Heliyon

Received:
12 July 2018
Revised:
25 December 2018
Accepted:
11 February 2019

Cite as: Desmond Kuupiel, Boikhutso Tlou, Vitalis Bawontuo, Tivani P. Mashamba-Thompson. Accessibility of pregnancy-related point-of-care diagnostic tests for maternal healthcare in rural primary healthcare facilities in Northern Ghana: A cross-sectional survey. Heliyon 5 (2019) e01236. doi: 10.1016/j.heliyon.2019.e01236

Accessibility of pregnancy-related point-of-care diagnostic tests for maternal healthcare in rural primary healthcare facilities in Northern Ghana: A cross-sectional survey

Desmond Kuupiel [a,*], **Boikhutso Tlou** [a], **Vitalis Bawontuo** [b], **Tivani P. Mashamba-Thompson** [a]

[a] *Department of Public Health Medicine, School of Nursing and Public Health, University of KwaZulu-Natal, Durban, South Africa*

[b] *Faculty of Health and Allied Sciences, Catholic University College of Ghana, Fiapre, Sunyani, Ghana*

[*] Corresponding author.

E-mail address: desmondkuupiel98@hotmail.com (D. Kuupiel).

Abstract

Background: Improving access to maternal healthcare in resource-limited settings plays a critical role in improving maternal health outcomes and reducing maternal deaths. However, barriers and challenges may exist in rural clinics and could affect successful implementation. This study assessed the current accessibility of pregnancy-related point-of-care (POC) diagnostic tests for maternal healthcare in rural primary healthcare (PHC) clinics in northern Ghana.

Method: We randomly selected 100 PHC clinics providing maternal healthcare from a total list of 356 PHC clinicss obtained from the Regional Health Directorate. Selected clinics were surveyed from February to March 2018, using an adopted survey tool. We obtained data for clinic-level staffing, availability, usage, and desired POC diagnostic tests. Stata 14 was used for data analysis.

Findings: Majority (64%) of the respondents were midwives. The mean ± standard deviation (SD) years of work experience and working hours per week were

https://doi.org/10.1016/j.heliyon.2019.e01236

estimated at 5.6 years ± 0.4 and 122 hours ± 5.2 respectively. Average antenatal clinic attendance (clinic census) per month was 65 ± 67 pregnant women (Range: 3−360). The mean ± SD POC tests available and use was 4.9 tests ± 2.2. POC tests for malaria, HIV, urine pregnancy, and blood pressure monitoring devices were available in most clinics. POC tests requested by the clinics to assist them care for pregnant women included: Glucose-6-phosphate dehydrogenase (95%); hepatitis C (94%); sickling (91%); tuberculosis, blood glucose and blood type (89%) each; urinary tract infection (87%); urine protein (81%); hepatitis B (78%); haemoglobin (76%); and syphilis (76%).

Interpretation: There is poor accessibility to pregnancy-related POC diagnostic tests for maternal healthcare due to low availability (≤5 tests per PHC clinic) of POC tests in rural PHC clinics in northern Ghana.

Keywords: Health profession, Public health, Obstetrics and gynecology, Reproductive medicine

1. Introduction

Reduction of maternal mortality is a high priority for the Government of Ghana (GOG) as well as globally [1, 2]. In 2015, it was estimated that 99% of maternal deaths occurred in low- and middle-income countries (LMICs) of Sub-Saharan Africa and Asia [3, 4, 5]. In Ghana, the maternal mortality ratio in 2015 was estimated to be 319/100000 live births [2, 3, 4]. Though Ghana's maternal mortality ratio is lower compared to other countries in LMICs such as, Guinea (604), Liberia (607), and Mauritania (428) per 100000 live births, it is still unacceptably higher than international averages [1, 5]. Improving access to maternal healthcare, especially in resource-limited settings is essential to reduce maternal deaths [2, 6, 7, 8]. In the light of this, Ghana, in her quest to achieve the United Nations Sustainable Development Goal (SDG) 3.1 (reducing maternal mortality to less than 70 per 100000 live births [9]), has expanded maternal healthcare services to primary healthcare (PHC) facilities such as the sub-district health centres and community-based health planning and services (CHPS) zones/compounds. However, studies have shown that rural health facilities often lack laboratory infrastructure to facilitate point-of-care (POC) testing and prompt disease management [10, 11, 12, 13].

Access to POC diagnostic tests therefore critically bridges the gap for diagnostic services in rural PHC clinics, not only for maternal healthcare, but also for the general population [12, 14, 15, 16]. The introduction of POC diagnostics in resource-constrained rural health facilities has been demonstrated to improve healthcare access and patient outcomes [17, 18, 19, 20, 21]. Early diagnosis of disease conditions or infections such as pre-eclampsia, haemorrhage, HIV, syphilis, and linkage to care during pregnancy, has improved maternal and neonatal health outcomes [1, 22, 23,

https://doi.org/10.1016/j.heliyon.2019.e01236

24, 25, 26]. To this extent, diagnostics plays an essential role in advancing universal health coverage, addressing health emergencies, and promoting healthier populations [27]. In recognition of this, the World Health Organization (WHO) created a model list of essential in vitro diagnostics (EDL) [27], including diagnostic tests for resource-limited PHC clinics.

Despite the critical role access to POC diagnostics plays in healthcare, coupled with improved availability of WHO prequalified POC diagnostics and guidelines for their use in resource-limited settings [28, 29, 30], barriers and challenges for successful implementation do exist [12, 31, 32, 33, 34, 35, 36]. Hence, access to POC testing may not be evenly provided in rural PHC clinics and could potentially result in limited access to vital healthcare services [34, 35, 37, 38, 39]. Identifying and addressing potential barriers and challenges is essential to facilitate implementation of sustainable POC diagnostic services at the PHC level for both maternal healthcare and the general population. The level of POC diagnostics accessibility, availability, usage and desired POC tests for maternal healthcare as well as for the general population in PHC facilities in Ghana is not known. Moreover, it is mandatory for pregnant women in Ghana to be screened and tested for the following: haemoglobin level, HIV, sickle cell, Glucose-6-phosphate dehydrogenase (G6PD), syphilis, and blood type. Pregnant women in Ghana also undergo screening for malaria, other sexually transmitted infections such as gonorrhea and chlamydia, urine protein for proteinuria, blood pressure monitoring, urine and stool for routine examinations, as well as ultrasound scans, depending on the stage of the pregnancy at the first ANC visit [40, 41]. We therefore assessed the current accessibility of pregnancy-related POC diagnostic tests for maternal healthcare in rural PHC facilities in Northern Ghana, focusing on competency of clinical staff, their experience, POC diagnostic tests availability, and usage of available POC tests. It is anticipated that the results of this study will be useful to the GOG, development partners, non-governmental organizations in health, donors, and diagnostics developers to improve access to POC diagnostic services for maternal health in rural PHC clinics. It is also hoped that the results of this study will help the GOG implement and sustain new POC tests in rural healthcare facilities throughout the country.

2. Methods

2.1. Ethical consideration

This study was approved by the Navrongo Health Research Centre Institutional Review Board/Ghana Health Service (approval number: NHRCIRB291) and the University of KwaZulu-Natal Biomedical Research Ethics Committee (approval number: BE565/17). Permission was obtained from the Upper East Regional Health Directorate prior to conducting the study. All study participants signed an informed

https://doi.org/10.1016/j.heliyon.2019.e01236

consent prior to participating in this study. Data for this study are the property of the University of KwaZulu-Natal and can be made available publicly. All interested researchers/readers/persons who meet the criteria to access confidential data can access the dataset via Dr Tivani Mashamba-Thompson, the project supervisor and the Academic Leader (Research) for the School of Nursing and Public Health via this email address: Mashamba-Thompson@ukzn.ac.za. Data access may also be requested from the University of KwaZulu-Natal Biomedical Research Ethics Committee (BREC) from the following contacts: The Chairperson Biomedical Research Ethics Administration Research Office, Westville Campus, Govan Mbeki Building University of KwaZulu-Natal P/Bag X54001, Durban, 4000 KwaZulu-Natal, South Africa Tel.: +27 31 260 4769 Fax: +27 31 260 4609 Email: BREC@ukzn.ac.za.

2.2. Study design, sample size, and sampling

We conducted a cross-sectional survey of PHC clinics in the Upper East Region (UER) of Ghana. We obtained a list of 356 PHC clinics rendering antenatal care from the Upper East Regional Health Directorate (RHD) of the Ghana Health Service (GHS). We randomly chose a weight-based sample of 100 PHC clinics from all the 13 districts in the region. To ensure uniformity of sampled clinics in all the districts, the following procedure was used: The clinics were first grouped into 13 clusters, with each cluster representing a district in the region. After this, we stratified the clinics into two strata. The first stratum comprised of 232 clinics with antenatal clinic attendance $\leq$100 per month, whilst the second stratum consisted of 124 clinics with antenatal clinic attendance $\geq$100 per month. Probability proportionate to size (PPS) was used to determine the proportion of clinics to be selected from each cluster and stratum, using this formula: $nh=(Nh/N)\times n$ [7], where nh is the sample size for cluster h, Nh the population size for cluster h, N the total population size and n is the total sample size. Based on this, 65 clinics were to be sampled from the first stratum and 35 clinics from the second stratum. Proportionate stratification was also applied to obtain the total number of clinics to be sampled from stratum one and two in each of the 13 strata (Table 1). Finally, a simple random sampling technique was used to draw the clinics for the study. Convenient sampling was however, used to select the respondents for the study.

2.3. Data collection

Data were collected from February to March, 2018, using an adopted POC diagnostics survey tool from Mashamba-Thompson et al., 2016 [7]. The survey tool (Supplementary file 1) was pre-tested in ten non-participatory rural PHC clinics in the UER and adjusted to suit the local context based on feedback from respondents. We surveyed each selected clinic and collected data on clinic type, ownership, number of health professionals' available, category of health professionals available, and

https://doi.org/10.1016/j.heliyon.2019.e01236

Table 1. Distribution of sampled PHC clinics for this study.

Name of district	PHC clinics population (Cluster)	No. with ANC attendance <100 (Stratum 1)	No. with ANC attendance≥100 (Stratum 2)	No. from stratum 1	No. from stratum 2	No. of clinics included
Bawku Municipal	19	12	7	3	2	5
Bawku West	34	19	15	5	4	9
Binduri	12	5	7	1	2	3
Bolgatanga Municipal	38	21	17	6	5	11
Bongo	43	32	11	9	3	12
Builsa North	18	13	4	4	1	5
Builsa South	18	11	7	3	2	5
Garu-Tempane	58	43	15	12	4	16
Kasena-Nankana Municipal	27	16	11	4	3	7
Kasena-Nankana West	37	24	13	7	4	11
Nabdam	12	7	5	2	1	3
Pusiga	14	8	6	2	2	4
Talensi	26	21	5	6	1	7
Total	**356**	**232**	**124**	**65**	**35**	**100**

work experience of the respondents. We also took data on the average number of pregnant women seen per month and the respondent average available working hours per week to determine the health facility characteristics. Data on POC diagnostics availability, usage, and future needs for POC tests were obtained from the respondents in order to measure the accessibility of POC diagnostic services in the UER, using the survey tool. Data on pregnancy-related POC diagnostic tests needed by the clinics to aid diagnosis at the clinic and facilitate their work were also obtained. We obtained the average monthly antenatal clinic attendance of each of the clinics in the region as recorded in the District Health Information Management System from the RHD.

2.4. Outcomes measures

The primary outcome of the study included: availability of POC tests for maternal healthcare, and use of the available POC diagnostic tests in the PHC clinics in UER, Ghana. The secondary outcome of this study was to ascertain the current POC diagnostic tests needed to help with early disease detection during pregnancy and prompt linkage to care.

2.5. Data analysis

Availability of diagnostic tests was determined as follows: 11−15 tests = high availability; 6−10 tests = average availability and 1−5 = low availability.

https://doi.org/10.1016/j.heliyon.2019.e01236

Responses on POC usage were analysed using a 0−100% score scale, where '100% = I do use' and '0% = I do not use'. Data were processed in Microsoft Excel and exported to Stata statistical software, version 14, for all analyses. Frequencies, means, standard deviations (SD) and 95% confidence intervals were generated for responses.

3. Results

3.1. Clinic and respondent characteristics

Table 2 shows the characteristics of the selected PHC clinics and the respondents in this study. The survey recorded a 100% response rate from the staff in the selected PHC clinics in the region. A total of 959 health professionals were found in all 100

Table 2. Description of 100 primary healthcare clinics surveyed in Upper East Region.

Variable	**Frequency (N = 959)**		
Staffing (Clinical staff)	**Number (n)**	**Percentage (%)**	**Range**
Number of Physician Assistants	37	3.9	0−2
Number of Midwives	124	12.9	0−6
Number of General Nurses	178	13.6	0−13
Number of Community Health Nurses	288	30	1−11
Number of Health Assistants (Clinical)	271	28.3	0−13
Number of Laboratory Technician/Assistants	38	4	0−2
Number of Dispensary Technician/Assistants	23	2.4	0−2

Clinic attendance	**Mean (Standard deviation)**	**95% Confidence Interval**
Average ANC attendance (clinic census)	65 clients ±67	52−78

Characteristics of respondents

N = 100	**Frequency (n)**	**Proportion**
Midwives	64	0.64
Community Health Nurses	29	0.29
Physician Assistants	4	0.04
Health Assistants (Clinical)	3	0.03

	Mean (Standard deviation)	**95% Confidence Interval**
Work experience (Years)	5.6 ± 0.4	4.8−6.3
Average working hours	122.2 ± 5.2	111.9−132.6

https://doi.org/10.1016/j.heliyon.2019.e01236

clinics with Community Health Nurses being the majority (30%) and Dispensary Technicians/Assistants being the minority (2.4%). The mean ± SD antenatal clinic attendance (Clinic census) per month was 65 clients ±67 (95%CI: 52−78). Majority (64%) of the respondents were Midwives, whilst only 3% of the respondents were Health Assistants (Clinical). Respondents mean ± SD years of working experience and number of working hours per week was 5.6years ± 0.4 (95%CI: 4.8−6.3) and 122hours ± 5.2 (95%CI: 111.9−132.6) respectively. No form of electronic option of communicating test results from referral clinics/hospitals was found in the PHC clinics surveyed.

3.2. Availability of POC diagnostic tests in the PHC clinics

Majority (78%) of the clinics reported low (≤5 tests) availability of POC diagnostic tests, whilst 18% reported average (6−10 tests) availability. Only 4% reported high (≥11 tests) availability of POC tests. The average number of POC diagnostic tests available in the PHC clinics was 4.9 tests ± 2 (95% CI: 4.5−5.4). POC tests that were available in almost all the PHC clinics surveyed were: malaria rapid (96%); HIV (93%); and urine pregnancy (90%). Syphilis and haemoglobin tests were available in only 24% of the PHC clinics surveyed. Diagnostic tests that were poorly (available in less than 10 % of the surveyed clinics) available in the 100 participated PHC clinics in this survey were: sickling (9%), hepatitis C (6%), blood type (4%), and tuberculosis (3%). Glucose-6-phosphate dehydrogenase (G6PD) enzyme deficiency test was not available in all selected PHC clinics for this survey. The study found an uneven availability of POC tests across the 13 districts. For instance, whilst the haemoglobin test was available in 50% (8/16) and 38.5% (5/13) of the PHC clinics in the Garu-Tempane and Bongo districts respectively, none of the PHC clinics in Binduri district, Bolgatanga, and Kasena Nankana Municipals were providing haemoglobin POC testing services. Table 3 shows the distribution of available diagnostic tests for all PHC clinics surveyed in the 13 districts.

3.3. Use of available POC diagnostic tests in the PHC clinics

This study found that all available POC diagnostic tests in all the 100 PHC clinics were being use. The average number of POC diagnostic tests in use was 4.9 tests ± 2 (95% CI: 4.5−5.4). Frequency of a POC test usage depended on the daily clinic attendance and the availability of the test. The following tests: G6PD, hepatitis C, sickle cell, blood type, blood glucose, tuberculosis, urinary tract infection, urine protein; hepatitis B, haemoglobin, and syphilis tests were shown to be largely unavailable in majority of the PHC clinics. However, majority of the clinics showed desire to have these diagnostic tests to assist them with diagnosing, monitoring, prompt linkage to care as well as reduce referral

https://doi.org/10.1016/j.heliyon.2019.e01236

Table 3. Distribution of available diagnostic tests for all PHC clinics surveyed in the 13 districts (N = 100).

Test	Total number of clinics test is available	Bongo (n = 13)	Bawku West (n = 10)	Kasena Nankana Municipal (n = 8)	Kasena Nankana West (n = 10)	Builsa North (n = 5)	Builsa South (n = 5)	Garu-Tempane (n = 16)
Haemoglobin	24	5	2	0	1	1	1	8
Blood glucose	10	2	2	0	2	1	0	1
HIV	93	11	9	7	9	4	4	16
Syphilis	24	1	0	2	2	2	2	7
Hepatitis B	21	2	0	2	2	2	0	5
Hepatitis C	6	1	0	1	2	1	0	1
Sickle cell	9	3	1	0	2	2	0	0
Blood type	4	1	1	0	0	0	0	0
G6PD	0	0	0	0	0	0	0	0
Malaria	96	12	9	8	9	5	5	16
Tuberculosis	3	0	1	0	0	0	0	1
Urine pregnancy	90	11	9	6	10	4	4	14
Urinary tract infection	13	3	1	1	2	2	0	1
Urine proteinuria	19	3	1	1	1	1	2	6

Test	Total number of clinics test is available	Pusiga (n = 4)	Bawku Municipal (N = 5)	Binduri (N = 3)	Nabdam (N = 3)	Talensi (N = 7)	Bolgatanga Municipal (N = 11)
Haemoglobin	24	2	2	0	1	1	0
Blood glucose	10	1	0	0	0	0	1
HIV	93	4	5	3	3	7	11
Syphilis	24	2	1	1	2	1	1
Hepatitis B	21	2	0	1	1	3	2
Hepatitis C	6	0	0	0	0	0	0
Sickle cell	9	0	0	0	0	0	1
Blood type	4	0	0	0	0	0	2
G6PD	0	0	0	0	0	0	0
Malaria	96	3	5	3	3	7	11
Tuberculosis	3	1	0	0	0	0	0
Urine pregnancy	90	4	5	3	3	7	10
Urinary Tract Infection	13	0	0	0	1	0	2
Urine proteinuria	19	1	0	0	1	0	2

https://doi.org/10.1016/j.heliyon.2019.e01236

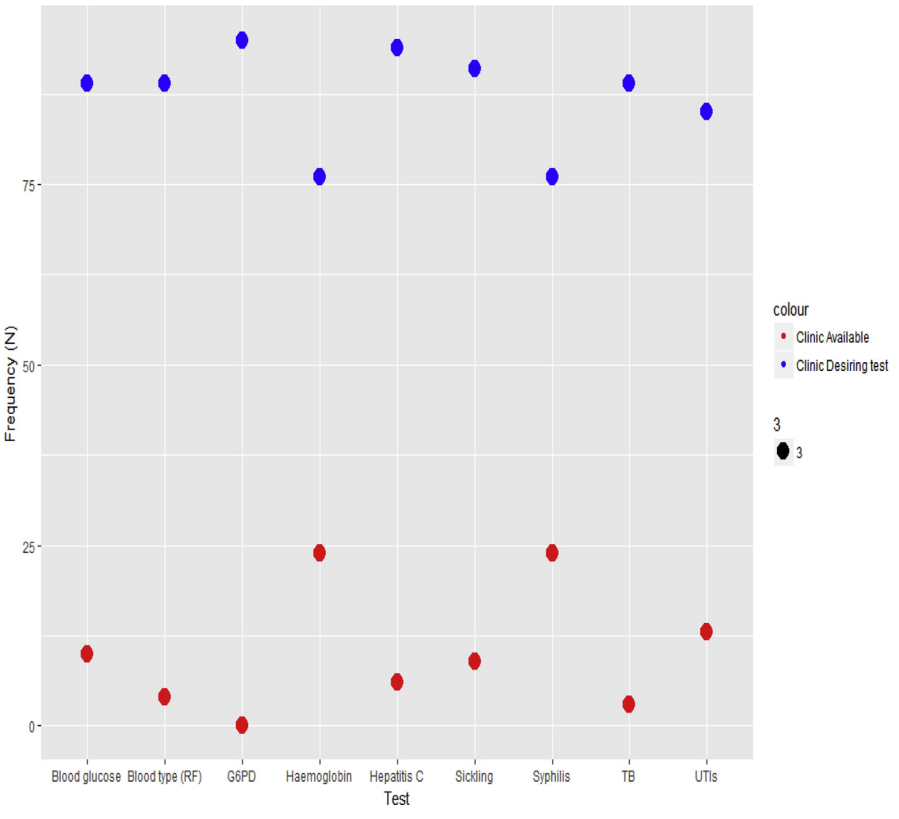

Fig. 1. Scatter plot of nine poorly available diagnostic tests and the number of clinics in need of these tests.

of patients/clients to higher level health facilities for a diagnostic test, as shown in Fig. 1. The average number of POC test requested by the clinics was 9.9 tests ±2.2 (95% CI: 9.4−10.3).

4. Discussion

Accessibility to POC diagnostic services for maternal healthcare may be influenced by factors such as availability of a test, usage of the test, availability of required human resources, cost of the test, socioeconomic characteristics of the client, and sometimes cultural practices [31]. However, we assessed the accessibility of pregnancy-related POC diagnostic tests for maternal healthcare in rural PHC clinics in the UER of Ghana, focusing particularly, on availability and usage of POC tests. This study results showed availability of pregnancy-related POC diagnostic tests in the UER's PHC clinics was low. POC tests for malaria, HIV, and pregnancy, were generally available and used in a majority of the rural PHC clinics in the region. Disparity in the availability of POC diagnostic tests across the 13 districts in the region was also revealed by this study. This study finding further showed that usage of POC diagnostic tests in the PHC clinics by the caregivers was directly proportional to

https://doi.org/10.1016/j.heliyon.2019.e01236

the number of tests available in each clinic. Moreover, the findings of this survey revealed a high number of POC diagnostic tests which were poorly available needed by the PHC clinics to assist them in the management of expectant mothers. These findings support the call to improve the quality of maternal healthcare in lower healthcare facilities [8].

The current survey results partially support the findings from a similar POC diagnostic survey conducted in rural PHC clinics in South Africa [35]. Mashamba-Thompson et al.'s study also revealed poor POC diagnostic accessibility, availability and usage in South Africa's rural PHC clinics [35]. Their study additionally demonstrated high POC test need in PHC clinics to facilitate decision making by healthcare workers for patient care [35]. Conversely, our study refuted their study findings, which found widely available and regular use of kidney function, urinary tract infection, and blood glucose POC tests in rural clinics throughout the KwaZulu-Natal province in South Africa [35]. However, our study findings disagreed with a study done in a high-income country that aimed to establish conditions for POC testing most useful to UK general practitioners for diagnosis, reduction of referrals, and monitoring of chronic conditions [42]. Turner et al.'s study reported that the most frequently cited conditions were urinary tract infections for diagnosis, pulmonary embolism/deep vein thrombosis for referral reduction, and international normalized ratio/anticoagulation for monitoring [42], which are in contrast with current study findings.

This study provides evidence-based information on the accessibility of pregnancy-related POC diagnostic tests in rural Ghana PHC clinics, to help improve as well as guide future implementation of POC diagnostic services for maternal healthcare. To the best of our knowledge, this study is the first comprehensive research to assess the accessibility of pregnancy-related POC diagnostic tests for maternal health in Ghana, covering more than one POC test. It aided the determination of the current availability, use, and needed POC diagnostic tests for antenatal care in rural PHC clinics in the UER, which could help guide POC diagnostic service implementers and policy makers in the region and in Ghana, as a country. In addition, this study will serve as a baseline for future research into POC diagnostic services in rural Ghana's PHC clinics. Notwithstanding these strengths, there are limitations worth noting. This study's data collection methodology was limited in its ability to determine the cause(s) of poor availability of POC tests in the clinics. The survey tool also did not include demographic characteristics of respondents, such as age, to help tie in the respondents' age with their years of experience as health professionals. Moreover, the study failed to include pregnant women to determine their side of POC diagnostics accessibility, such as the location and distance of health facilities for POC diagnostic services, traveling time, and the cost involved in accessing POC testing. This information is worthwhile, as it can guide implementers on the most beneficial interventions and POC tests to prioritize

https://doi.org/10.1016/j.heliyon.2019.e01236

during the implementation of new POC tests and to ensure sustainability of POC diagnostic services.

The 2008 Ghana Demographic and Health Survey stated that "the healthcare that a mother receives during pregnancy, at the time of delivery, and soon after delivery is important for the survival and well-being of both the mother and her child" [43]. Therefore, one way of achieving an improvement in the health of pregnant women and their unborn babies is by improving access to pregnancy-related POC diagnostic tests during ANC and delivery in rural PHC clinics, in line with WHO recommendations [27]. The establishment of a country level EDL, as encouraged by the WHO, is very much needed now, especially for resource-limited and rural PHC clinics, and work on Ghana's EDL ought to begin now [27]. Poor accessibility of POC diagnostic tests for maternal care, as shown in this study, could potentially affect Ghana's quest to achieve SDG 3.1, which is aimed to reduce maternal mortality to less than 70 deaths per 100000 live births [9], as well as realizing universal health coverage. Antenatal care has been included by the WHO as one of the 16 essential health service indicators of the level of universal health coverage [44]. In view of this, an urgent supply of these essential POC diagnostic tests is crucial to address the unmet needs of pregnant women in rural and resource-limited settings. To ensure the successful supply of essential POC diagnostic tests to these rural PHC clinics, adequate supply chain management is vital. Whilst we recommend the adoption of a proposed lean and agile framework for improving the accessibility and efficiency of POC diagnostic services in LMICs [31], a parallel primary study to audit the supply chain management of rural PHC clinics is recommended. Further research to assess the role of the geographical location of the PHC clinics, distance and traveling time, as well as cost, to the nearest referral hospital for comprehensive ANC POC diagnostic services is also highly recommended. In addition, efforts to enable appropriate implementation of future POC tests for maternal healthcare in rural PHC clinics in the UER are essential.

5. Conclusion

This study has revealed poor accessibility of pregnancy-related POC diagnostic tests and the need to scale up POC tests in rural PHC clinics in the UER due to low availability of POC tests. Availability of POC tests in the UER's PHC clinics therefore, is a major challenge for successful implementation of POC diagnostic tests in these facilities. Hence, conscious efforts are required by major stakeholders such as: the Ministry of Health, GHS, local and international organizations, and donors, to increase procurement and supply of available WHO prequalified POC diagnostic tests to rural PHC clinics in the region. A study to assess the spatial accessibility of poorly available diagnostic tests in PHC clinics such as tuberculosis and G6PD tests is recommended.

https://doi.org/10.1016/j.heliyon.2019.e01236

Declarations

Author contribution statement

Desmond Kuupiel: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Boikhutso Tlou: Contributed analysis tools or data.

Vitalis Bawontuo: Conceived and designed the analysis; Contributed analysis tools or data.

Tivani P Mashamba-Thompson: Conceived and designed the analysis; Analyzed and interpreted the data; Contributed analysis tools or data.

Funding statement

This work was supported by the University of KwaZulu-Natal, College of Health Sciences Research Scholarship.

Competing interest statement

The authors declare no conflict of interest.

Additional information

Supplementary content related to this article has been published online at https://doi.org/10.1016/j.heliyon.2019.e01236.

Acknowledgements

We are thankful to the University of KwaZulu-Natal for providing us with essential research resources during the course of this study. The authors are also grateful to all the PHC members of staff who participated in this study. The authors would like to thank the authorities of the Upper East Regional Health Directorate, the District Health Management Teams, and all the rural PHC managers for granting us permission to conduct this study. Finally, we would like to thank the staff of the Department of Public Health Medicine for their diverse support.

References

[1] E.M. Der, C. Moyer, R.K. Gyasi, A.B. Akosa, Y. Tettey, P.K. Akakpo, et al., Pregnancy related causes of deaths in Ghana: a 5-year retrospective study,

Ghana Med. J. 47 (4) (2013) 158−163. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3961851/.

[2] E.K. Ameyaw, R.E. Kofinti, F. Appiah, National health insurance subscription and maternal healthcare utilisation across mothers' wealth status in Ghana, Health Econ. Rev. 7 (1) (2017) 16.

[3] World Health Organization, World health statistics 2016: monitoring health for the SDGs sustainable development goals, World Health Organization, 2016. https://www.who.int/gho/publications/world_health_statistics/2016/en/.

[4] United Nattions Development Progrmme, Ghana Millennium Development Goals Report: 2015 Report, United Nattions Development Progrmme, Ghana, 2015. http://www.gh.undp.org/content/dam/ghana/docs/Doc/Inclgro/UNDP_GH_2015%20Ghana%20MDGs%20Report.pdf.

[5] N.J. Kassebaum, R.M. Barber, Z.A. Bhutta, L. Dandona, P.W. Gething, S.I. Hay, et al., Global, regional, and national levels of maternal mortality, 1990−2015: a systematic analysis for the Global Burden of Disease Study 2015, Lancet 388 (10053) (2016) 1775−1812.

[6] World Health Organisation, WHO recommendations on antenatal care for a positive pregnancy experience, WHO Press, Geneva, 2016. Available from: http://www.who.int/nutrition/publications/guidelines/antenatalcare-pregnancy-positive-experience/en/.

[7] T. Mashamba-Thompson, P. Drain, B. Sartorius, Evaluating the accessibility and utility of HIV-related point-of-care diagnostics for maternal health in rural South Africa: a study protocol, BMJ Open 6 (2016).

[8] P.A. Afulani, Determinants of stillbirths in Ghana: does quality of antenatal care matter? BMC Pregnancy Childbirth 16 (1) (2016) 132.

[9] SDGs, UN, United Nations Sustainable Development Goals, 2015. http://www.un.org/sustainabledevelopment/news/communications-material/.

[10] M.L. Mugambi, K.M. Palamountain, J. Gallarda, P.K. Drain, Exploring the Case for a Global Alliance for Medical Diagnostics Initiative, Diagnostics (Basel) 7 (1) (2017).

[11] E.O. Udjo, P. Lalthapersad-Pillay, Estimating maternal mortality and causes in South Africa: national and provincial levels, Midwifery 30 (2014).

[12] N.P. Pai, C. Vadnais, C. Denkinger, N. Engel, M. Pai, Point-of-care testing for infectious diseases: diversity, complexity, and barriers in low-and middle-income countries, PLoS Med. 9 (2012).

https://doi.org/10.1016/j.heliyon.2019.e01236

[13] C.A. Petti, C.R. Polage, T.C. Quinn, A.R. Ronald, M.A. Sande, Laboratory medicine in Africa: a barrier to effective health care, Clin. Infect. Dis. 42 (2006).

[14] A. MacKinney, A. Coburn, J. Lundblad, T. McBride, K. Mueller, S. Watson, Access to Rural Health Care—A Literature Review and New Synthesis. Policy Report Rupri, Rural Policy Research Institute, 2014. https://www.rupri.org/?library=access-to-rural-health-care-a-literature-review-and-new-synthesis-report-prepared-by-the-rupri-health-panel-august-2014.

[15] R. McNerney, Diagnostics for developing countries, Diagnostics 5 (2015).

[16] P.K. Drain, N.J. Garrett, The arrival of a true point-of-care molecular assay—ready for global implementation? Lancet Glob Health 3 (2015).

[17] D.C. Mabey, K.A. Sollis, H.A. Kelly, A.S. Benzaken, E. Bitarakwate, J. Changalucha, et al., Point-of-care tests to strengthen health systems and save newborn lives: the case of syphilis, PLoS Med. 9 (6) (2012) e1001233.

[18] A. Smith, M. Sabidó, E. Camey, A. Batres, J. Casabona, Lessons learned from integrating simultaneous triple point-of-care screening for syphilis, hepatitis B, and HIV in prenatal services through rural outreach teams in Guatemala, Int. J. Gynecol. Obstet. 130 (Supplement 1) (2015) S70—S72.

[19] G. Alemnji, J.N. Nkengasong, B.S. Parekh, HIV testing in developing countries: What is required? Indian J. Med. Res. 134 (6) (2011) 779.

[20] É.M. Ansbro, M.M. Gill, J. Reynolds, K.D. Shelley, S. Strasser, T. Sripipatana, et al., Introduction of syphilis point-of-care tests, from pilot study to national programme implementation in Zambia: a qualitative study of healthcare workers' perspectives on testing, training and quality assurance, PLoS One 10 (6) (2015) e0127728.

[21] W. Stevens, N. Gous, N. Ford, L.E. Scott, Feasibility of HIV point-of-care tests for resource-limited settings: challenges and solutions, BMC Med. 12 (1) (2014) 173.

[22] T.P. Mashamba-Thompson, R.L. Morgan, B. Sartorius, B. Dennis, P.K. Drain, L. Thabane, Effect of Point-of-Care Diagnostics on Maternal Outcomes in Human Immunodeficiency Virus—Infected Women: Systematic Review and Meta-analysis, Point Care 16 (2) (2017) 67—77. https://europepmc.org/articles/pmc5726275.

[23] L. Myer, D. Wilkinson, C. Lombard, K. Zuma, K. Rotchford, S.A. Karim, Impact of on-site testing for maternal syphilis on treatment delays, treatment

https://doi.org/10.1016/j.heliyon.2019.e01236

rates, and perinatal mortality in rural South Africa: a randomised controlled trial, Sex. Transm. Infect. 79 (2003).

[24] S.A. Nogueira, J.S. Lambert, A.L. Albuquerque, R. Rodrigues, S. Reis, R. Bornia, et al., Assessment of a rapid HIV test strategy during labor: a pilot study from Rio de Janeiro, Brazil J. Hum. Virol. 4 (2000). https://europepmc.org/abstract/med/11907385.

[25] R.E. Bonawitz, J. Duncan, E. Hammond, L. Hamomba, J. Nambule, K. Sambambi, et al., Assessment of the impact of rapid syphilis tests on syphilis screening and treatment of pregnant women in Zambia, Int. J. Gynaecol. Obstet. 130 (Suppl 1) (2015) S58−S62.

[26] M.D.S. Shephard, B.C. Mazzachi, A.K. Shephard, K.J. McLaughlin, B. Denner, G. Barnes, The impact of point of care testing on diabetes services along Victoria's Mallee track: results of a community-based diabetes risk assessment and management program, Rural Rem. Health 5 (2005).

[27] World Health Organization, World Health Organization Model List of Essential In Vitro Diagnostics, first ed., World Health Oraganization, Geneva, 2018, 2018 2018, https://www.who.int/medical_devices/diagnostics/WHO_EDL_2018.pdf.

[28] D. Mabey, R.W. Peeling, A. Ustianowski, M.D. Perkins, Diagnostics for the developing world, Nat. Rev. Microbiol. 2 (2004). https://www.nature.com/articles/nrmicro841.

[29] P.K. Drain, E.P. Hyle, F. Noubary, K.A. Freedberg, D. Wilson, W.R. Bishai, et al., Diagnostic point-of-care tests in resource-limited settings, Lancet Infect. Dis. 14 (2014).

[30] Y.Y. Broza, R. Vishinkin, O. Barash, M.K. Nakhleh, H. Haick, Synergy between nanomaterials and volatile organic compounds for non-invasive medical evaluation, Chem. Soc. Rev. (2018).

[31] D. Kuupiel, V. Bawontuo, T.P. Mashamba-Thompson, Improving the Accessibility and Efficiency of Point-of-Care Diagnostics Services in Low-and Middle-Income Countries: Lean and Agile Supply Chain Management, Diagnostics 7 (4) (2017) 58.

[32] P.J. Garcia, P. You, G. Fridley, D. Mabey, R. Peeling, Point-of-care diagnostic tests for low-resource settings, Lancet Glob Health 3 (2015).

[33] S. Wang, M.A. Lifson, F. Inci, L.-G. Liang, Y.-F. Sheng, U. Demirci, Advances in addressing technical challenges of point-of-care diagnostics in resource-limited settings, Expert Rev. Mol. Diagn 16 (2016).

https://doi.org/10.1016/j.heliyon.2019.e01236

[34] G. Alemnji, P. Fonjungo, B. Van Der Pol, T. Peter, R. Kantor, J. Nkengasong, The centrality of laboratory services in the HIV treatment and prevention cascade: The need for effective linkages and referrals in resource-limited settings, AIDS Patient Care STDS 28 (5) (2014) 268−273.

[35] T.P. Mashamba-Thompson, B. Sartorius, P.K. Drain, Operational assessment of point-of-care diagnostics in rural primary healthcare clinics of KwaZulu-Natal, South Africa: a cross-sectional survey, BMC Health Serv. Res. 18 (1) (2018) 380.

[36] N. Engel, K. Wachter, M. Pai, J. Gallarda, C. Boehme, I. Celentano, et al., Addressing the challenges of diagnostics demand and supply: insights from an online global health discussion platform, BMJ Global Health 1 (4) (2016).

[37] T.L. Thomas, R. DiClemente, S. Snell, Overcoming the triad of rural health disparities: how local culture, lack of economic opportunity, and geographic location instigate health disparities, Health Educ. J. 73 (2013).

[38] N. Douthit, S. Kiv, T. Dwolatzky, S. Biswas, Exposing some important barriers to health care access in the rural USA, Publ. Health 129 (2015).

[39] A. Dhai, A health system that violates patients' rights to access health care, S. Afr. J. Bioethics Law 5 (2012). https://journals.co.za/content/m_sajbl/5/1/EJC122386.

[40] Ministry of Health, Ghana Health Service, Maternal Health Record Book, in: Reproduction and Child Health, 2016.

[41] Republic of Ghana, Ghana Health Service, A guide for maternal and newborn care part one: Maternal care, 2017.

[42] P.J. Turner, A. Van den Bruel, C.H.D. Jones, A. Plüddemann, C. Heneghan, M.J. Thompson, et al., Point-of-care testing in UK primary care: a survey to establish clinical needs, Fam. Pract. 33 (4) (2016) 388−394.

[43] Ghana Statistical Service, Ghana demographic and health survey 2008. Accra, Ghana: Ghana Statistical Service, Ghana Health Service, and ICF Macro, 2009. https://www.dhsprogram.com/pubs/pdf/FR221/FR221[13Aug2012].pdf.

[44] World Health Organization, Universal health coverage, UHC, 2017 updated 31/12/2017. Available from: http://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc.

 https://doi.org/10.1016/j.heliyon.2019.e01236