach?
5. Does your facility provide counseling?
6. Does your facility offer palliative care services?

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data	15*	Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

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Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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