BMC Health Services Research

RESEARCH

Open Access

Geographical Access to Point-of-care diagnostic tests for diabetes, anaemia, Hepatitis B, and human immunodeficiency virus in the Bono Region, Ghana

Monica Ansu-Mensah[1,2*], Themba G. Ginindza[1,3], Samuel Kofi Amponsah[4], Mulugeta Shegaze Shimbre[1], Vitalis Bawontuo[5] and Desmond Kuupiel[1,6]

Abstract

Background Diabetes mellitus, human immunodeficiency virus (HIV), hepatitis B and anaemia are major global public health issues according to the World Health Organization (WHO). Access to diagnostic testing is essential for their prompt detection and treatment. The WHO has recommended a list of essential in-vitro diagnostics for testing at all levels of care. However, a survey preceding this study showed limited availability of point-of-care (POC) tests for these conditions in the Bono Region (BR) of Ghana. This study assessed the geographical access to diabetes, anaemia, hepatitis B, and HIV POC testing in the BR, Ghana for targeted improvement.

Methods We gathered the geolocated data of 137 facilities (CHPS, Clinics, healthcare centres, and hospitals) in the BR that were providing glucose, haemoglobin (Hb), Hepatitis B Surface Antigen (Hep B), and HIV POC testing services in July 2022. We used ArcGIS 10.1 to quantify the geographical access (distance and travel time) to the nearest available testing site for each test and show places with inadequate access, for targeted improvement. The journey time was calculated assuming a speed of 20 kilometres (km)/h. ArcMap 10.1 was employed to run spatial autocorrelation (Moran Index (MI)) to determine the spatial distribution of the facilities providing the tests investigated.

Results Of the 137 facilities, the glucose test was available in 67 (49%), the Hb test in 55 (40%), the Hep B test in 44 (32%), and the HIV test in 73 (53%). The mean (standard deviation (SD)) for obtaining glucose tests in the region was 7.4 ± 3.7 km, Hb was 8.1 ± 4.06 km, Hep B was 8.2 ± 4.1 km, and HIV test was 7.3 ± 3.7 km by a motorised cycle. The mean SD travel time in the region to obtain the glucose test was 94.4 ± 47.2 min compared to 95.7 ± 47.8 min for Hb, 95.9 ± 47.93 min for Hep B, and 92.7 ± 46.3 min for the HIV test. Three districts (Berekum East, Dormaa East, and Jaman North) recorded shorter distances (< 10 km) and a shorter travel time to the glucose, Hb, Hep B, and HIV tests compared to the Banda district, which recorded more than 10 km for all tests investigated. Positive IM values were recorded for all the POC tests, suggesting that the health facilities providing the glucose, Hb, Hep B, and HIV tests in the BR were spatially distributed at random.

*Correspondence:
Monica Ansu-Mensah
manvam3@yahoo.com

Full list of author information is available at the end of the article

Conclusions The findings revealed moderate access to all the tests in districts across the region. However, geographical access to glucose, Hb, Hep B, and HIV POC testing was poor (distance ≥ 10 km and travel time of ≥ 93 min), in the Banda district. This study showed the need to prioritise the Banda district for targeted improvement for all the tests. A further study is recommended to identify potential solutions to addressing the POC testing implementation in the BR, as demonstrated by this study.

Keywords POC tests, Geographical access, CHPS, Referral facilities

Introduction

Diabetes mellitus, human immunodeficiency virus (HIV), hepatitis B, and anaemia are major global public health concerns [1–6]. The World Health Organization (WHO) indicates that the number of people with diabetes rose from 108 million in 1980 to 422 million in 2014 [7, 8]. Between 2000 and 2019 there was a 3% increase in diabetes mortality rates by age 7, and in 2019 alone diabetes caused an estimated 2 million deaths [9, 10]. The WHO also estimated that 296 million people were living with chronic hepatitis B infection in 2019 (which resulted in an estimated 820,000 deaths), with 1.5 million new infections occurring each year [11, 12]. The WHO further estimated that 38.4 million people were living with HIV at the end of 2021 (and almost 650,000 people died from HIV-related causes), two-thirds of whom (25.6 million) are in the WHO African Region [13, 14]. Anaemia, according to the WHO 2023 report, affected approximately 40% of all children aged 6–59 months, 37% of pregnant women, and 30% of women 15–49 years of age globally in 2019 [15, 16].

Ghana, one of the sub-Saharan African countries (SSA) with high HIV prevalence, recorded 346,120 (1.7%) per the 2020 Sentinel Survey [17, 18]. Bono Region (BR) among the areas with the high prevalence in Ghana in 2019 [19] recorded the highest (4.2%) in 2020 [17]. Diabetes and HIV were among the top ten causes of death in Ghana in 2021 [20]. The prevalence of anaemia in pregnancy (at 36 weeks) was about 28.1% [21] in 2021. Moreover, the prevalence of Hepatitis B infection in 2019 was estimated at 9.1% [22].

Several efforts are being made to reduce the burden of diabetes, HIV, anaemia, and hepatitis B locally and internationally through the promulgation and implementation of policies. A global action plan was recommended with sets of indicators and targets for the prevention and control of non-communicable diseases (NCDs) including the rising diabetes prevalence [23]. Among these targets is the recommendation of the 80% availability of affordable basic technologies including diagnostics to strengthen the screening, monitoring, and management of diabetes [23]. The WHO Global Nutrition Policy also aims to reduce anaemia among women of reproductive age by 50% by 2025, as well as to monitor and evaluate the implementation of an anaemia control programme through diagnostics [24]. The Joint United Nations Programme on HIV/AIDS (UNAIDS), through its 95-95-95 programme, also targets to ensure 95% of HIV-positive people know their HIV status, of whom 95% receive sustained antiretroviral therapy, and of whom 95% have viral suppression by 2030 [25, 26]. The WHO guidelines and treatment of the chronic hepatitis B virus include the screening of all pregnant women, infants born to hepatitis B-positive mothers, and persons with HIV in all countries in Africa [27]. Again, the recent WHO update on the 2017 Guidelines on Hepatitis B, focussed on Hepatitis B Surface Antigen (Hep B) point-of-care (POC) viral load testing, among other tests, to combat hepatitis B [28].

Diagnostic tests aid accurate disease diagnosis and as such are considered a pillar of medicine through which most causative pathogens are identified and the safest treatment is given [29–33]. As a result, the WHO list of essential in-vitro diagnostics has recommended tests for all levels of care [34]. In Ghana healthcare facilities at the community level such as community-based health planning and service (CHPS) compounds and health centres are mostly facilities without laboratories. Hence POC tests (diagnostic tests are those administered near patients outside the laboratory) play an essential role in facilities without laboratories [35–37]. However, previous studies involving POC tests in Ghana evidenced the limited availability of POC tests in health facilities without laboratories [38, 39], mostly due to poor supply chain management and stock-outs [40], price (the cost of a test) [41], distance from the supply unit to the healthcare facility [42], and funding challenges [40]. In addition, studies that evaluated the geographical access to Glucose-6-phosphate dehydrogenase (G6PD) [42], tuberculosis [43], POC testing for hypertension diseases in pregnancy [44], and antenatal care POC [45] highlighted the poor physical access to these diagnostic tests in Ghana. Our survey in the BR of Ghana of WHO-recommended POC tests for health facilities without laboratories showed a poor availability of Glucose, Hb, Hep B, and HIV diagnostic tests [39]. Knowledge of the geographic access to these POC diagnostic tests (Hb, Hep B, and HIV) in the BR might be essential to inform targeted improvement and reduce the impact on patients of diabetes, anaemia, hepatitis B, and HIV. Therefore, this present study evaluated the geographical access to glucose, Hb, Hep B, and HIV diagnostic tests in the BR, Ghana.

Methods

Study design and study setting

This is a follow-up study on a cross-sectional survey previously carried out to describe the availability, stock levels and funding of POC diagnostic tests in 102 CHPS facilities from all the districts in the BR of Ghana [39]. Of the 102 facilities involved, glucose was 28 (27.4%), Hb was 20 (20%), Hep B was 8 (8%), and HIV was 38 (37.2%) available at CHPS [39]. The current study included 35 additional referral health facilities to the CHPS facilities in the region. The current study therefore mapped the geographical access to glucose, Hb, Hep B, and HIV POC testing services in the BR. A detailed description of the setting of this study has been provided in the cross-sectional study [39].

Study subject and sampling

Data collection procedure

This study used the data collected from the 102 CHPS for the previous cross-sectional study [39]. In addition, data on all 35 referral health facilities providing glucose, Hb, Hep B, and HIV testing in the region were obtained in July 2022. The spatial (geo-located data) and non-spatial data, e.g., the list of facilities from the Regional Health Directorate, and the availability of tests from facilities were collected. Open Data Kit (ODK) was installed on the researchers' phones to identify coordinates of all the participating facilities. The researchers cross-checked all the data from the Regional Health Directorate against that collected with the ODK app. Finally, Google Maps and the Ghana Post GPS app were employed to reconcile all discrepancies.

Variables and operational classifications

These were as follows:

Availability

The availability of healthcare facilities providing (any or all) glucose, Hb, Hep. B, and HIV testing services.

Distance

The nearness from a CHPS facility to the closest healthcare facility providing (any or all) glucose, Hb, Hep. B, or HIV testing service where ≤10 kilometres (km) is considered a short distance, and ˃ 10 km is considered a long distance.

Travel time

Approximated time to be spent by a patient travelling by a motorised tricycle from a CHPS facility to any referral healthcare facility in the BR for either glucose, Hb, Hep. B, or HIV testing where ≤60 min were considered the fastest travel time and ˃ 60 min were considered the longest travel time [43].

Statistical analysis and mapping

The researchers linked data on CHPS facilities, referral health facilities providing glucose, Hb, Hep B, and HIV tests, and the geographic coordinates of all the health facilities to the ArcGIS version 10.1 software and base map. All the 102 CHPS facilities from the previous cross-sectional survey were used as inputs to quantify the distance in km to the nearest healthcare facilities providing glucose, Hb, Hep B, and HIV tests in their specified area. The Euclidean distance from the CHPS facilities as well as from all areas in the BR to their nearest health facilities was calculated using the near function analysis tools in ArcGIS version 10.1. The researchers used an assumed speed of 20 km per hour of the most available and generally used public transport in the region commonly known as "Pragya" (a motor-powered tricycle) to estimate the travel time from all locations. The estimated distance and travel times for each of the CHPS to the nearest health facilities providing glucose, Hb, Hep B, and HIV testing services in the districts and all areas in the BR were exported to Stata version 17 software for analysis, where the mean and standard deviation (SD) were calculated and reported. A study showed that there is an association between the distance to healthcare facilities and better health outcomes for individuals [46]. The spatial autocorrelation (Moran's Index (MI)) of the health facilities providing Glucose, Hb, Hep B, and HIV diagnostic testing services and the z-score and p-value reported where MI ˂ 0 was considered as dispersed distribution, MI=0 was considered as randomly distributed, and MI ˃ 0 was considered as a clustered distribution. Hence, this study determines distances of ≤10 km to the nearest referral facility providing glucose, Hb, Hep B, and HIV screening tests as areas of good geographical accessibility.

Results

Characteristics of participating healthcare facilities

One hundred and thirty-seven (137) health facilities were included in this study, comprising 74.5% (102) CHPS facilities, 13% (18) healthcare centres, and 11% (15) and 1.4% (2) hospitals and clinics respectively. Of the 137 participating facilities, most 13% (18) were found in Sunyani West District, and few 4% (5) each were found in Banda and Dormaa West Districts. No hospital was found in the Banda District (Table 1).

Availability, and geographical access to glucose, Hb, Hep B, and HIV in the BR

Of all the tests included in the study involving 137 facilities, HIV was the most available 73 (53%) compared to 44 (32%) Hep B tests found in the facilities. Sunyani West recorded the highest number of facilities with glucose tests 9 (13%), Hb 8 (14%), and Hep B 6 (14%) whilst Wenchi District had the highest number of facilities 12 (16%)

Table 1 Characteristics of included facilities in the districts

Name of district	No. of CHPS	Clinics	Health-care centres	Hospitals	Total
Banda	3	0	2	0	5
Berekum East	7	2	0	1	10
Berekum West	4	0	1	1	6
Dormaa East	7	0	1	1	9
Dormaa Central	10	0	3	1	14
Dormaa West	4	0	0	1	5
Jaman North	9	0	1	1	11
Jaman South	13	0	1	1	15
Sunyani	12	0	0	2	14
Sunyani West	12	0	3	3	18
Tain	10	0	3	1	14
Wenchi	11	0	3	2	16
Total	102	2	18	15	137

with HIV tests. Dormaa West had the fewest number of glucose tests 1 (1.5%) Hb 2 (4%), and HIV 1 (1.4%), and Berekum West, Dormaa West, and Sunyani had the fewest facilities 5 (5%) each with Hep B tests. Apart from Dormaa West which had 1 facility providing glucose or HIV tests, at least 2 facilities in every district provide glucose, Hb, Hep B, and HIV POC diagnostic testing.

Of all tests, Hep B was the poorest 44 (23%) accessible test found within 10 km compared to 73 (58%) of HIV. Dormaa Central, Jaman South, and Sunyani West had the highest number of facilities 6 each found within 10 km providing glucose tests. Most facilities found within 10 km of local CHPS to access Hb and Hep B were from Sunyani West. However, Banda District had a few facilities accessible within 10 km for all tests (Table 2).

Approximated distance to obtain the Hb, Hep B and HIV tests

The analysis showed that the mean and SD distance to a CHPS facility and the nearest referral facility providing the following POC tests in the region was approximately 7.4±3.7 km - glucose, 8.1±4.1 km - Hb, 8.2±4.1 km – Hep B, and 7.3±3.6 km – HIV (Fig. 1).

Of the 12 districts, Dormaa East District had the shortest mean distance to obtain the glucose test (4.9±2.4 km) and Banda District recorded the longest mean distance to obtain the glucose test (13.3±6.7 km) (Fig. 1A). Jaman North District had the shortest mean distance to obtain the Hb test (4.6±2.3 km), whereas Banda District had the longest mean distance to obtain the Hb test (13.78±68.9 km) (Fig. 1B). Whilst Jaman North District had the shortest mean distance to obtain the Hep B test (4.6±2.3 km), Banda District had the longest mean distance to a health facility offering Hep B testing (12.4±6.2 km) (Fig. 1C). Berekum East District had the shortest distance to obtain an HIV test with a mean and SD of 4.02±2.01 km, while Banda District recorded the longest distance with a mean and mean distance of 13.45±6.73 km (Fig. 1D).

Approximated travel time to obtain the Hb, Hep B and HIV tests

The analysis showed the mean and SD travel time to a health facility providing the following POC tests in the region: glucose was 94.4±47.2 min, Hb was 95.6±47.8 min, Hep B was 95.9±47.9 min, and HIV was 92.7±46.3 min (Fig. 2). Of the 12 districts, Dormaa East had the shortest mean travel time (56.0±28.0 min) to a facility providing glucose tests, and Banda District had the longest mean travel time (146.4±73.2 min) to a facility providing glucose testing (Fig. 2A). Jaman North District had the shortest mean travel time of 58.0±29.0 min

Table 2 Distribution of the number of facilities, and CHPS 10 km to referral facilities

	Total number of facilities with tests in the districts:				No. of CHPS, 10 km to referral facilities providing:			
Name of district	Glucose	Haemoglobin (Hb)	Hepatitis B surface antigen (Hep. B)	HIV	Glucose test	Hb test	Hep. B test	HIV test
Banda	4	4	3	3	1	1	1	1
Berekum East	4	5	3	3	5	3	2	3
Berekum West	5	5	2	5	3	2	1	4
Dormaa East	5	3	3	6	4	2	1	6
Dormaa Central	6	5	5	7	6	3	2	6
Dormaa West	1	2	2	1	1	1	1	1
Jaman North	7	6	5	6	5	3	3	5
Jaman South	7	4	3	7	6	4	2	6
Sunyani	4	2	2	4	3	2	1	3
Sunyani West	9	8	6	10	6	4	4	8
Tain	8	7	5	9	5	2	2	6
Wenchi	7	5	6	12	5	3	3	9
Total	**67**	**56**	**44**	**73**	**50**	**30**	**23**	**58**

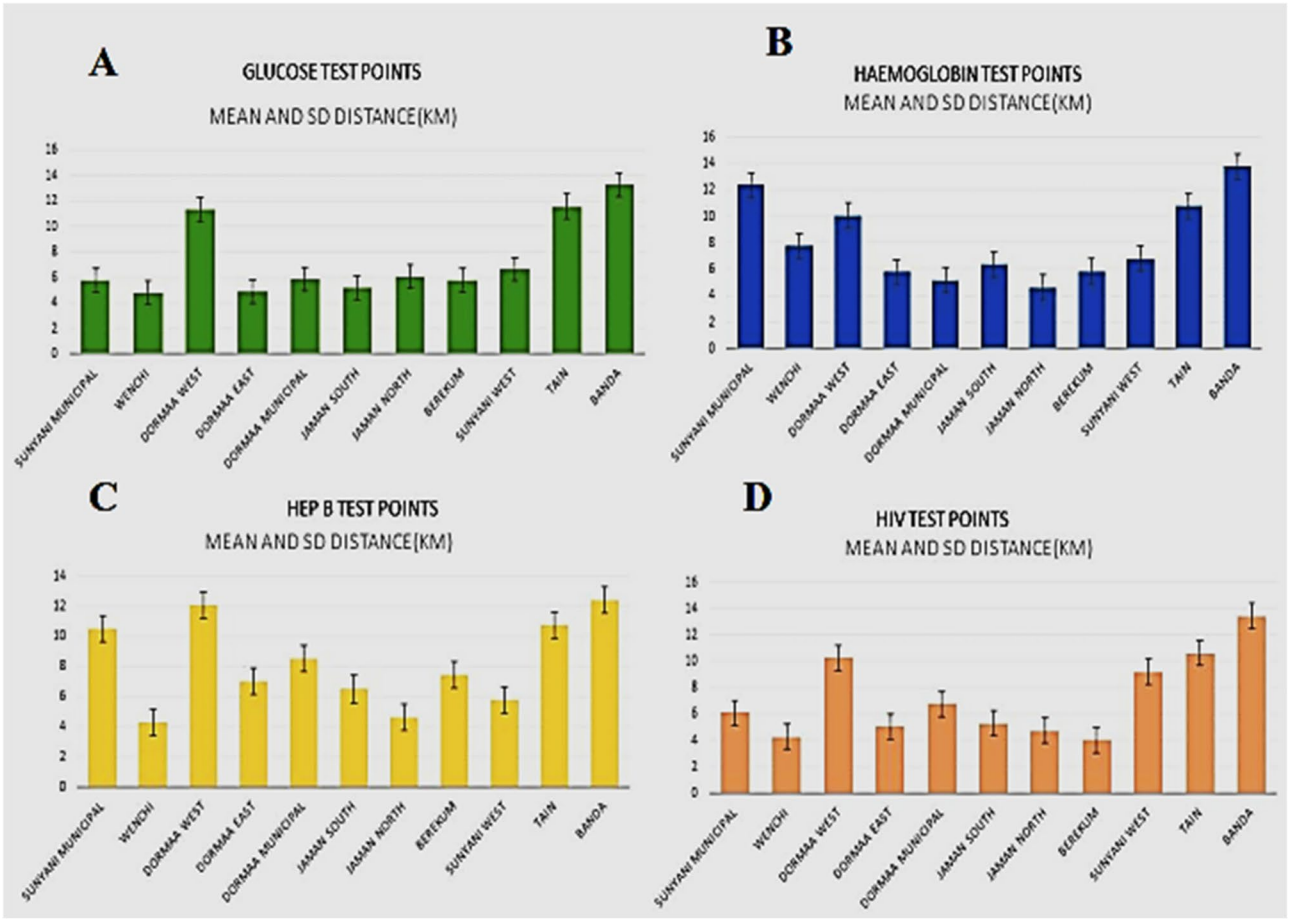

Fig. 1 Mean and Standard Deviation (SD) of distance from CHPS to the nearest health facility providing tests

to obtain the Hb test from a facility, and Banda District had the longest mean travel time of 155.0±77.5 min to obtain the Hb test from the nearest facility (Fig. 2B). Jaman North District had the shortest mean travel time (53.4±26.7 min) to obtain a Hep B test from a facility, while Banda District had the longest mean travel time of 149.0±74.5 min to a facility providing Hep B testing (Fig. 2C). Berekum East District had the shortest mean time travel (45.1±22.6 min) to obtain an HIV test from a facility, and Banda District had the longest mean time travel (149.0±74.5 min) to a facility offering HIV testing (Fig. 2D).

Spatial accessibility to glucose, Hb, Hep B, and HIV POC diagnostic tests

Figure 3 shows the spatial autocorrelation analysis of health facilities providing glucose, Hb, Hep B, and HIV tests in the BR. The MI values for all the tests included in this study were positive. The results were as follows: glucose was MI=0.22; z-score=0.25; *p*-value=0.80 (Fig. 3A); Hb was MI=0.14; z-score=0.17; *p*-value=0.87 (Fig. 3B); Hep B was MI=0.35; z-score=0.39; *p*-value=0.70 (Fig. 3C); and HIV test was MI=0.87; z-score=0.94; *p*-value=0.35 (Fig. 3D). These positive IM values imply that the health facilities providing glucose, Hb, Hep B, and HIV tests and POC tests were randomly distributed in the BR.

Discussions

The study aimed to determine the geographical accessibility to POC testing for glucose, Hb, Hep B, and HIV in the BR of Ghana. It revealed the poor and varied geographical accessibility of glucose, Hb, Hep B, and HIV testing services in the region. However, Banda District had the longest distance and travel time to access all the tests.

A similar study by Schols et al. aimed at evaluating access to POC diagnostics revealed limited and varying access to POC testing coupled with low availability [47]. Limited access to POC testing was also evidenced by the Subic et al. study that investigated how to improve access to therapy in Hepatitis B patients [48]. Another study on an overview of POC testing for Hep B by Xiao et al. accords with the Subic et al. study which evidenced limited access to Hep B testing [49]. Xiao et al. further stated that few Hep B POC tests have been ratified and

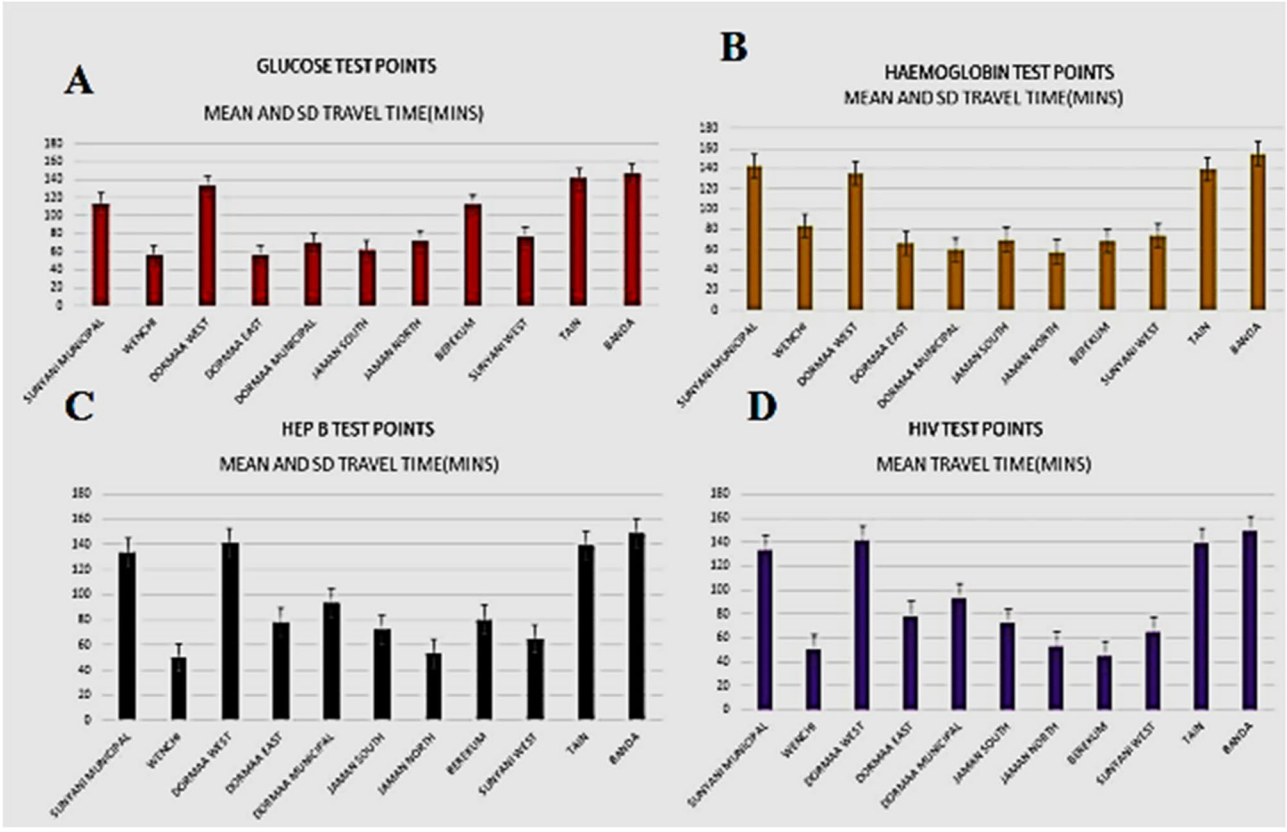

Fig. 2 Mean and SD travel times from CHPS to the nearest health facility providing diagnostic tests

approved by international regulatory bodies for clinical use [49]. This study's results also support the evidence revealed by a study that documented the implementation gap in Hepatitis B infection control in Ghana [50]. The Pascom et al. study conducted in Brazil on HIV POC testing by peers also revealed that reaching a key population where they live increases access to POC testing [51]. The only study on the topic of geographical accessibility to POC tests that was found indicates that the closer the POC tests are located to the population to be served, the more the utilisation of it [36]. It also found that geographical information systems enable us to compare the effectiveness of POC test implementation strategies and put into perspective the benefits of its adoption into health networks [36].

This study also reveals that the health facilities providing the POC tests included were spatially distributed at random. Although no study was found in Ghana reporting on the geographical accessibility to glucose, Hb, Hep B, or HIV, similar studies have assessed the geographical access to health facilities for tuberculosis [43], G6PD deficiency [42], Blood Group, and Rhesus Type POC testing for comprehensive antenatal services in Northern Ghana and reported poor accessibility and, random spatial distribution with district variation [52].

The study demonstrated variations in the distance of obtaining glucose, Hb, Hep B, and HIV testing. Distance to obtaining the Hep B test was the longest (8.2±4.1 km), compared to the distance to obtaining glucose (7.4±3.7 km), Hb (8.1±4.1 km), and HIV (7.3±3.6 km) in the region. Only four districts (Berekum East, Dormaa East, Jaman North, and Wenchi) recorded mean distances less than 10 km to health facilities providing glucose, Hb, Hep B, and HIV tests compared to Banda district which recorded more than 10 km (ranging between 12.4±6.2 km and 13.8±6.9 km) for all the testes. These results connote geographical barriers to accessing POC tests which may affect the health outcomes of individuals especially, compulsory maternal screening in the Banda District where few facilities were found (Fig. 4). Poor geographical access to POC testing for glucose, Hb, Hep B, and HIV evidenced by this present study may have possible consequences on Ghana's CHPS core mandate of removing healthcare accessibility barriers as programmed by the Ghana Health Service. Healthcare professionals in low-resource settings may result in treatment by clinical judgment without knowledge about blood-sugar levels, Hb levels, and whether infection such as Hepatitis B or HIV is present. This will automatically delay the right treatment regime which can consequently

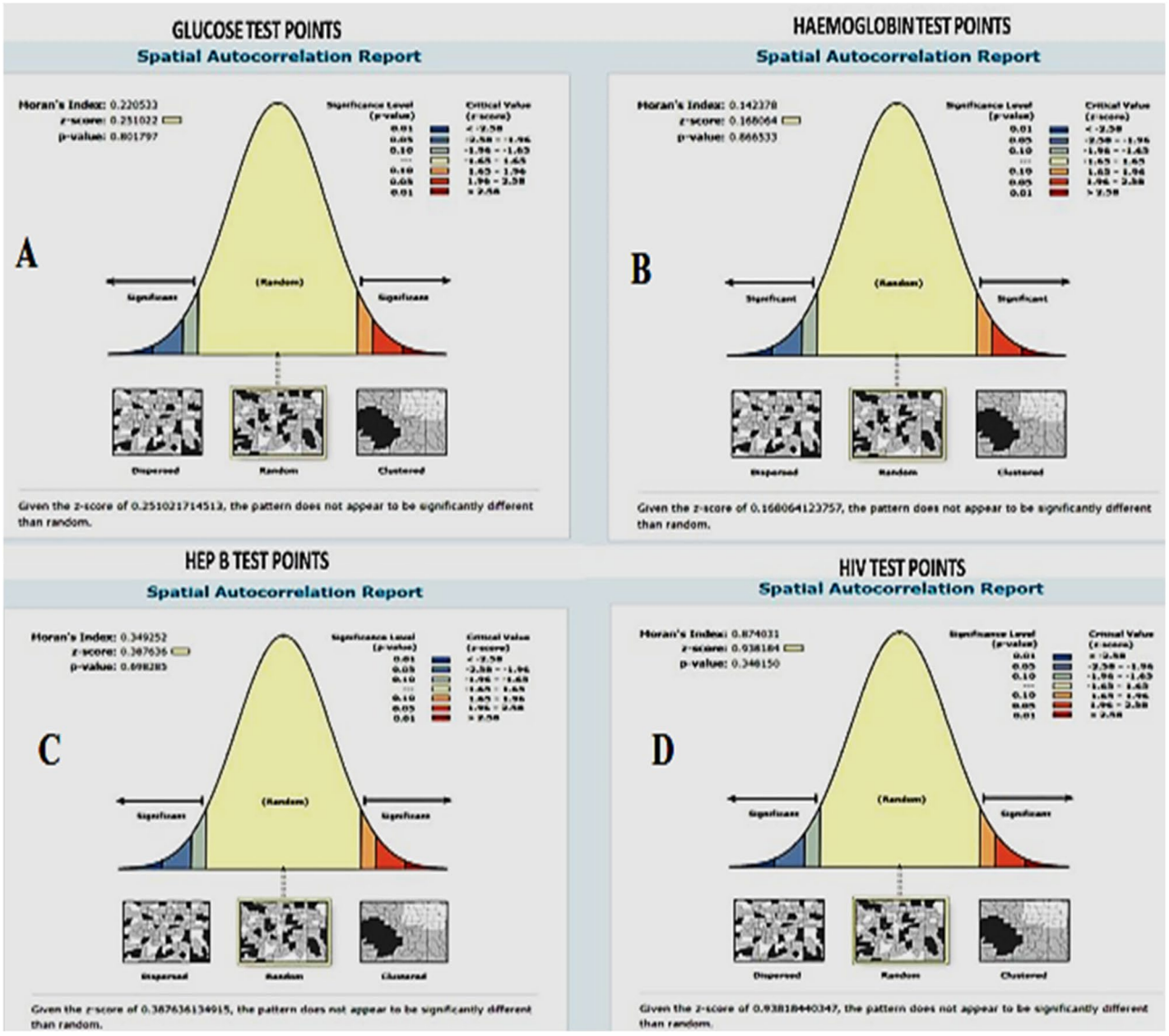

Fig. 3 Spatial autocorrelation analysis of health facilities providing glucose, Hb, Hep B, and HIV tests

result in severe complications and subsequent premature deaths.

The distance to glucose testing sites might account for the high burden of diabetes in the region, as many patients in the rural areas may not be able to afford the cost of the transport and its associated challenges such as the long travel time to the referral units [45]. Hb screening is critical in diagnosing gestational diabetes [53]. Therefore, it is possible that much of the anaemia in 36 weeks of pregnancy recorded in the area might be related to a lack of screening and might contribute to maternal deaths. For instance, a study found that the lack of a Hb POC test readily accessible at an antenatal and obstetric clinic to identify all anaemia cases and to facilitate postpartum haemorrhage management increases maternal mortality [37]. Improving the poor geographical access to glucose and Hb POC testing as shown in Fig. 4 in the region, especially in, the Banda District, will help improve the health outcomes of individuals. Poor Hb POC testing may also imply that blood transfusion prescriptions may not be supported by Hb results. Conversely, in severe malaria cases, anaemia not detected early may cause premature death, especially during pregnancy. Ghana is known to be a region where malaria is endemic, and there is a high prevalence of sickle cell in SSA [54,55]. Anaemia is common in areas of high malaria transmission due to reduced Hb concentration, particularly among pregnant women, the aged and children with sickle cell [55]. Although about 55% of the facilities with Hb tests were within 10 km, there is still room for improvement. Therefore, scaling up Hb testing in the region and implementing it into the malaria control programme would help

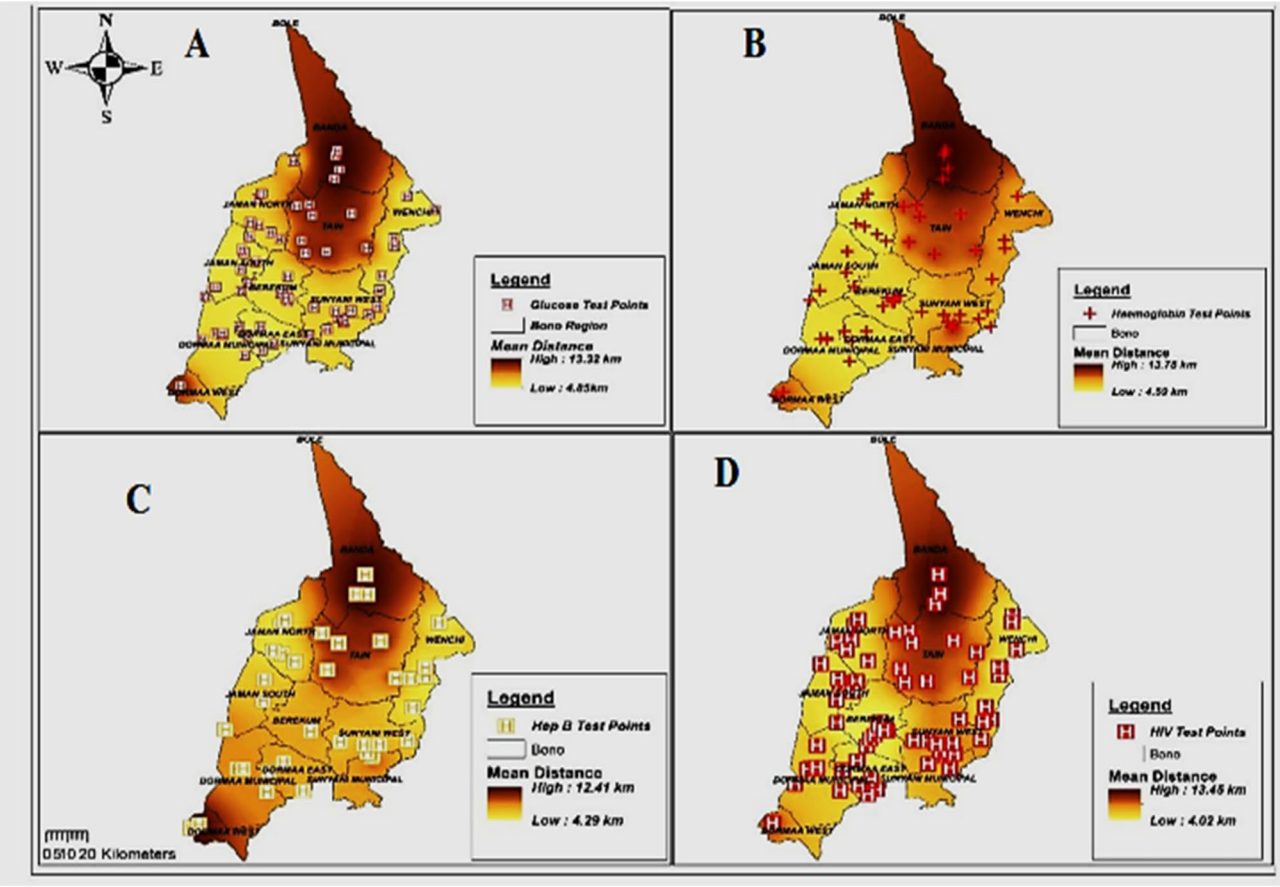

Fig. 4 Distribution of distance (km) from all residential areas to health facilities providing tests

improve the health outcomes of individuals. In severe maternal cases, like postpartum haemorrhage, the presence of Hb POC testing would save travel time, especially in rural areas, and would be conducive to early detection and management.

Moreover, poor geographical access could hamper Hep B and HIV screening for pregnant women for the prevention of mother-to-child transmission. The long distance to treatment centres and the travel time involved, as shown in Figs. 4 and 5, might have added to the prevalence of Hepatitis B infection. Therefore, interventions such as pre-exposure prophylaxis may not be introduced because patients may fail to do tests at referral facilities due to the long turnaround time, the lack of a means of transport, and the exorbitant fares. This may consequently affect the health outcomes of the mother and the newborn child in addition to increasing the prevalence of Hepatitis B infection.

Though the participants in this study included many stakeholders from relevant healthcare facilities and depots there were still limitations in their selection. Other key stakeholders such as the clients were excluded, and the clients' perspective on geographical access to POC tests is therefore still not known. Also, the present study analysed the use of only one mode of transport (Pragya) to referral facilities and failed to assess the cost-benefit analysis of alternative means of transport.

Poor geographical access to glucose, Hb, Hep B, and HIV POC tests might account for the high maternal mortality rate in the region as well as poor health outcomes. However, providing glucose, Hb, Hep B, and HIV POC tests near used communities would enhance the early detection of diseases for proper case management and improve the health outcomes of rural populations, as well as contribute to the SDGs target of UHC.

Conclusion and recommendation

The implementation of POC testing for glucose, Hb, Hep B, and HIV would help to achieve SDG target 3.8, which seeks to ensure universal health coverage and improve access to quality health care. Screening from referral facilities may have financial and economic implications such as the costs of transportation to the referral facilities, delays in reaching the facilities due to the long distances to be covered and time it takes to travel such distances, the poor road network, and long waiting times at main laboratories. These issues may also influence patients' expectations. To address the shortcomings

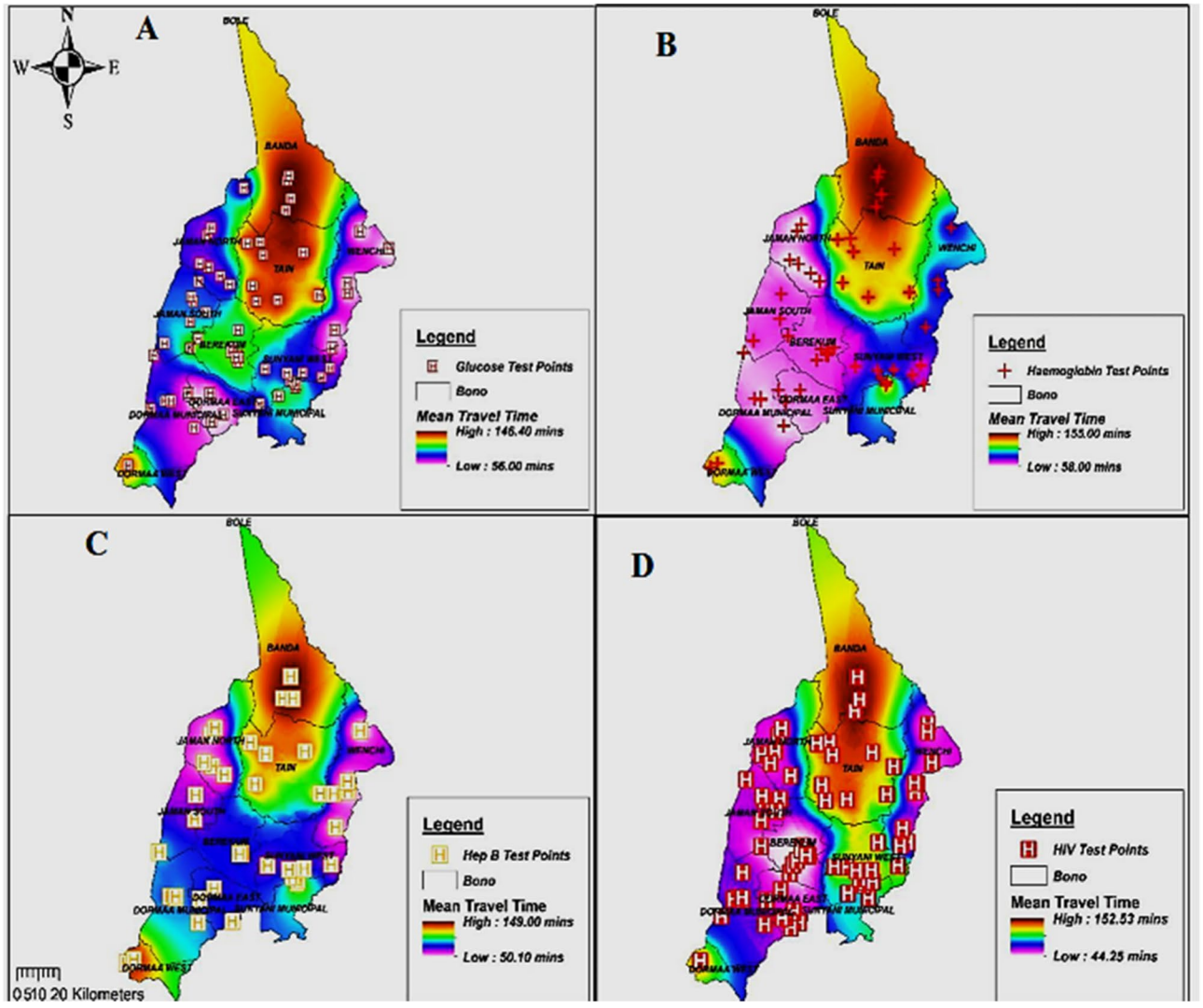

Fig. 5 Distribution of travel time (mins) from all residential areas to health facilities providing tests

with regards to the provision of POC testing services for glucose, Hb, Hep B, and HIV and to prevent presumptive treatment by healthcare professionals towards improving patients' health outcomes. We strongly recommend the scale-up of the provision of POC diagnostic testing services close to rural communities in low-resource settings in the BR of Ghana. Again, a POC testing scale-up for glucose, Hb, Hep B, and HIV in the rural districts of BR is recommended to improve essential healthcare services in the areas of diagnosis, monitoring, management/treatment, and surveillance. Locations with poor geographical access (long distance ≥ 10 km, and long travel time ≥ 60 min) such as the Banda and Dormaa West Districts should be prioritised in the POC testing implementation to promote easy access to POC testing service in those communities. As recommended by the WHO for the national adaptation and prioritisation of POC tests, we recommend that POC testing accessibility for glucose, Hb, Hep B, and HIV should be improved in the rural setting, with consideration being given to the issue of the distance to user communities, improve service delivery.

Abbreviations

CHPS	Community health-based planning and services
G6PD	Glucose-6-phosphate dehydrogenase
Hb	Haemoglobin
Hep B	Hepatitis B surface antigen
HIV	Human immunodeficiency virus
MI	Maron's Index
NCDs	Non-communicable diseases
PHC	Primary healthcare
POC	Point-of-care
SD	Standard deviation
SDGs	Sustainable development goals
SSA	Sub-Saharan Africa
UHC	Universal health coverage
WHO	World Health Organisation

Acknowledgements

We owe a debt of gratitude to the Health Economics and HIV and AIDS Research Division Scholarship, The Swedish International Development

Cooperation Agency, and the entire staff of the Discipline of Public Health Medicine, University of KwaZulu-Natal, Durban, South Africa for their diverse support and assistance.

Institutional Review Board Statement
We followed the guidelines of the Declaration of Helsinki. We obtained approval for the study (GHS-ERC:018/03/22), and (BREC/00004499/2022) from the Ghana Health Service Review Ethics Committee, and the Biomedical Research Ethics Committee of the University of KwaZulu-Natal respectively.

Authors' contributions
MA-M and DK conceptualized the study. The study's methodology was developed by MA-M, DK, and TGG. Data was collected by MA-M as well as analyzing and writing of the original draft. SKA Assisted in the geographical and spatial analysis of results and reviewed by MSS. Critical reviews and editing were done by VB, DK, and TGG. All authors read and agreed on the final prepared manuscript.

Funding
No external funding was obtained for this research.

Data availability
Data for this study remains the property of the Ghana Health Service Review Ethics Committee (GHSREC), and the University of KwaZulu-Natal and cannot be made publicly available. All interested readers can access the data set from the GHSREC, and the University of KwaZulu-Natal Biomedical Research Ethics Committee (BREC) from the following contacts: The chairperson, Ghana Health Service Review Ethics Committee, Research & Development Division, Ghana Health Service, P. O. 190, Accra. Digital Address: GA-050-3303, Mob.: +233 503539896 Tel.: +233 302 681109 Email: ethics.research@ghsmail.org. The Chairperson, BREC Administration Research Office, Westville Campus, Govan Mbeki Building, University of KwaZulu-Natal, Private Bag X54001, Durban 4000, South Africa. Or Tel: +27 312604769 Or Fax: +27 31260 4609 Or Email: BREC@ukzn.ac.za.

Declarations

Ethics approval and consent to participate
Ethical approval was obtained from the Ghana Health Service Ethics Review Committee (Approval Number: GHS-ERC:018/03/22), and the University of KwaZulu-Natal Biomedical Research Ethics Committee (approval number: BREC/00004499/2022) after a review of this study protocol for ethical issues and all necessary permissions issued to the concerned health authorities. Therefore, a gatekeeper's permit was provided by the Bono Regional Health Directorate of Ghana to conduct this study. All participants signed informed consent forms before enrolling in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Discipline of Public Health Medicine, School of Nursing and Public Health, University of KwaZulu-Natal, Durban 4001, South Africa
[2]Sunyani Technical University Clinic, Sunyani, Bono Region, Ghana
[3]Cancer & Infectious Diseases Epidemiology Research Unit (CIDERU), College of Health Sciences, University of KwaZulu-Natal, Durban, South Africa
[4]Department of Health Information Management, Christian Health Association of Ghana, Accra, Ghana
[5]Department of Health Services Management and Administration, School of Business, SD Dombo University of Business and Integrated Development Studies, Wa, Ghana
[6]Department of Global Health and Sustainability, Faculty of Health Sciences, Durban University Technology, Durban, South Africa

Received: 7 June 2023 / Accepted: 23 October 2024
Published online: 29 October 2024

References

1. Frempong MT, Ntiamoah P, Annani-Akollor ME. Hepatitis B and C infections in HIV-1 and non-HIV infected pregnant women in the Brong-Ahafo Region, Ghana. PLoS ONE. 2019;14(7):e0219922.
2. Agyeman AA, Ofori-Asenso R. Prevalence of HIV and Hepatitis B coinfection in Ghana: a systematic review and meta-analysis. AIDS Res Ther. 2016;13:23.
3. Palmer T, Aiyenigba AO, Bates I. Improving the effectiveness of point of care tests for malaria and anaemia: a qualitative study across three Ghanaian antenatal clinics. BMC Heal Serv Res. 2020;20(444):1–13.
4. Ayensu J, Annan R, Lutterodt H. Prevalence of anaemia and low intake of dietary nutrients in pregnant women living in rural and urban areas in the Ashanti region of Ghana. PLoS ONE. 2020;15(1):e0226026.
5. Allali S, Brousse V, Sacri AS. Anemia in children: prevalence, causes, diagnostic work-up, and long-term consequences. Expert Rev Hematol. 2017;10(11):1023–8.
6. Chaparro CM, Suchdev PS. Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. Ann N Y Acad Sci. 2019;1450(1):15–31.
7. World Health Organisation. Key Fact: Diabetes 2023. https://www.who.int/news-room/fact-sheets/detail/diabetes.
8. Nazir MA, AlGhamdi L, AlKadi M. The burden of diabetes, its oral complications and their Prevention and Management. Open Access Maced J Med Sci. 2018;6(8):1545–53.
9. Koye DN, Magliano DJ, Nelson RG. The global epidemiology of diabetes and kidney disease. Advanc Chronic Kidn Diseas. 2018;25(2):121–32.
10. Mirjalili H, Dastgheib SA, Shaker SH, Bahrami R, Mazaheri M, Sadr-Bafghi SMH, et al. Proportion and mortality of Iranian diabetes mellitus, chronic kidney disease, hypertension and cardiovascular disease patients with COVID-19: a meta-analysis. J Diabetes Metab Disord. 2021;20(1):905–17.
11. World Health Organisation, Global Hepatitis Report. 2017 Geneva [https://www.who.int/publications/i/item/9789241565455.
12. World Health Organisation. Key Fact: Hepatitis B2022 12 May 2023. https://www.who.int/news-room/fact-sheets/detail/hepatitis-b.
13. Kirichenko A, Kireev D, Lopatukhin A. Prevalence of HIV-1 drug resistance in eastern European and central Asian countries. PLoS ONE. 2022;17(1):e0257731.
14. World Health Organisation. HIV and AIDS: Key facts 2023 [updated 12 May 2023.
15. World Health Organisation. Anaemia 2023. https://www.who.int/health-topics/anaemia#tab=tab_1.
16. Accelerating anaemia reduction: A comprehensive framework for action. Geneva: World Health Organisation. 2023. Contract No.: Licence: CC BY-NC-SA 3.0 IGO.
17. Ghana News Agency. Bono Region Records highest HIV Prevalence in 2020. 2021 [cited 2023]. https://gna.org.gh/2021/11/bono-region-records-highest-hiv-prevalence-in-2020/.
18. Boah M, Yeboah D, Kpordoxah MR, Issah AN, Adokiya MN. Temporal trend analysis of the HIV/AIDS burden before and after the implementation of antiretroviral therapy at the population level from 1990 to 2020 in Ghana. BMC Public Health. 2023;23(1):1399.
19. Ghana Health Service. 2019 HIV Sentinel Survey Report. 2019.
20. World Health Organisation. Health data overview for the Republic of Ghana 2024 [https://data.who.int/countries/288].
21. Asare-tabi G. 2021 Half Year Performance Ranking Bono Region. 2021.
22. World Health Organisation. Renewed hope for all people living with viral hepatitis in Ghana 2023 [https://www.who.int/news-room/feature-stories/detail/renewed-hope-for-all-people-living-with-viral-hepatitis-in-ghana#].
23. Grabowski D, Aagaard-Hansen J, Willaing I. Principled Promotion of Health: implementing five Guiding Health Promotion principles for Research-based Prevention and Management of Diabetes. Societies. 2017;7(2):10.
24. World Health Organisation. Global Nutrition Targets 2025: anaemia policy Geneva 2014 [https://www.who.int/publications-detail-redirect/WHO-NMH-NHD-14.4].
25. Klatt EC. Pathology of HIV/AIDS 2022.
26. Arora N, Quaife M, Hanson K. Discrete choice analysis of health worker job preferences in Ethiopia: separating attribute non-attendance from taste heterogeneity. Health Econ. 2022;31(5):806–19.
27. Terrault NA, Lok ASF, McMahon BJ. Update on prevention, diagnosis, and treatment of chronic hepatitis B: AASLD 2018 hepatitis B guidance. Hepatology. 2018;67(4):1560–99.
28. World Health Organization. WHO announces the update of hepatitis B guidelines on testing and treatment 2023 [updated May 7 2023]. https://www.

who.int/news/item/29-04-2023-who-announces-the-update-of-hepatitis-b-guidelines-on-testing-and-treatment.
29. Hui Chen KL, Zhao, Li. Ping Wang. Point of Care Testing for Infectious Diseases. 2019.
30. Garcia-Basteiro AL, DiNardo A, Saavedra B. Point of care diagnostics for tuberculosis. Pulmono. 2018;24(2):73–85.
31. Patient G, Action S. Towards eliminating avoidable harm in health care2021.
32. World Health Organisation. The WHO Model List of Essential In Vitro Diagnostics (EDL) https://www.who.int/medical_devices/diagnostics/selection_in-vitro/en/2020.
33. Global Patient Safety action. Plan 2021–2030: towards eliminating avoidable harm in health care. Geneva: World Health Organisation; 2021.
34. World Health Organisation. Second WHO Model List of Essential In Vitro Diagnostics2019 (Licence: CC BY-NC-SA 3.0 IGO.):[1–52 pp.]. Available from: WHO/MVP/EMP/2019.05.
35. Moran Z, Sacks JA, Frimpong FK. Performance of the BD-FACS presto for CD4 count and hemoglobin measurement in a district hospital and rural laboratory in Ghana. PLoS ONE. 2019;14(2):e0212684.
36. Ferguson WJ, Kemp K, Kost G. Using a geographic information system to enhance patient access to point-of-care diagnostics in a limited-resource setting. Int J Health Geogr. 2016;15(1):1–12.
37. Uyoga S, George EC, Bates I. Point-of-care haemoglobin testing in African hospitals: a neglected essential diagnostic test. Briti Journ Haemato. 2021;193(5):894–901.
38. Kuupiel D, Tlou B, Bawontuo V. Accessibility of pregnancy-related point-of-care diagnostic tests for maternal healthcare in rural primary healthcare facilities in Northern Ghana: a cross-sectional survey. Heliy. 2019;5(2):e01236–e.
39. Ansu-Mensah M, Kuupiel D, Bawontuo V, Ginindza TG. Availability, stock levels and usage of In-vitro diagnostics in the Bono region, Ghana: a cross-sectional study. Afr J Prim Health Care Fam Med. 2023;15(1):e1–10.
40. Kuupiel D, Boikhutso T, Vitalis B. Poor supply chain management and stock-outs of point-of-care diagnostic tests in Upper East Region's primary healthcare clinics, Ghana. PLoS ONE. 2019;14(2):1–15.
41. Kuupiel D, Bawontuo V, Mashamba-thompson TP. Improving the accessibility and Efficiency of Point-of-Care Diagnostics Services in low-and Middle-Income countries: lean and agile supply Chain Management. Diagnost MDPI. 2017;7(58):1–14.
42. Kuupiel D, Adu KM, Bawontuo V. Geographical accessibility to glucose-6-Phosphate Dioxygenase Deficiency Point-of-care testing for Antenatal Care in Ghana. Diagnos MDPI. 2020;10(4).
43. Kuupiel D, Adu KM, Apiribu F. Geographic accessibility to public health facilities providing tuberculosis testing services at point-of-care in the upper east region, Ghana. BMC Publi Healt. 2019:1–12.
44. Kuupiel D, Adu KM, Bawontuo V. Geographical access to point-of-care testing for hypertensive disorders of pregnancy as an integral part of maternal healthcare in Ghana. BMC Pregn Childbi. 2020;6:1–9.
45. Kuupiel D, Manu K, Bawontuo V. Geographical accessibility to District Hospitals / Medical Laboratories for Comprehensive Antenatal Point-of-Care Diagnostic Services in the Upper East. EClinicalMedi. 2019;13:74–80.
46. Kelly C, Hulme C, Farragher T. Are differences in travel time or distance to healthcare for adults in global north countries associated with an impact on health outcomes? A systematic review. BMJ Open. 2016;6(11):e013059.
47. Schols AM, Stevens F, Zeijen CG. Access to diagnostic tests during GP out-of-hours care: a cross-sectional study of all GP out-of-hours services in the Netherlands. Eur J Gen Pract. 2016;22(3):176–81.
48. Subic M, Zoulim F. How to improve access to therapy in hepatitis B patients. Liver Int. 2018;38(Suppl 1):115–21.
49. Xiao Y, Thompson AJ, Howell J. Point-of-care tests for Hepatitis B: an overview. Cells. 2020;9(10):1–18.
50. Abesig J, Chen Y, Wang H. Prevalence of viral hepatitis B in Ghana between 2015 and 2019: a systematic review and meta-analysis. PLoS ONE. 2020;15(6):e0234348.
51. Pascom AR, Dutra de Barros CH, Lobo TD. Point-of-care HIV tests done by peers, Brazil. Bull World Health Organ. 2016;94(8):626–30.
52. Kuupiel D, Adu KM, Bawontuo V. Estimating the spatial accessibility to Blood Group and Rhesus Type Point-of-care testing for Maternal Healthcare in Ghana. MDPI Diagnost. 2019;9(175):1–14.
53. Sissala N, Mustaniemi S, Kajantie E. Higher hemoglobin levels are an independent risk factor for gestational diabetes. Sci Rep. 2022;12(1):1686.
54. Oppong M, Lamptey H, Kyei-Baafour E. Prevalence of sickle cell disorders and malaria infection in children aged 1–12 years in the Volta Region, Ghana: a community-based study. Malar J. 2020;19(1):426.
55. White NJ. Anaemia and malaria. Malar J. 2018;17(1):371.

Publisher's Note