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Service Readiness and Limiting Factors to Manage Non-Communicable Diseases in Malawi: an Analysis of the 2019 Harmonized Health Facility Assessment Survey

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3 Service Readiness and Limiting Factors to Manage Non-Communicable Diseases in Malawi:
4 an Analysis of the 2019 Harmonized Health Facility Assessment Survey
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ABSTRACT

Objectives: The burden of non-communicable diseases (NCDs) continues to grow in low- and middle-income countries (LMICs), including Malawi. To inform policymakers and planners on the preparedness of the Malawian healthcare system and areas with limited services, we estimated the readiness of NCD services in the Malawian publicly financed healthcare facilities.

Method: We analyzed data from 564 publicly financed facilities in Malawi from the Harmonized Health Facility Assessment (HHFA) census survey, including 512 Primary Healthcare (PHC) and 52 Secondary and Tertiary health facilities. To characterize service readiness, we estimated the percentage of facilities where the necessary components required to provide NCD services are "available" and the percentage of facilities where the necessary components to provide NCD services are "functional" in a manner that allows service provision. Further, we estimated permanently unavailable items to identify service readiness bottlenecks.

Results: Less than 40% of the PHCs were ready to deliver service for any of the 13 NCDs included in the analysis. Only 5% of the PHC facilities were ready to provide chronic type 1 diabetes services, and only 7% and 8% were ready to provide services for chronic Rheumatic Heart Disease (RHD) and chronic Asthma. Around 38% of the Secondary and Tertiary facilities were ready to manage heart failure, and only 29% were ready to provide pain management services. Ensuring the availability of potential bottlenecks to service readiness like insulin and beclomethasone inhalers would improve the proportion of PHC facilities ready to provide type 1 diabetes and chronic asthma services from 5% to 43% and 8% to 71%, respectively.

Conclusion: We estimate that public health facilities in Malawi, especially at the PHC level, remain to experience gaps in essential medicines and equipment required for NCDs diagnosis and management. Targeted investments can support the health system in Malawi to make substantial improvements in NCDs services readiness.

Strengths and limitations of this study

- The HHFA survey does not include questions about the availability of the peak flow meter and micro nebulizer, which are essential for treating acute asthma.
- Data from the 2015 SPA survey about the availability of these two items suggest that we may have overestimated the service readiness for acute asthma.
- We haven't conducted any imputation for missingness.
- The HHFA survey did not collect data regarding the majority of medical components required for inpatient management apart from surgical services.
- The study is limited by the HHFA survey methodology, as the survey only covered a subset of medicines and equipment in surveying permanent unavailability.

OBJECTIVES

The growing burden of NCDs in low- and middle-income countries (LMICs) is particularly concerning. According to World Health Organization (WHO), 77% of the annual global NCD deaths occur in LMICs.(1) In 2021, NCDs caused 41 million deaths worldwide, among which

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3 29 million died of the four major conditions, including cardiovascular disease, cancer,
4 chronic respiratory disease, and diabetes. Several studies have reported low levels of NCD
5 service readiness in LMICs.(2,3)
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7 Located in sub-Saharan Africa with an 18.6 million population, Malawi remains one of the
8 world's poorest countries, with a national Gross Domestic Product (GDP) of only \$640 per
9 capita in 2021.(4) As a low-income country, Malawi suffers from the high burden of NCDs
10 and their economic consequences that affect overall economic development and lead to
11 catastrophic health expenditures (CHE) for Malawians seeking care.(5–7) As of 2019, NCDs
12 accounted for 40% of Malawi's mortality, which increased from 30% in 2010.(8) A
13 household survey conducted in 2012 in three rural districts in Malawi estimated that 21.3 %
14 of all households with at least one member seeking care for an NCD condition incurred CHE
15 due to NCDs.(7) Therefore, characterizing the readiness of health systems to manage NCDs
16 in Malawi will enable the identification of areas that require investment to alleviate the
17 existing and growing burden of NCDs.
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21 Several prior studies have provisionally assessed the preparedness of the Malawian
22 healthcare system. A 2018 study collected data from the 2013-2015 Malawi Service
23 Provision Assessment (SPA) surveys and computed readiness scores to indicate the
24 availability of medications, equipment, staff, and protocols in health facilities.(3) The study
25 found that among diabetes, CVD, and chronic respiratory disease, diagnosing and treating
26 diabetes have the lowest readiness.(3) Another SPA-based study on first-referral level
27 hospitals in eight low-income countries, including Malawi, estimated the percentages of
28 facilities with complete minimal sets of medications and equipment needed for thirteen
29 conditions, including chronic asthma, acute asthma, chronic type 1 diabetes, chronic type 2
30 diabetes, acute diabetic events, hypertension (HTN), heart failure, and rheumatic heart
31 disease (RHD), acute epilepsy, pain care, and minor surgery.(9) The study found that acute
32 epilepsy services were the most available (95%), and acute asthma services were unavailable
33 at any first-referral level hospitals in Malawi. However, findings from these studies only
34 presented assessments around 2015, when the SPA dataset was published.(3,9) A report using
35 more recent health facility data is necessary to present a current picture to inform policy and
36 planning purposes. A more recent study estimated screening, diagnosis, management, and
37 rehabilitation services readiness for NCDs based on a survey of 22 health facilities between
38 November 2019 and March 2020.(10) The study found that cardiology and renal care were
39 only available at two of the four surveyed tertiary hospitals and none of the district hospitals
40 or health centers.(10) The two district hospitals surveyed had clinics where services for
41 diabetes and hypertension were available.(10) At health centers, ten of 16 offered
42 hypertension services, six offered diabetes care, and two offered asthma or COPD care.(10)
43 In addition, only seven of the overall 22 facilities had half the essential drugs to treat
44 NCDs.(10) Many facilities also lacked laboratory testing used in diagnosing and managing
45 NCDs.(10)
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53 Our study aims to fill the knowledge gap about the service readiness of the Malawian
54 healthcare system for major NCD conditions using the most recent 2019 Harmonized Health
55 Facility Assessment (HHFA) survey data that covered all publicly financed health facilities in
56 the country. Our study has two main goals. The first goal is to estimate the service readiness
57 of Malawian healthcare facilities by analyzing the availability and functionality of essential
58 medications and equipment to diagnose and treat common NCD conditions that present early
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3 in life and are associated with a significant disease burden. The conditions included in the
4 analysis are acute and chronic asthma, hypertension (HTN), stage 1 and 2 and complicated
5 HTN, heart failure, rheumatic heart disease (RHD), type 1 and 2 diabetes mellitus (DM),
6 epilepsy, injuries, and minor surgical conditions, and chronic pain (Appendix Table 1).
7 Because primary care facilities and secondary/tertiary hospitals are designed to provide
8 different levels of care, we summarized the major NCD services at each level. The second
9 aim is to identify potential bottleneck items that limit the facilities' service readiness.
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12 **METHODS**

13 **Sample and Representativeness**

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15 The healthcare delivery system in Malawi is divided into three ownership categories: public,
16 private for-profit (PFP), and private not-for-profit (PNFP).⁽¹¹⁾ While PFP and PNFP
17 facilities are slowly growing fee-charging systems, the publicly financed sector is free for
18 everyone.⁽¹²⁾ PFP and PNFP facilities are not open to everyone and only represent 11% of
19 the facilities in the Malawian health system.⁽¹³⁾ We focused on the free publicly financed
20 facilities owned by the Malawian government or the Christian Health Associations of Malawi
21 (CHAM) because of their accessibility to the population and because they comprise the large
22 majority of the health system.⁽¹⁴⁾ The Malawi health system consists of three levels:
23 primary, secondary, and tertiary. Health centers and community hospitals are on the primary
24 care level and offer ambulatory and maternity services. Secondary facilities are first-referral
25 level hospitals (also called district hospitals), and the central hospitals are on the tertiary
26 level.⁽¹¹⁾
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30 With a catchment area of 11 to 40 primary health centers, district hospitals serve a range of
31 populations between 140,000 and 1,400,000.⁽¹⁵⁾ District and central hospitals in Malawi are
32 designed to provide Secondary and Tertiary Care. In contrast, health centers and
33 rural/community hospitals are widely accessible to residents within local communities and
34 thus recognized as Primary Healthcare (PHC) facilities.
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36 The 2019 HHFA is a cross-sectional survey funded and developed by the World Health
37 Organization, the World Bank, and other collaborators. It is an update of the Service
38 Availability and Readiness Assessment (SARA) survey, built upon the SPA survey. The HHFA
39 has a census sample of all facilities in Malawi. In this study, we acquired data from the 2019
40 HHFA, which surveyed 1,098 Malawian health facilities across all levels and ownerships. Our
41 study sample included 576 public facilities in total: 515 PHCs (471 health centers and 41
42 rural/community hospitals) and 52 Secondary and Tertiary facilities (48 district hospitals and
43 4 central hospitals). The spatial distribution of all facilities is displayed in Appendix Figure 1.
44 The 48 district hospitals included actual district hospitals, large health centres functioning as
45 first-level-referral hospitals in certain districts (quasi-district hospitals), and first-referral-level
46 CHAM hospitals. We removed Zomba Mental Hospital from our sample because we are only
47 interested in facilities that provide general care. PHCs were expected as the first contact of the
48 healthcare system for patients in Malawi. Patients in PHC facilities will be referred to the
49 Secondary and Tertiary facilities for comprehensive diagnostics or more sophisticated care.
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53 The total number of facilities in each category is summarized in Table 1. As a census survey
54 database, the HHFA collected data from all functional facilities at the time of the survey. There
55 were 485 health centres registered by the Administration of Health and only 471 surveyed by
56 the HHFA. Therefore, the 14 health centres not surveyed in HHFA were defined as "non-
57 functional." Our sample captures all publicly financed facilities; thus, the estimates represent
58 the readiness of the publicly funded Malawian healthcare system.
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Table 1. Summary of facility representation in each category

Facility type	Primary Healthcare			Secondary and Tertiary facilities		
	Health centres	Rural/Community hospitals (RCH)	Total	District hospitals	Central hospitals	Total
HHFA samples	471**	41	512	48	4	52
Non-functional facilities*	14	0	14	0	0	0
Total	485	41	526	48	4	52

*We consider the facilities not surveyed by the HHFA as "non-functional" because HHFA is a census survey.

**Three quasi-district hospitals were categorized as "District Hospitals": Ndirande Health Centre, Matawale Health Centre, and Mzuzu Health Centre.

Data Analysis

This study focused on the service readiness to diagnose and treat thirteen NCD conditions, including five acute and seven chronic conditions (see Appendix Table 1 for the list of conditions). Service readiness is measured as the percentage of health facilities with all functional medications and equipment to diagnose and treat common NCD conditions. We applied the list of medications and equipment for each condition from Gupta et al. study with minor refinements.(9)

We consulted local partners in the Ministry of Health to determine the expected facility level for each of the thirteen services. (Appendix Table 1) In addition to identifying expected services by facility type, we also examine data missingness to refine whether the required medicines and equipment are expected by facility type. The corresponding data in the HHFA survey were extracted for analysis, and we detailed the conditions, items, indicators, and related facility types in Appendix Table 2. When certain services were not expected at health centers, we only estimated these services in rural/community hospitals at the PHC level.

Regarding missingness, the HHFA survey did not include questions on peak flow meters and micro-nebulizers, which are the required equipment for asthma management. Therefore, we examined SPA data to understand how these missing variables might have affected the asthma readiness measure. For the variables with close to 100% missing data, we assumed that the item was not expected at the facility level.

Patient and Public Involvement:

No patient involved.

Measures

A medicine or equipment can be "available and functional," "available but not functional," "not available (at this time)," or "never available" at the facility. For each item, we calculated three

indicators: 1) availability, 2) functionality, and 3) permanent unavailability.

Availability refers to the physical presence of the medicines or equipment required to provide services at the health facility during the survey. For example, a stethoscope is necessary for blood pressure measurement, and we measure the percentage of health facilities with a stethoscope.

$$Availability = \frac{\sum \# \text{ of facilities with available element}}{\text{Total number of facilities}}$$

Functionality refers to the presence of the medicines or equipment required to provide the service in operating conditions that allow service provision at the time of the survey. For example, the surveyor checked whether a stethoscope was working and whether insulin for type 1 diabetes was not expired and stored at the required temperature. We measure the percentage of facilities with available and working elements.

$$Functionality = \frac{\sum \# \text{ of facilities with available and working element}}{\text{Total \# of facilities}}$$

Permanent unavailability is when the medicines or equipment is never present at the health facility. For example, insulin for type 1 diabetes was not present in the pharmacy for patients to dispense the prescription, and it was not a temporary situation.

$$Permanently \text{ unavilable service} = \frac{\sum \# \text{ of facilities with elements that were never present}}{\text{Total \# of facilities}}$$

For each facility, we estimated service readiness based on the functionality of all required items. We estimated service readiness bottlenecks based on permanent unavailability. The computation process is expressed as follows:

$$Service \text{ Readiness} = \frac{\sum f_i}{N}, \quad i \in [1, N],$$

$$f_i = \begin{cases} 1, & \text{if } item_1 = item_2 = item_j = item_m = 1, \quad j \in [1, m] \\ 0, & \text{if } \min(item_j) = 0. \end{cases}$$

According to the law of the minimum, service readiness is dictated by the limiting factor, a principle developed in agricultural science by Carl Sprengel (1840).⁽⁹⁾ The limiting factor that prevents the service from being ready was identified in our analysis.

$$Supply \text{ Bottleneck} = \frac{\sum pu_i}{N}, \quad i \in [1, N]$$

Where f_i refers to functionality at facility i , and pu_i refers to permanent unavailability at facility i . When a facility has all essential components available and functioning, it is labeled "ready." Otherwise, the facility is labeled as "Not ready." We estimated service readiness by NCD condition.

RESULTS

Overall service readiness by condition and item functionality are presented in Figure 1. Certain

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3 items contributed substantially to low service readiness scores for conditions. For example,
4 beclomethasone inhalers, salbutamol inhalers, and stethoscopes were needed to manage
5 chronic asthma. Although 71% and 92% of PHC were equipped with functional salbutamol
6 inhalers and stethoscopes, the service readiness was 8% because only 8% of PHC were
7 equipped with beclomethasone inhalers. Beclomethasone inhaler was a limiting item for
8 chronic asthma service readiness among PHCs. Other limiting items among PHCs include
9 calcium channel blockers for hypertension services, insulin for type 1 diabetes, ultrasound
10 equipment for heart failure, injectable epinephrine in case of an allergic reaction to injectable
11 benzathine penicillin for chronic RHD, and functional x-ray machines for acute asthma.
12 Among the Secondary and Tertiary facilities, increasing the number of functional
13 beclomethasone inhalers would also improve their readiness for chronic asthma service.
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16 Regarding missingness and potential bias, nebulizer and peak-flow meter measures were not
17 included in the HHFA survey, and we analyzed 2015 SPA data to understand potential bias in
18 our estimates. It turns out that nebulizers were available at three of four central hospitals but
19 only at 22% of rural/community hospitals. Peak-flow meters were available at one of four
20 central hospitals but only at 5% of rural/community hospitals. Our estimates based on 2019
21 HHFA data are likely to overestimate asthma service readiness. Service readiness for acute
22 asthma was estimated to be 15%-17% at the PHC level and 44%-50% at secondary and tertiary
23 hospitals based on HHFA surveys. However, the service availability among first-level referral
24 hospitals was estimated to be 0 based on 2015 SPA data, in which the peak flow meter was the
25 limiting factor at 5% availability. If the peak flow meter and nebulizer had been at the same
26 level as the 2015 SPA survey results (Appendix Table 3), acute asthma service readiness would
27 have been less than 5% at PHCs and less than 6% at secondary and tertiary hospitals. While
28 availability may have grown since 2015, if availability remains unchanged, it may be an
29 alarming limiting factor for the overall readiness for acute asthma care.
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33 Given that SPA data were collected in 2015 and with a smaller sample size than HHFA, we
34 did not incorporate 2015 SPA data into 2019 HHFA data. Instead, we used it to shed light on
35 potential biases. This is an example to show that when the missing variable is the limiting factor,
36 the missingness might significantly bias the estimation of service readiness. According to the
37 guideline and missing data investigation, we assumed that the following services were not
38 expected at health centers: heart failure, chronic RHD, acute asthma, acute diabetic events,
39 acute epilepsy, and injuries. Except for the aforementioned missingness, all other variables
40 have less than 25% missing data.
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58 **Figure 1:** Service readiness and service functionality for each essential medical component at
59 PHCs and Secondary and Tertiary facilities
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To compare the service readiness of both PHC and Secondary and Tertiary facilities for chronic and acute NCD conditions, we visualized the readiness score in Figure 2. Overall, for all NCD conditions, the service readiness of Secondary and Tertiary facilities was higher than the PHCs in Malawi. We found that the service readiness was lower than 35% for all NCD conditions we studied in PHC facilities. The readiness to treat type 1 diabetes and chronic RHC was only 5% and 7%, respectively. In contrast, we found that Secondary and Tertiary facilities in Malawi were reaching full readiness for type 2 diabetes (94%), hypertension (88%), and acute epilepsy (85%). However, relatively lower readiness was also identified for chronic asthma, pain care, heart failure, chronic Rheumatic Heart Disease (RHD), moderate/severe acute asthma, and injuries/ acute minor surgical services.

Figure 2: NCD service readiness of the Malawi health system by level

In this research, we further analyzed the essential equipment and medications that are “permanently unavailable.” As shown in Table 2, one of our “bottleneck” items, the beclomethasone inhaler, has been permanently unavailable in 74% of PHCs. In addition, 81% of the PHCs never have access to insulin. Table 2 also reveals items well in stock in the Malawi healthcare system. Oral pain medications, salbutamol inhalers, and diazepam injections were three examples with zero permanent unavailability in the HHFA survey.

Table 2: Permanent unavailability of essential equipment and medications among PHC and Secondary and Tertiary facilities.

	Condition	Essential Equipment & Medication	PHC (N = 512)	Secondary & Tertiary facilities (N = 52)
Chronic Conditions	Chronic Asthma (PHC)	Beclomethasone inhaler	74%	29%
		Salbutamol inhaler	8%	0%
	Hypertension (PHC)	At least two or three of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	12%	0%
	Type 1 diabetes (PHC)	Insulin	81%	2%
	Type 2 diabetes (PHC)	Metformin or glibenclamide	48%	0%
	Pain care	Oral pain medication	0%	0%
Injectable morphine or pethidine		7%	19%	

		Atenolol or other beta-blocker	24%	6%
		Captopril, enalapril or other ACE inhibitor	20%	6%
	Heart failure	Furosemide	12%	2%
		Benzathine penicillin	44%	8%
	Chronic RHD	Injectable epinephrine	5%	10%
Acute Conditions	Mild/moderate acute asthma	Prednisolone	10%	0%
		Salbutamol inhaler	0%	0%
	Moderate/severe acute asthma	Prednisolone	10%	0%
		Salbutamol inhaler	0%	0%
		Hydrocortisone injection	32%	8%
	Acute diabetic events	Injectable glucose	0%	2%
		Insulin	49%	2%
	Acute epilepsy	Diazepam injection	0%	0%
	injuries/ acute minor surgical conditions	Lidocaine in minor surgical area	2%	0%
		Skin disinfectant in minor surgical area	5%	2%
Sutures in minor surgical area		5%	0%	

DISCUSSION

In this research, we estimated service readiness for NCD treatment in Malawi based on the 2019 HHFA database. The analysis reveals that less than 40% of PHCs in Malawi are ready to deliver service for any of the 13 NCD services included in the analysis. PHC facilities' readiness to provide care for chronic conditions is low, with the highest readiness of 34% for managing Stage 1/2 hypertension, while only 5% of the PHC facilities were ready to manage type 1 diabetes. PHC facilities' service readiness for acute conditions management was highest for acute epilepsy, with 37% of the PHC facilities having diazepam injections, while only 15% of the PHC facilities were ready to manage moderate and severe asthma. Compared to PHC facilities, service readiness for the 13 NCD conditions included in the analysis is considerably higher in secondary and tertiary facilities. However, services for chronic conditions like pain care, heart failure, and chronic asthma have low readiness scores even at secondary and tertiary facilities (29%, 38%, and 40%, respectively). Our results lined up with other studies that Malawi's health system requires substantial improvement to prepare for the growing burden of NCDs in the country.(9,10,16)

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3 It is globally recognized that PHC facilities are essential in providing services for NCDs and
4 routine care for the elderly and are a cornerstone for achieving universal health coverage. In
5 2013 the WHO Package of Essential Non-communicable Disease Interventions (WHO PEN)
6 included managing cardiovascular diseases, diabetes, chronic respiratory diseases, and cancer
7 prevention and screening through primary care platforms as a minimum requirement for
8 universal coverage reforms in low-resource settings.(17) The 2018 Declaration of Astana on
9 PHC emphasizes the role of PHC facilities in providing comprehensive services, including the
10 control and management of NCDs.(18) The World Bank recommends reinforcing PHC
11 networks to provide universal coverage of services required for the prevention, early detection,
12 and low-cost, high-quality management of chronic NCDs.(19) The essential health package
13 (EHP) developed by the Ministry of the health of Malawi (MOH) included the management of
14 diabetes type 1 and 2, hypertension, and treatment of injuries as interventions to be provided
15 as free services at the point of care at primary and secondary levels.(20) However, our study
16 shows that most PHC facilities had low service readiness for common chronic conditions, while
17 required medicines and equipment for chronic condition management were more ready at
18 secondary and tertiary levels. Our analysis indicates suboptimal functionality of essential
19 services that are part of the EHP. This is in line with MOH concerns about the suboptimal
20 implementation of the EHP policy due to inadequate resources, low awareness among
21 stakeholders, and insufficient operationalization of the policy due to the lack of clear financial
22 mechanisms to ensure the provision of free-of-charge services at the point of care.(20)

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26
27 Ensuring the availability of limiting items would improve the proportion of PHCs ready to
28 provide care for type 1 diabetes from 6% to 43%. Similarly, increasing the availability of
29 beclomethasone inhalers would enhance the service readiness for chronic asthma from 8% to
30 71% among PHCs and from 50% to 88% among Secondary and Tertiary facilities. Asthma
31 management is not part of the NCD intervention package included in the EHP of Malawi, and
32 the Standard Treatment Guidelines for Malawi state that beclomethasone is only expected to
33 be provided at the tertiary level.(20,21) However, the WHO considers beclomethasone as an
34 essential and cost-effective intervention that can be provided through PHC platforms.(22,23)
35 Service readiness for NCD treatment in Malawi can be significantly improved by ensuring the
36 availability and functionality of these items. Increasing the availability of limiting items is in
37 line with the WHO calls to increase coverage and close the gap between the available and
38 needed high-impact essential NCD interventions to reduce the burden, healthcare costs, and
39 suffering due to major NCDs in LMICs.(17,24) This study sheds light on the compatibility of
40 regulatory guidelines and recommends updating the 2015 Standard Treatment Guidelines for
41 Malawi in line with changing priorities and policies.

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44 This study has the merit of a census sample for analysis and specified facility types. An
45 assessment of service readiness for NCDs in five countries, including Malawi, reported a total
46 NCD service capacity score of 59 out of 100 in their study, indicating a low readiness compared
47 to the benchmark (3), leaving condition-specific readiness unknown. In addition, some prior
48 research only analyzed the service readiness for first-level-referral hospitals and all facilities
49 in Malawi, missing detailed information about each service level.(3,9) In our study, we divided
50 facilities by PHCs and Secondary and Tertiary facilities and categorized facilities into health
51 centers, rural/community hospitals, district hospitals, and central hospitals. The census samples
52 from HHFA provide the opportunity to estimate NCD service readiness at the primary,
53 secondary, and tertiary levels. Banda and colleagues assessed capacity across a range of facility
54 types; however, the sample consisted of only 22 facilities out of over 550 in the country(3,9,10).

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58 Overall service readiness scores depended partly on the total number of items comprising the
59 score. When the number of required equipment and medications increased, the likelihood of
60

service readiness decreased. For example, seven essential medications are required for heart failure treatment, and the overall readiness score is only 38% because only a small number of facilities have all seven components ready. In contrast, for acute epilepsy, which only required diazepam injection, the service readiness was 85%.

There are several limitations of this study. First, the HHFA survey does not include questions about the availability of the peak flow meter and micro nebulizer, which are essential for treating acute asthma. Data from the 2015 SPA survey about the availability of these two items suggest that we may have overestimated the service readiness for acute asthma. Second, we haven't conducted any imputation for missingness; future research is warranted in dealing with missing data through imputation. Third, apart from basic surgical care, the HHFA survey did not collect data regarding the majority of medical components required for inpatient management. Fourth, our study is limited by the HHFA survey methodology, as the survey only covered a subset of medicines and equipment in surveying permanent unavailability. Hence understanding of permanently unavailable items does not represent the full set of items required for NCDs management. In addition, the study by Banda et al.(10) of a smaller number of health facilities assessed other dimensions not included in the HHFA survey, such as whether facilities kept reliable records for NCD patients, and also supplemented the data with qualitative interviews that deepened the understanding of constraints. Last but not least, future studies should also investigate the Malawi health system's preparedness for emergency and critical care, which we did not include in this study.

Our findings have several implications for improving the service readiness of NCDs in Malawi. First, there is a gap between the readiness of PHCs and Secondary and Tertiary facilities. Our study suggests that PHCs require high-priority investments to improve NCD service availability. While health centres and rural/community hospitals may not be expected to perform complete diagnostics or treatment for complicated conditions, these primary care facilities are well-positioned to provide a comprehensive set of basic NCD services, given their accessibility. Second, targeting items on our list of limiting factors and permanently unavailable times presents an opportunity to update regulatory guidelines and achieve the most significant increases in service readiness for particular conditions. The efficient investment in NCD treatment potentially speeds up the medical service optimization in Malawi.

Figures Legend:

Figure 1: Service readiness and service functionality for each essential medical component at PHCs and Secondary and Tertiary facilities	The figure presents service readiness for 13 NCD conditions and illustrates the components contributing to the service readiness score calculation comparing PCH and higher-level health facilities.
Figure 2: NCD service readiness of the Malawi health system by level	The figure presents the service readiness of 13 NCD conditions in the health facilities in Malawi. Figure 2 compares acute and chronic NCD service availability across the health service levels.

a. Contributorship statement

Contributors ZW, YC, and SA led the literature review and wrote the first draft of the manuscript. PT and JC provided data and supporting documents. ZW and LB analyzed the data, and MM replicated the estimates. ZW and MM produced the tables. YC and SA had the figures. MC, PT, EW, and DW contributed to conceiving the study, refining the methods, and interpreting the results. DW acquired funding for the research. YS led the study design, method development, and result interpretation. All the authors have made significant intellectual or practical contributions, critically revised the manuscript, and approved the final version of this paper.

b. Competing interests

We declare that non of the authors and coauthors have any financial or non-financial competing interests that may influence the analysis or the interpretation of this paper.

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d. Data sharing statement

The data supporting this study's findings were obtained through the FMOH Malawi and are not available in a public, open-access repository.

e. Ethics approval statement

Not a human subject research.

Ethical approval exempt

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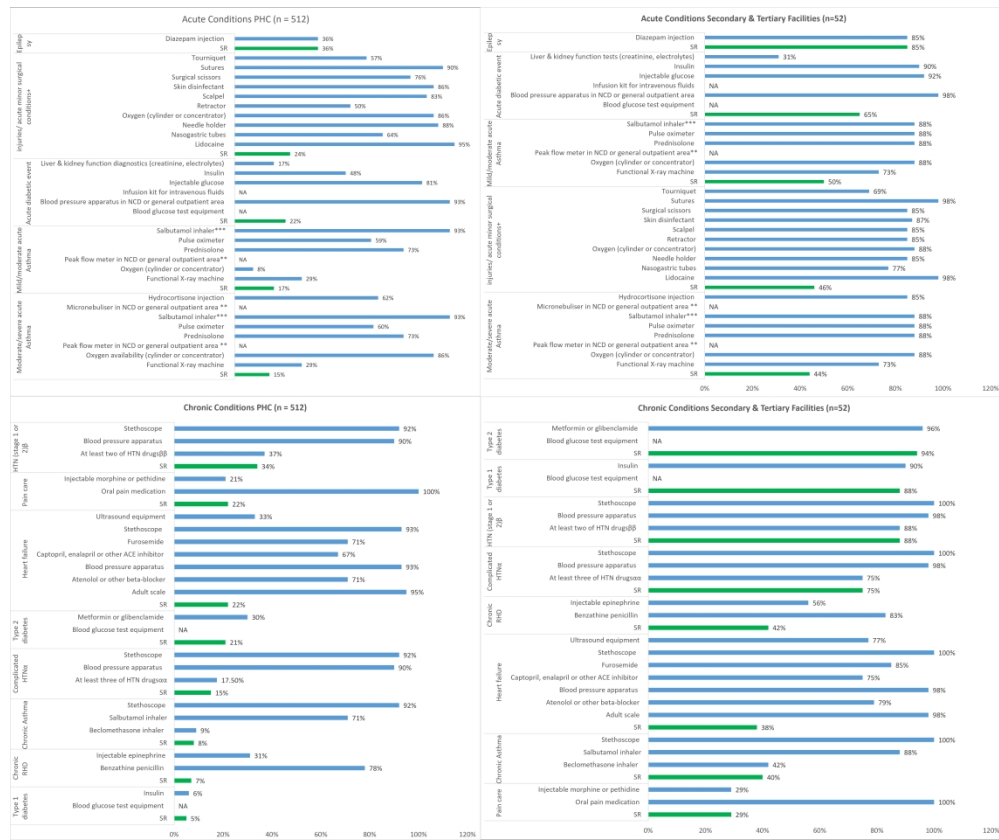


Figure 1: Service readiness and service functionality for each essential medical component at PHCs and Secondary and Tertiary facilities

1243x1035mm (130 x 130 DPI)

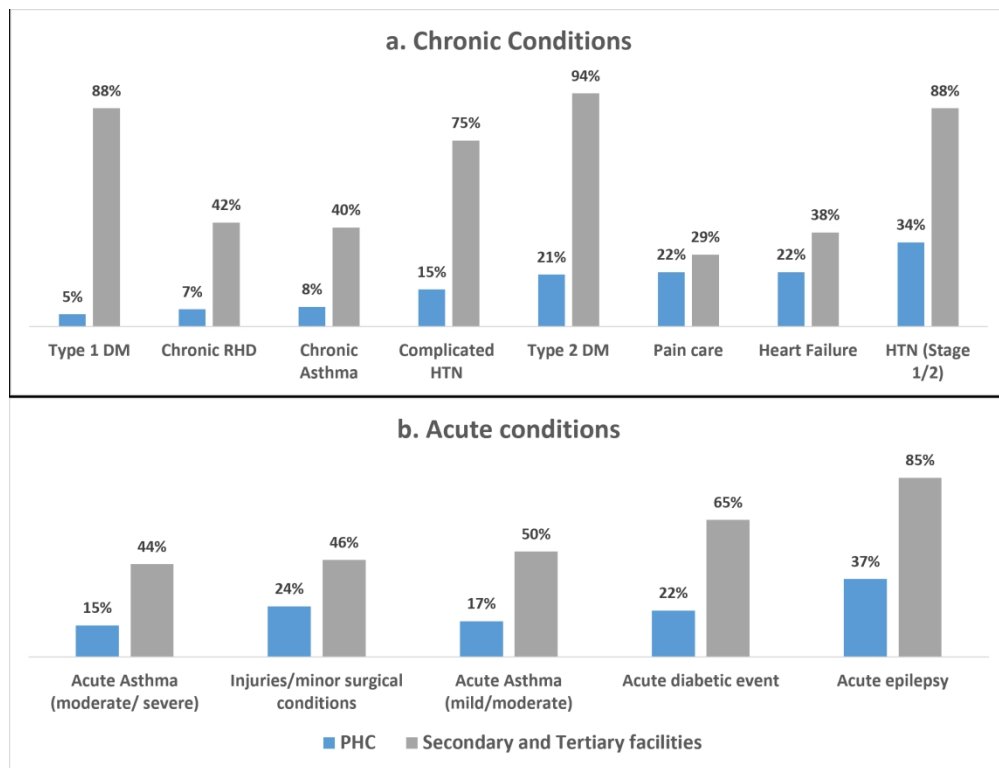


Figure 2: NCD service readiness of the Malawi health system by level

512x390mm (130 x 130 DPI)

Appendix Table 1: Service expected at each level

Condition	Primary Health Care		Secondary and Tertiary facilities	
	Health Centers	Rural/Community Hospitals	District Hospitals	Central Hospitals
Chronic conditions				
Chronic asthma	x	x	x	x
Hypertension (stage 1 or 2)	x	x	x	x
Type 1 diabetes	x	x	x	x
Type 2 diabetes	x	x	x	x
Oral pain care	x	x	x	x
Injectable pain care		x	x	x
Hypertension requiring three or more antihypertensive classes	x	x	x	x
Heart failure		x	x	x
Chronic RHD		x	x	x
Acute conditions				
Mild/moderate acute Asthma		x	x	x
Moderate/severe acute Asthma		x	x	x
Acute diabetes		x	x	x
Acute epilepsy		x	x	x
injuries/ acute minor Surgical conditions+		x	x	x

Appendix Table 2: Service Indicators

Conditions	Essential equipment and medications	Availability Indicators	Functionality Indicators	“Never Available” Data Availability	Facility Types Surveyed*
Mild/moderate acute Asthma	Functional X-ray machine	T125_01 (Y = 1,2,3; N = 4,NA)	T125_01 (Y = 1; N = 2,4,NA)	No Data	1,2,3
	Oxygen availability (cylinder or concentrator)	HH101_22 (Y = “Yes”, N = “No”, NA) OR HH101_23 (cylinder) (Y = “Yes”, N = “No”, NA)	HH101A22 (Y = “Yes”, N = “No”, NA) OR HH101A23 (Y = “Yes”, N = “No”, NA)	No Data	1,2,3,4
	Peak flow meter in NCD or general outpatient area	No Data (used SPA data for estimation)	No Data	No Data	No Data
	Prednisolone	U103_10 (Y = 1, 2; N = 3,4,5,NA)	U103_10 (Y = 1; N = 2,3,4,5,NA)	U103_10 (Y = 1; N = 2,3,4,5,NA)	1,2,3,4
	Pulse oximeter	HH101_8 (Y = “Yes”, N = “No”, NA)	HH101A8 (Y = “Yes”, N = “No”, NA)	No Data	1,2,3,4
	Salbutamol inhaler	U103_21 (Y = 1,2; N = 3,4,5,NA)	U103_21 (Y = 1; N = 2,3,4,5,NA)	U103_21 (Y = 1; N = 2,3,4,5,NA)	1,2,3,4
Moderate/severe acute Asthma	Functional X-ray machine	T125_01 (Y = 1,2,3; N = 4,NA)	T125_01 (Y = 1; N = 2,4,NA)	No data	1,2,3
	Oxygen availability	HH101_22 (Y = “Yes”, N = “No”, NA)	HH101A22 (Y = “Yes”, N = “No”, NA)	No data	1,2,3,4

	(cylinder or concentrator)	“No”, NA) OR HH101_23 (cylinder) (Y = “Yes”, N = “No”, NA)	“No”, NA) OR HH101A23 (Y = “Yes”, N = “No”, NA)		
	Peak flow meter in NCD or general outpatient area	No Data (used SPA data for estimation)	No data	No data	No data
	Prednisolone	U103_10 (Y = 1, 2; N = 3,4,5,NA)	U103_10 (Y = 1; N = 2,3,4,5,NA)	U103_10 (Y = 1; N = 2,3,4,5,NA)	1,2,3,4
	Pulse oximeter	HH101_8 (Y = “Yes”, N = “No”, NA)	HH101A8 (Y = “Yes”, N = “No”, NA)	No data	1,2,3,4
	Salbutamol inhaler	U103_21 (Y = 1,2; N = 3,4,5,NA)	U103_21 (Y = 1; N = 2,3,4,5,NA)	U103_21 (Y = 1; N = 2,3,4,5,NA)	1,2,3,4
	Micro nebulizer in NCD or general outpatient area	No Data (used SPA data for estimation)	No Data	No Data	No Data
	Hydrocortisone injection	U103_11 (Y = 1,2; N = 3,4,5,NA)	U103_11 (Y = 1; N = 2,3,4,5,NA)	U103_11 (Y = 1; N = 2,3,4,5,NA)	1,2,3,4
Acute diabetes	Blood glucose test equipment	T105_01 (Y = 1,2; N = 3,NA)	No Data	No Data	1,2,3,4
	Blood pressure apparatus in NCD or general outpatient area	HH101_15 (Y = “Yes, N = “No”,NA)	HH101A15 (Y = “Yes”, N = “No”,NA)	No Data	1,2,3,4

	Infusion kit for intravenous fluids	M116_161 (Y = "Yes", N = "No")	No Data	No Data	1,2,3,4
	Injectable glucose	U103_03 (Y = 1,2; N = 3,4,5,NA)	U103_03 (Y = 1; N = 2,3,4,5,NA)	U103_03 (Y = 1; N = 2,3,4,5,NA)	1,2,3,4
	Insulin	U103_02 (Y = 1,2; N = 3,4,5,NA)	U103_02 (Y = 1; N = 2,3,4,5,NA)	U103_02 (Y = 1; N = 2,3,4,5,NA)	1,2,3,4
	Liver and kidney function diagnostics (creatinine, electrolytes)	T113_03 (Y = 1,2; N = 3,NA) Or T122_01 (Y = 1,2; N = 3,NA) Or T123_01 (Y = 1,2,3; N = 4,NA)	T123_01 (Y = 1; N = 2,3,4,NA)	T123_01 (Y = 1; N = 2,3,4,NA)	1,2,3
Acute epilepsy	Diazepam injection	U125_16 (Y = 1,2; N = 3,4,5,NA) or U126_05 (Y = 1,2; N = 3,4,5,NA)	U125_16 (Y = 1; N = 2,3,4,5,NA) or U126_05 (Y = 1; N = 2,3,4,5,NA)	U125_16 (Y = 1; N = 2,3,4,5,NA) And U126_05 (Y = 1; N = 2,3,4,5,NA)	All facility types AND M103. Yes.Contains (8)
Injuries/ acute minor surgical conditions+	Lidocaine in minor surgical area	U125_12 (Y = 1,2; N = 3,4,5,NA)	U125_12 (Y = 1; N = 2,3,4,5,NA)	U125_12 (Y = 1; N = 2,3,4,5,NA)	1,2,3,4
	Nasogastric tubes in minor surgical area	RR115_7 (Y = "Yes", N = "No", NA)	RR115A7 (Y = "Yes", N = "No", NA)	No Data	1,2,3
	Needle holder in minor surgical area	RR115_3 (Y = "Yes", N = "No", NA)	RR115A3 (Y = "Yes", N = "No", NA)	No Data	1,2,3

	Oxygen availability (cylinder or concentrator)	HH101_2 2 (Y = "Yes", N = "No", NA) OR HH101_2 3 (cylinder) (Y = "Yes", N = "No", NA)	HH101A22 (Y = "Yes", N = "No", NA) OR HH101A23 (Y = "Yes", N = "No", NA)	No Data	1,2,3,4
	Retractor in minor surgical area	RR115_5 (Y = "Yes", N = "No", NA))	RR115A5 (Y = "Yes", N = "No", NA))	No Data	1,2,3
	Scalpel in minor surgical area	RR115_4 (Y = "Yes", N = "No", NA))	RR115A4 (Y = "Yes", N = "No", NA))	No Data	1,2,3
	Skin disinfectant in minor surgical area	U125_05 (Y = 1,2; N = 3,4,5,NA)	U125_05 (Y = 1, N = 2,3,4,5,NA)	U125_05 =5	1,2,3,4
	Surgical scissors in minor surgical area	RR115_6 (Y = "Yes", N = "No", NA)	RR115A6 (Y = "Yes", N = "No", NA)	No Data	1,2,3
	Sutures in minor surgical area	U125_09 (Y = 1,2; N = 3,4,5)	U125_09 (Y = 1; N = 2,3,4,5)	U125_09 =5	1,2,3,4
	Tourniquet in minor surgical area	RR115_8 (Y = "Yes", N = "No", NA)	RR115A8 (Y = "Yes", N = "No", NA)	No Data	1,2,3
Disease	Availability of complete essential equipment and medications	Availability Indicators	Functionality Indicators	"Never Available" Data Availability	Facility Types Surveyed
Chronic asthma	Beclomethasone inhaler	U103_09 (Y = 1,2; N = 3,4,5,NA)	U103_09 (Y = 1; N = 2,3,4,5,NA)	U103_09 =5	1,2,3,4

			2,3,4,5,NA)		
	Salbutamol inhaler	U103_21 (Y = 1,2; N = 3,4,5,NA)	U103_21 (Y = 1; N = 2,3,4,5,NA)	U103_21 ==5	1,2,3,4
	Stethoscope	HH101_13 (Y = "Yes", N = "No", NA)	HH101A3 (Y = "Yes", N = "No", NA)	No Data	1,2,3,4
	At least two of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	U103_04, U103_05, U103_06, U103_07 (Y = 1,2; N = 3,4,5)	U103_04, U103_05, U103_06, U103_07 (Y = 1; N = 2, 3,4,5)	U103_04 ==5 AND U103_05 ==5 AND U103_06 ==5 AND U103_07 ==5	1,2,3,4
Hypertension (stage 1 or 2)	Blood pressure apparatus	HH101__15 (Y = "Yes, N = "No",NA)	HH101A15 (Y = "Yes", N = "No",NA)	No data	1,2,3,4
	Stethoscope	HH101_13 (Y = "Yes", N = "No", NA)	HH101A3 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
	At least three of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	U103_04, U103_05, U103_06, U103_07 (Y = 1,2; N = 3,4,5)	U103_04, U103_05, U103_06, U103_07 (Y = 1; N = 2, 3,4,5)	U103_04 ==5 AND U103_05 ==5 AND U103_06 ==5 AND U103_07 ==5	1,2,3,4
Hypertension requiring three or more antihypertensive classes	Blood pressure apparatus	HH101__15 (Y = "Yes, N = "No",NA)	HH101A15 (Y = "Yes", N = "No",NA)	No data	1,2,3,4
	Stethoscope	HH101_13 (Y = "Yes", N = "No", NA)	HH101A3 (Y = "Yes", N = "No", NA)	No data	1,2,3,4

	Adult scale	HH101_1 (Y = "Yes", N = "No", NA)	HH101A1 (Y = "Yes", N = "No", NA)	No Data	1,2,3,4
	Atenolol or other beta- blocker	U103_06 (Y = 1,2; N = 3,4,5,NA)	U103_06 (Y = 1; N = 2,3,4,5,NA)	U103_06 =5	1,2,3,4
	Blood pressure apparatus	HH101__1 5 (Y = "Yes, N = "No",NA)	HH101A15 (Y = "Yes", N = "No",NA)	No data	1,2,3,4
Heart failure	Captopril, enalapril or other ACE inhibitor	U103_04 (Y = 1,2; N = 3,4,5,NA)	U103_04 (Y = 1; N = 2,3,4,5,NA)	U103_04 =5	1,2,3,4
	Furosemide	U103_13 (Y = 1,2; N = 3,4,5,NA)	U103_13 (Y = 1; N = 2,3,4,5,NA)	U103_13 =5	1,2,3,4
	Stethoscope	HH101_13 (Y = "Yes", N = "No", NA)	HH101A3 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
	Ultrasound equipment	T125_02 (Y = 1,2,3; N = 4,NA)	T125_02 (Y = 1; N = 2,3,4,NA)	No Data	1,2,3
	Benzathine penicillin	U106_18 (Y = 1,2; N = 3,4,5,NA)	U106_18 (Y = 1; N = 2,3,4,5,NA)	U106_18 =5	1,2,3,4
chronic RHD	Injectable epinephrine	U125_20 (Y = 1,2; N = 3,4,5,NA) OR U103_12 (Y = 1,2; N = 3,4,5,NA)	U125_20 (Y = 1; N = 2,3,4,5,NA) OR U103_12 (Y = 1; N = 2,3,4,5,NA)	U125_20 =5 AND U103_12 =5	1,2,3

	Blood glucose test equipment	T105_01 (Y = 1,2; N = 3,NA)	No data	No data	1,2,3,4
Type 1 diabetes	Insulin	U103_02 (Y = 1,2; N = 3,4,5,NA)	U103_02 (Y = 1; N = 2,3,4,5,NA)	U103_02 =5	1,2,3,4
	Blood glucose test equipment	T105_01 (Y = 1,2; N = 3,NA)	No data	No data	1,2,3,4
Type 2 diabetes	Metformin or glibenclamide	U103_01 (Y = 1,2; N = 3,4,5,NA) OR U103_14 (Y = 1,2; N = 3,4,5,NA)	U103_01 (Y = 1; N = 2,3,4,5,NA) OR U103_14 (Y = 1; N = 2,3,4,5,NA)	U103_01 =5 AND U103_14 =5	1,2,3,4
	Injectable morphine or pethidine	U127_07 (Y = 1,2; N = 3,4,5,NA)	U127_07 (Y = 1; N = 2,3,4,5,NA)	U127_07 =5	1,2,3
Pain care	Oral pain medication (paracetamol, ibuprofen, aspirin or diclofenac)	U103_20 OR U103_17 OR U111_08 OR U103_08; Y = 1,2; N = 3,4,5,NA	U103_20 OR U103_17 OR U111_08 OR U103_08; Y = 1; N = 2,3,4,5,NA	U103_20 =5 AND U103_17 =5 AND U111_08 =5 AND U103_08 =5	1,2,3,4

* Facility types: 1 = central hospitals, 2 = district hospitals, 3 = rural/community hospitals, 4 = health centers

Appendix Table 3: nebulizer and peak-flow meter availability from SPA data, 2015

Medical component	Facility type	Total facilities	Facilities with availability	% availability
Nebulizer	Central hospital	4	3	75.00
	District hospital	24	6	25.00
	Other hospital	47	28	59.25
	Rural / community hospital	41	9	21.95
	Health center	473	24	5.07
	Clinic	317	38	12.02
	Health post	20	NA	NA
	Maternity	4	NA	NA
	Dispensary	47	1	2.00
	Total		977	109
Peak-flow meter	Central hospital	4	1	25.00
	District hospital	24	1	4.17
	Other hospital	47	13	27.58
	Rural / community hospital	41	2	4.88
	Health center	473	8	1.68
	Clinic	317	12	3.79
	Health post	20	NA	0.00
	Maternity	4	NA	0.00
	Dispensary	47	NA	0.00
	Total		977	37

Appendix Table 4: Missingness in HHFA data

		Health Center (n=471)		Rural Community Hospital (n=41)		District Hospital (n=48)		Central Hospital (n=4)	
Condition	Essential Equipment & Medication	Missing data: Available Components	Missing data: Functional Components	Missing data: Available Components	Missing data: Functional Components	Missing data: Available Components	Missing data: Functional Components	Missing data: Available Components	Missing data: Functional Components
Chronic Conditions									
Chronic asthma	Beclomethasone	0%	0%	0%	0%	0%	0%	0%	0%

	inhaler								
	Salbutamol inhaler	0%	0%	0%	0%	0%	0%	0%	0%
	Stethoscope	1%	1%	0%	0%	0%	0%	0%	0%
Hypertension (stage 1 or 2)	At least two of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	0%	0%	0%	0%	0%	0%	0%	0%
	Blood pressure apparatus	1%	7%	0%	0%	0%	0%	0%	0%
	Stethoscope	1%	1%	0%	0%	0%	0%	0%	0%
Type 1 diabetes	Blood glucose test equipment	2%	100%	0%	100%	0%	100%	0%	100%
	Insulin	0%	0%	0%	0%	0%	0%	0%	0%
Type 2 diabetes	Blood glucose test equipment	2%	100%	0%	100%	0%	100%	0%	100%
	Metformin or glibenclamide	0%	0%	0%	0%	0%	0%	0%	0%
Pain care	Oral pain	0%	0%	0%	0%	0%	0%	0%	0%

	medication								
	Injectable morphine or pethidine	99%	99%	15%	15%	17%	17%	0%	0%
Hypertension requiring three or more antihypertensive classes	At least three of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	0%	0%	0%	0%	0%	0%	0%	0%
	Blood pressure apparatus	1%	7%	0%	0%	0%	0%	0%	0%
	Stethoscope	1%	1%	0%	0%	0%	0%	0%	0%
Heart failure	Adult scale	1%	7%	0%	2%	0%	2%	0%	0%
	Atenolol or other beta-blocker	0%	0%	0%	0%	0%	0%	0%	0%
	Blood pressure apparatus	1%	7%	0%	0%	0%	0%	0%	0%
	Captopril, enalapril or other ACE inhibitor	0%	0%	0%	0%	0%	0%	0%	0%

	r								
	Furose mide	0%	0%	0%	0%	0%	0%	0%	0%
	Stetho cope	1%	1%	0%	0%	0%	0%	0%	0%
	Ultraso und equipm ent	99%	99%	15%	15%	17%	17%	0%	0%
chronic RHD	Benzath ine penicilli n	0%	0%	0%	0%	0%	0%	0%	0%
	Injectab le epineph rine	0%	0%	0%	0%	0%	0%	0%	0%
Acute Conditions									
Mild/m oderate acute Asthma	Funcio nal X- ray machine	99%	99%	15%	15%	17%	17%	0%	0%
	Oxygen availabi lity (cylinde r or concent rator)	1%	75%	0%	12%	0%	13%	0%	0%
	Peak flow meter in NCD or general outpatie nt area	100%	100%	100%	100%	100%	100%	100%	100%
	Prednis olone	0%	0%	0%	0%	0%	0%	0%	0%
	Pulse oximete r	2%	84%	2%	8%	2%	8%	0%	0%

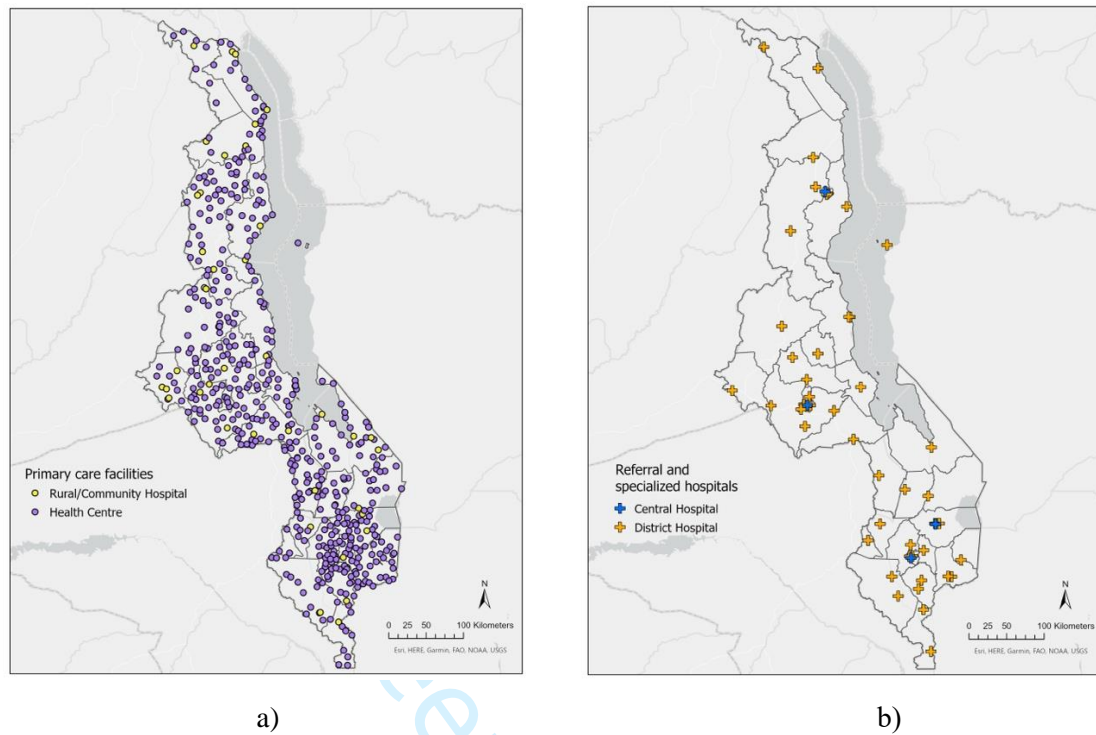
	Salbutamol inhaler	0%	0%	0%	0%	0%	0%	0%	0%
	Functional X-ray machine	99%	99%	15%	15%	17%	17%	0%	0%
	Oxygen availability (cylinder or concentrator)	1%	75%	0%	12%	0%	13%	0%	0%
	Peak flow meter in NCD or general outpatient area	100%	100%	100%	100%	100%	100%	100%	100%
	Prednisolone	0%	0%	0%	0%	0%	0%	0%	0%
	Pulse oximeter	2%	84%	2%	8%	2%	8%	0%	0%
	Salbutamol inhaler	0%	0%	0%	0%	0%	0%	0%	0%
	Micro nebulizer in NCD or general outpatient area	100%	100%	100%	100%	100%	100%	100%	100%
Moderate/severe acute Asthma	Hydrocortisone injection	0%	0%	0%	0%	0%	0%	0%	0%
Acute diabete	Blood glucose	2%	100%	0%	100%	0%	100%	0%	100%

s	test equipment								
	Blood pressure apparatus in NCD or general outpatient area	1%	7%	0%	0%	0%	0%	0%	0%
	Infusion kit for intravenous fluids	11%	100%	6%	100%	6%	100%	0%	100%
	Injectable glucose	0%	0%	0%	0%	0%	0%	0%	0%
	Insulin	0%	0%	0%	0%	0%	0%	0%	0%
	Liver and kidney function diagnostics (creatinine, electrolytes)	97%	97%	6%	6%	6%	6%	0%	0%
Acute epilepsy	Diazepam injection	99%	99%	15%	15%	17%	17%	0%	0%
Injuries / acute minor surgical conditions+	Lidocaine in minor surgical area	0%	0%	0%	0%	0%	0%	0%	0%
	Nasogastric tubes in	99%	99%	13%	23%	15%	25%	0%	0%

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3									
4	minor								
5	surgical								
6	area								
7									
8	Needle								
9	holder								
10	in								
11	minor								
12	surgical								
13	area	99%	99%	13%	15%	15%	17%	0%	0%
14									
15	Oxygen								
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20	concent								
21	rator)	1%	75%	0%	12%	0%	13%	0%	0%
22									
23	Retracto								
24	r in								
25	minor								
26	surgical								
27	area	99%	99%	13%	15%	15%	17%	0%	0%
28									
29	Scalpel								
30	in								
31	minor								
32	surgical								
33	area	99%	99%	13%	15%	15%	17%	0%	0%
34									
35	Skin								
36	disinfec								
37	tant in								
38	minor								
39	surgical								
40	area	0%	0%	0%	0%	0%	0%	0%	0%
41									
42	Surgical								
43	scissors								
44	in								
45	minor								
46	surgical								
47	area	99%	99%	13%	15%	15%	17%	0%	0%
48									
49	Sutures								
50	in								
51	minor								
52	surgical								
53	area	0%	0%	0%	0%	0%	0%	0%	0%
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	Tourniquet in minor surgical area	99%	99%	13%	31%	15%	31%	0%	25%
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Appendix Figure 1. Spatial distribution of facilities in Malawi for a) PHCs and b) RSHs

Appendix Table 5: Service availability and service functionality for each essential medical component at PHCs and Secondary and Tertiary facilities

		PHC (n = 512)		Secondary and Tertiary Facilities (n=52)	
Condition	Essential Equipment & Medication	% Available	% Functional	% Available	% Functional
Chronic Conditions					
Chronic Asthma	Service Readiness (SR)	-	8%	-	40%
	Beclomethasone inhaler	9%	9%	42%	42%
	Salbutamol inhaler***	71%	71%	88%	88%
	Stethoscope	93%	92%	100%	100%
	SR		34%		88%

Hypertension (stage 1 or 2)	At least two of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	37%	37%	88%	88%
	Blood pressure apparatus	93%	90%	100%	98%
	Stethoscope	93%	92%	100%	100%
Type 1 diabetes	SR		5%		88%
	Blood glucose test equipment	44%	NA	98%	NA
	Insulin	7%	6%	90%	90%
Type 2 diabetes	SR		21%		94%
	Blood glucose test equipment	44%	NA	98%	NA
	Metformin or glibenclamide	30%	30%	96%	96%
Pain care	SR		22%		29%
	Oral pain medication	100%	100%	100%	100%
	Injectable morphine or pethidine	21%	21%	31%	29%
Hypertension requiring three or more antihypertensive classes	SR		15%		75%
	At least three of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	17.5%	17.5%	75%	75%
	Blood pressure apparatus	93%	90%	100%	98%
	Stethoscope	93%	92%	100%	100%
Heart failure (RCH* only)	SR		22%		38%
	Adult scale	98%	95%	98%	98%
	Atenolol or other beta-blocker	71%	71%	81%	79%
	Blood pressure apparatus	95%	93%	100%	98%

	Captopril, enalapril or other ACE inhibitor	67%	67%	75%	75%
	Furosemide	71%	71%	85%	85%
	Stethoscope	95%	93%	100%	100%
	Ultrasound equipment	33%	33%	83%	77%
Chronic RHD (RCH only)	SR		7%		42%
	Benzathine penicillin	78%	78%	83%	83%
	Injectable epinephrine	31%	31%	58%	56%
Acute Conditions					
Mild/moderate acute Asthma (RCH only)	SR		17%		50%
	Functional X-ray machine	34%	29%	83%	73%
	Oxygen availability (cylinder or concentrator)	85%	8%	88%	88%
	Peak flow meter in NCD or general outpatient area**	NA	NA	NA	NA
	Prednisolone	73%	73%	88%	88%
	Pulse oximeter	61%	59%	92%	88%
	Salbutamol inhaler***	93%	93%	88%	88%
Moderate/severe acute Asthma (RCH only)	SR		15%		44%
	Functional X-ray machine	33%	29%	83%	73%
	Oxygen availability (cylinder or concentrator)	86%	86%	88%	88%
	Peak flow meter in NCD or general	NA	NA	NA	NA

	outpatient area **				
	Prednisolone	73%	73%	88%	88%
	Pulse oximeter	62%	60%	92%	88%
	Salbutamol inhaler***	93%	93%	88%	88%
	Micronebuliser in NCD or general outpatient area **	NA	NA	NA	NA
	Hydrocortisone injection	62%	62%	85%	85%
Acute diabetic event (RCH only)	SR		22%		65%
	Blood glucose test equipment	95%	NA	98%	NA
	Blood pressure apparatus in NCD or general outpatient area	95%	93%	100%	98%
	Infusion kit for intravenous fluids	88%	NA	92%	NA
	Injectable glucose	81%	81%	92%	92%
	Insulin	48%	48%	90%	90%
	Liver and kidney function diagnostics (creatinine, electrolytes)	45%	17%	85%	31%
Acute epilepsy (RCH only)	SR		36%		85%
	Diazepam injection	36%	36%	85%	85%
injuries/ acute minor surgical	SR		24%		46%

conditions+ (RCH only)	Lidocaine in minor surgical area	95%	95%	98%	98%
	Nasogastric tubes in minor surgical area	67%	64%	77%	77%
	Needle holder in minor surgical area	90%	88%	85%	85%
	Oxygen availability (cylinder or concentrator)	86%	86%	88%	88%
	Retractor in minor surgical area	50%	50%	85%	85%
	Scalpel in minor surgical area	86%	83%	85%	85%
	Skin disinfectant in minor surgical area	86%	86%	87%	87%
	Surgical scissors in minor surgical area	89%	76%	85%	85%
	Sutures in minor surgical area	93%	90%	98%	98%
	Tourniquet in minor surgical area	57%	57%	69%	69%

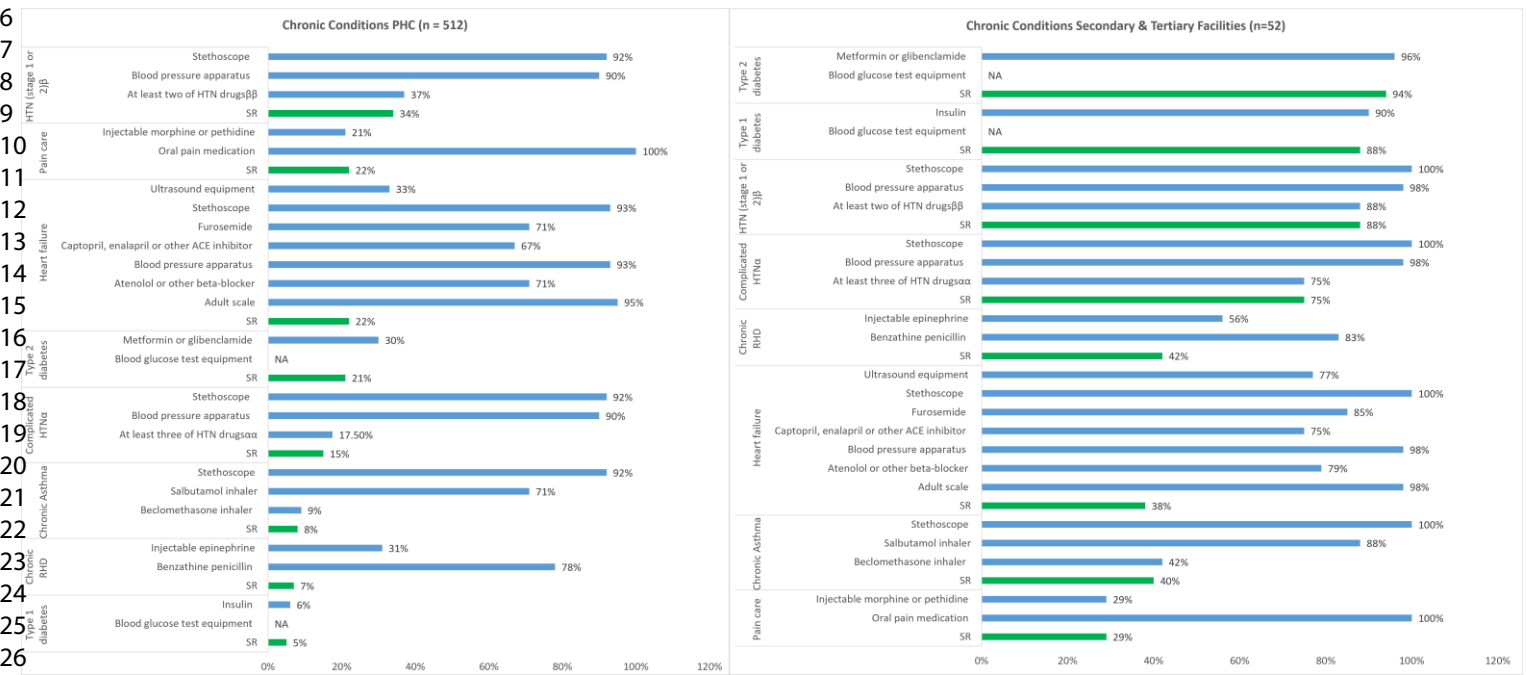
*RCH : Rural Community Hospital which is considered a higher level PHC facility

**Data not available in 2019 HHFA.

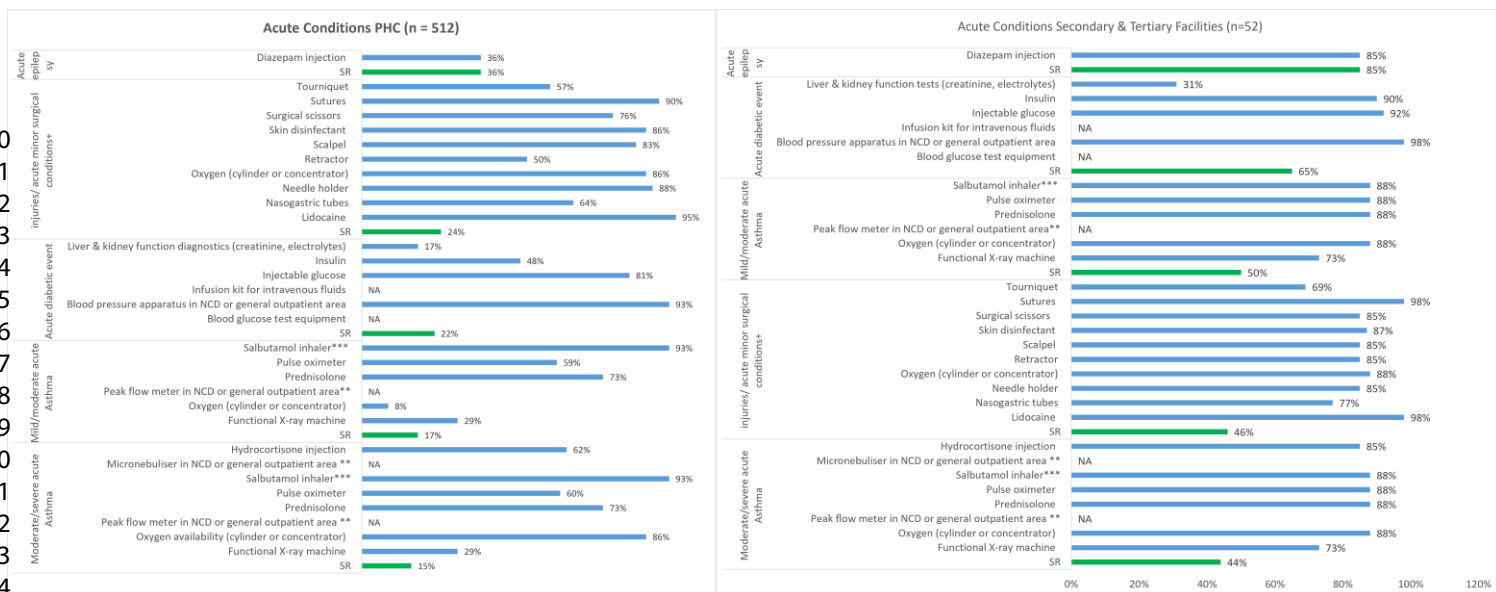
***Expected to be provided at primary level.

Appendix: Figure 2: Service readiness and service functionality for each essential medical component at PHCs and Secondary and Tertiary facilities- Chronic Conditions

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Appendix: Figure 3: Service readiness and service functionality for each essential medical component at PHCs and Secondary and Tertiary facilities- Acute Conditions



BMJ Open

Service readiness for the management of non-communicable diseases in publicly financed facilities in Malawi: findings from the 2019 Harmonized Health Facility Assessment census survey

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3 **Service readiness for the management of non-communicable diseases in publicly financed**
4 **facilities in Malawi: findings from the 2019 Harmonized Health Facility Assessment**
5 **census survey**
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ABSTRACT

Introduction: Non-communicable diseases (NCDs) are rising in low-and middle-income countries (LMICs), including Malawi. To inform policymakers and planners on the preparedness of the Malawian healthcare system to respond to NCDs, we estimated NCD service readiness in publicly financed healthcare facilities in Malawi.

Methods: We analyzed data from 564 facilities surveyed in the 2019 Harmonized Health Facility Assessment (HHFA), including 512 primary health care (PHC) and 52 secondary and tertiary care (STC) facilities. To characterize service readiness, applying the law of minimum, we estimated the percentage of facilities where the equipment and medicines required to provide NCD services were functional. Further, we estimated permanently unavailable items to identify service readiness bottlenecks.

Results: Fewer than 40% of PHC facilities were ready to deliver services for any of the 13 NCDs analyzed. Insulin and beclomethasone inhalers had the lowest stock levels at PHC facilities (6% and 8%, respectively). Almost half of rural and community hospitals (RCHs) have never had insulin and benzathine penicillin (49% and 44%, respectively). STC facilities had varying service readiness, ranging from 27% for managing acute diabetes complications to 94% for chronic type 2 diabetes management. Only 38% of STC facilities were ready to manage heart failure. Oral pain medicines were widely available at all levels of health facilities; however, only 22% of RCH and 29% of STCs had injectable morphine or pethidine.

Conclusion: Publicly financed facilities in Malawi are generally unprepared to provide NCD services, especially at the PHC level. Targeted investments in PHC can substantially improve service readiness for chronic NCD conditions in local communities and enable STC to respond to acute NCD complications and more complex NCD cases.

Strengths and limitations of this study

- This study quantified non-communicable disease (NCD) service readiness critical to achieving universal health coverage (UHC) with a census sample of publicly financed facilities.
- Our approach provides generalizable results for all health facilities in Malawi.
- Our analyses by facility and service type can help planners better target investments to lagging areas.
- The analysis is limited to service-specific readiness and does not assess broader dimensions of health facility readiness, like human resources and basic infrastructure.
- The HHFA survey collects data on a subset of equipment and medicines required to manage NCDs and minor surgical conditions, constraining how service readiness is defined.

INTRODUCTION

Non-communicable diseases (NCDs) are responsible for 60% of early death and disability globally, and their growing burden in low- and middle-income countries (LMICs) is particularly concerning. According to the World Health Organization (WHO), 77% of the annual global NCD deaths occur in LMICs.(1) In 2021, NCDs caused 41 million deaths worldwide, among which 29 million died of the four major conditions, including cardiovascular disease (CVD), cancer, chronic respiratory disease, and diabetes. Several studies have reported low levels of NCD service readiness in LMICs.(2,3)

Located in Sub-Saharan Africa (SSA) with an 18.6 million population, Malawi remains one of the world's poorest countries, with a national Gross Domestic Product (GDP) of only \$645 per capita in 2022.(4) Malawi suffers from a high burden of NCDs and their economic consequences that affect the country's overall economic development and lead to catastrophic health expenditures (CHE) for many Malawians seeking care.(5–7) As of 2019, NCDs accounted for 40% of mortality in Malawi, an increase from 30% in 2010.(8)

Characterizing service readiness to manage NCDs in Malawi can help identify areas for investment to better respond to NCDs. Several prior studies provisionally assessed the preparedness of the Malawian healthcare system. A 2018 study analyzed data from the 2013-2015 Malawi Service Provision Assessment (SPA).(3) Another SPA-based study assessed the preparedness of first-referral level hospitals in eight low-income countries, including Malawi, and estimated the percentages of facilities with complete minimal sets of equipment and medicines needed for thirteen NCD conditions.(9) The results from these studies only presented assessments around 2015, when the SPA dataset was published.(3,9) A recent study estimated screening, diagnosis, management, and rehabilitation services readiness for NCDs based on a survey of 22 health facilities between 2019 and 2020.(10) The study employed a limited sample, which warrants caution in extrapolating the findings to all health facilities in Malawi. Having up-to-date and comprehensive information regarding health facilities' NCD service readiness in Malawi is essential for formulating evidence-informed health policies and judicious resource allocation. This study aims to fill a knowledge gap about service readiness for major NCD conditions using the most recent 2019 Harmonized Health Facility Assessment (HHFA) survey. This study has two main objectives. First, we estimate NCD service readiness by analyzing the availability and functionality of essential equipment and medicines to diagnose and treat common NCD conditions. Second, we identify potential bottlenecks that limit NCD service readiness.

METHODS

Study setting

Healthcare in Malawi is delivered through public, private for-profit (PFP), and private not-for-profit (PNFP) facilities.(11) The publicly-financed sector is intended to be universally accessible without payment at the point of care, while PFP and PNFP facilities are not open to everyone and only represent 11% of the facilities in the Malawian health system.(12,13) We focused our analysis on publicly financed facilities owned by the government and the Christian Health Association of Malawi (CHAM). The government is the leading healthcare provider in Malawi, while CHAM offers approximately 75% of healthcare services in remote and rural

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3 areas.(14,15) Besides, in 2006, the government sought to enhance healthcare access for
4 underserved rural populations by partnering with CHAM through a service legal agreement,
5 wherein CHAM provides healthcare services at no cost to users and is later reimbursed by the
6 government for the incurred service expenses.(15) The health system in Malawi is structured
7 into primary, secondary, and tertiary levels. Primary care at health centers and rural community
8 hospitals (RCH) offers ambulatory and maternity services. Secondary care includes first-
9 referral (district) hospitals, while central hospitals constitute tertiary care.(11) Our analysis is
10 disaggregated into PHC facilities (health centers and RCHs) and STC facilities (district and
11 central hospitals) (Figure 1).
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16 **Data source**

17 Our study analyzes the 2019 HHFA, funded by the WHO, the World Bank, and other
18 collaborators. The HHFA is an update of the Service Availability and Readiness Assessment
19 (SARA) survey, which was, in turn, built upon the SPA survey. The 2019 HHFA covered all
20 publicly financed health facilities in the country. This survey adopted a census sample approach,
21 covering all functional publicly financed facilities in Malawi (n=1098), of which 564 were
22 owned by the Government and CHAM. The remaining facilities surveyed by the HHFA were
23 owned by faith-based organizations other than CHAM and NGO-owned facilities falling under
24 the private for-profit (PFP) and private not-for-profit (PNFP) categories. The HHFA assessed
25 service readiness by asking whether the equipment and medicines required to provide different
26 NCD services were available and functional.
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30 Our analysis included all facilities that were supposed to provide NCD services and
31 functioning during the survey. We removed one hospital, Zomba Mental Hospital, from our
32 sample because it did not offer NCD services included in our analysis. According to the
33 Administration of Health records, there were 485 registered health centers. However, only
34 471 of these were assessed by the HHFA. As a result, the 14 centers that were not surveyed
35 were considered 'non-functional.'
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37 The final sample we included in our analysis (n=564) consisted of 512 PHC facilities (471
38 health centers and 41 rural/community hospitals) and 52 STC facilities (48 district hospitals
39 and 4 central hospitals (Appendix Table 1). The 48 district hospitals included actual district
40 hospitals, large health centers functioning as quasi-district hospitals and first-referral-level
41 CHAM hospitals. The spatial distribution of sampled facilities is displayed in Figure 1.
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45 **Data analysis**

46 This study focused on the readiness of basic equipment and medicines to diagnose and treat
47 five acute and seven chronic NCD conditions. The conditions included in the analysis are acute
48 and chronic asthma, hypertension, heart failure, rheumatic heart disease (RHD), diabetes,
49 epilepsy, injuries, and minor surgical conditions, and chronic pain (Appendix Table 2).
50 Assessing the service availability for these conditions aligns with recommendations from the
51 Disease Control Priorities Project and related publications on priority interventions for NCDs
52 (16–19). The conditions included in our study are also prioritized in the Malawi Ministry of
53 Health National Action Plan for NCD Prevention and Management 2017-2022.(20) We defined
54 service readiness as having functional equipment and medicines stock to provide the NCD
55 service in question. We considered equipment functional if it was operational and present in
56 general outpatient or minor surgical areas. Medicines were considered “functional” if they were
57 in stock, not expired, and appropriately stored in a manner that preserves the medicine's
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potency.

Operational definitions and measures

Partners in the Ministry of Health advised us on the expected availability of NCD services at different levels of health facilities based on national guidelines and policies (Appendix Table 2). We extracted the corresponding indicators from the HHFA survey for analysis and examined data missingness to refine our indicator for each service. We detail the conditions, items, indicators, and related facility types in Appendix Table 3 and the missingness analysis in Appendix Table 4. When certain services were not expected to be offered at health centers, we only included rural/community hospital data in the denominator for those services' indicators.

Regarding missingness, the HHFA survey did not include questions on peak flow meters and micro-nebulizers required for asthma management in the outpatient setting. Therefore, we examined SPA data to understand how these missing variables might have affected the asthma readiness measure (Appendix Table 5). For the variables with close to 100% missing data, we assumed that the item was not expected to be available at the facility level.

The HHFA survey classifies medicines or equipment as "available and functional," "available but not functional," "not available (at this time)," or "never available" at the facility. Accordingly, we calculated three indicators: 1) functionality, 2) permanent unavailability, and 3) service readiness.

Functionality: Functionality refers to the presence of the functioning items (equipment and stock of medicines, not expired and properly stored) involved in providing a given NCD service.

$$\text{Functionality} = \frac{\text{number of facilities with available and functioning item}}{\text{Total number of facilities}}$$

Service readiness: For each facility, we estimated service readiness based on the functionality of the set of basic items required to provide a given NCD service.

Permanent unavailability: Permanent unavailability is when the item (medicine or equipment) is never present at the health facility, i.e., not temporarily unavailable due to supply issues.

$$\text{Permanent unavailability} = \frac{\text{number of facilities with items that were never present}}{\text{Total number of facilities}}$$

When a facility had all essential components available and functioning, it was labeled "ready" to provide that service. Otherwise, the facility was labeled as "Not ready."

Applying Carl Sprengel's Law of the Minimum, this study likens service readiness to an organism's growth.⁽²¹⁾ We pinpoint the limiting factor impeding readiness, analogous to the lowest point in a barrel regulating water level (Figure 2). This method guarantees a robust service readiness assessment, as absent data on non-limiting factors does not bias the results. However, if data on the limiting factor is missing, service readiness may be overestimated, as seen in the difference between the complete and incomplete barrels in Figure 2.

Patient and public involvement

None.

RESULTS

We included 564 facilities (i.e., 512 PHC facilities and 52 STC facilities) in our analysis.

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3 There were 14 non-functioning health centers and one specialized tertiary hospital excluded
4 from our analysis. Based on the Ministry of Health guidelines and missing data, we assumed
5 that the following services were not expected to be delivered at health centers: chronic heart
6 failure care, chronic rheumatic heart disease care, treatment of acute asthma exacerbations,
7 acute complications of diabetes, acute epilepsy (seizures), and injuries (Appendix Table 2).
8 Except for the missing data on conditions at health centers, all other variables had less than
9 25% missing data (Appendix Table 4).
10

11 NCD service readiness Figure 3 compares the service readiness of PHC and STC facilities for
12 chronic and acute NCD services. Overall, the readiness of STC facilities was higher than
13 PHCs. We found that the service readiness was lower than 40% for NCD services at PHC
14 facilities. Among the chronic NCD services, PHC facilities were least ready to provide
15 services for type 1 diabetes and chronic asthma (5% and 8%, respectively). Among the acute
16 services included in the analysis, RCHs were least ready to manage acute complications of
17 diabetes (12%), acute asthma exacerbations (less than 20%), and injuries/acute minor surgical
18 conditions (24%). PHCs had higher readiness scores for managing acute epilepsy (among
19 RCH in PHC estimation) and stage 1 and 2 hypertension. STC facilities were near full
20 readiness for type 2 diabetes (94%), type 1 diabetes (88%), stage 1 and 2 hypertension (88%),
21 and acute epilepsy treatment (85%). However, STC facilities were least ready to provide care
22 for acute complications of diabetes (27%) and had relatively lower readiness for managing
23 chronic asthma, pain, heart failure, rheumatic heart disease, moderate/severe acute asthma,
24 and injuries/ acute minor surgical conditions.
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31 **Equipment functionality and Medicine stock**

32 Figure 4 shows the functionality of equipment and medicines stock required to provide the 13
33 services we included in the analysis. Insulin for type 1 diabetes and beclomethasone inhalers
34 for managing chronic asthma had the lowest stock at the PHC level (6% and 8%, respectively).
35 Around 90% of STCs had insulin, but beclomethasone inhalers show low stock (42%) at STC
36 health facilities. Availability of antihypertensives is low in PHC facilities, with only 16%
37 having “at least three or more antihypertensive classes” of medication and only 37% having at
38 least two, compared to 75% and 88% in STC facilities. The availability of functional diagnostic
39 equipment was limited, even in RCHs. For example, functional X-ray machines were found in
40 only 29% of the RCHs, and ultrasound was functional in 34%.
41
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43 Additionally, only 46% of RCH stock insulin for managing acute complications of diabetes,
44 compared to 90% of STC facilities. However, RCH and STC facilities had low availability of
45 functioning diagnostic tests required to manage acute complications of diabetes. Liver and
46 kidney function tests were functional in only 17% of the RCH and 31% of STC facilities.
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49 **Permanently unavailable items**

50 As shown in Figure 5, beclomethasone was a "bottleneck item" for chronic asthma service
51 readiness at all levels since it was never available at 74% of PHC and 29% of STC facilities.
52 Basic medicines for managing type 1 and 2 diabetes and acute complications of diabetes were
53 bottleneck items for diabetes care readiness at PHC facilities. For chronic rheumatic heart
54 disease management, 44% of RCH did not have benzathine penicillin. However, Figure 5 also
55 shows that there were items consistently in stock. These include oral pain medicines,
56 salbutamol inhalers, and diazepam injections, among others.
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DISCUSSION

Our analysis reveals significant gaps and disparities in the readiness of health facilities to respond to the growing burden of NCDs in Malawi. Fewer than 40% of PHCs are ready to diagnose and manage any of the 13 NCD services included in the analysis. Although STC facilities had higher readiness scores, 50% or fewer were not ready to diagnose and treat conditions like acute diabetes events, asthma, injuries/minor surgeries, chronic heart failure, chronic rheumatic heart disease, and pain. PHCs were least ready with basic equipment and medicines to manage type 1 diabetes and chronic asthma (less than 10%) and were most ready to treat acute epilepsy (37%). PHCs had higher readiness to manage Stage 1 and 2 hypertension (34%) but were less ready to treat complicated hypertension requiring three or more antihypertensive classes.

Our findings are consistent with prior studies that illustrate an urgent need to invest more in health systems across sub-Saharan Africa, including Malawi, to respond to NCDs.(3,9,10) In line with previous analyses, we found notable gaps and limited readiness to manage NCDs, particularly in PHC facilities.(3,10,22) Analysis of 2013-2015 SPA data for primary, secondary, and tertiary level facilities in Malawi showed that only 37.7% of PHC facilities were ready to provide services for diabetes, Chronic Respiratory Disease, and CVD compared to 96% of STC facilities.(3) Compared to the 2013-2015 SPA analysis of 43 first-referral level facilities, chronic asthma service readiness had increased to 40% in STC facilities compared to 5% in 2015.(9) STC facility readiness to manage type 1 and 2 diabetes increased from around 40% to 90%. Readiness for managing hypertension stages 1 and 2 increased from 44% to 88%, while services for hypertension requiring three or more antihypertensive classes increased from 26% to 75%. Readiness of STC facilities increased from 12% to 38% for chronic heart failure and from 9% to 42% for chronic rheumatic heart disease, but there was no increase in readiness for managing acute complications of diabetes. Service readiness for acute epilepsy and pain care decreased from 95% to 85% and 58% to 29%, respectively.

The deficiencies in NCD services are not unique to Malawi. Studies analyzing SPA data revealed low readiness of NCD services in countries like Tanzania, Singal, and Ethiopia.(3,9) Additional cross-sectional surveys to assess NCD services readiness revealed a similar pattern in Zambia but slightly higher readiness scores in Kenya, but the difference might stem from the dissimilarity in the service readiness calculation method.(22,23) Also, a systematic analysis of survey data focused on diabetes in sub-Saharan Africa reported low diagnostic capacity and supply of diabetes medicines in 14 African countries.(24)

Our analysis revealed a number of bottleneck items for NCD care in Malawi, including beclomethasone inhalers. Asthma management is not part of the NCD intervention package included in the essential health package of Malawi, and the Standard Treatment Guidelines for Malawi state that beclomethasone is only expected to be provided at the tertiary level.(25,26) However, the WHO considers beclomethasone as an essential and cost-effective intervention for chronic asthma care that can be provided at PHC facilities.(27,28) Our study suggests that the 2015 Standard Treatment Guidelines for Malawi could be revised to align with WHO recommendations, ensuring better access to asthma care in the community.

Addressing NCDs is a critical component of the health-related SDGs.(19)The essential health package developed by the Ministry of Health specified that management of diabetes, hypertension, and injuries be provided at primary and secondary facilities.(26) Unfortunately, our study shows that most PHC facilities had low service readiness for these services and others. The Ministry of Health has acknowledged concerns about the suboptimal implementation of the Essential Health Package due to inadequate resources, low awareness among stakeholders,

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3 and the lack of clear financial mechanisms to ensure the provision of free-of-charge services at
4 the point of care. To make progress on NCDs, the Ministry will need to explore options for
5 increasing healthcare financing in a manner that will benefit the entire range of healthcare needs,
6 including NCDs.
7

8
9 This study has several limitations. Notably, our definition of service readiness is constrained
10 by the methodology used in the HHFA survey, which focuses on a specific subset of equipment
11 and medicines. This can introduce bias depending on the criteria and items used to define
12 service readiness. For example, as the HHFA survey does not assess the availability of the
13 nebulizers and peak flow meter in the outpatient departments, we did not include them as part
14 of the essential equipment required for treating acute asthma. To address this, we analyzed
15 2013-2015 SPA data to understand potential bias in our estimates. Data from the 2013-2015
16 SPA survey about the peak flow meter suggests that we may have overestimated the service
17 readiness for acute asthma (Appendix Table 5). While availability may have grown since 2015,
18 if availability remains unchanged, it may be an alarming limiting factor for the overall readiness
19 for acute asthma care. Second, the HHFA covers a limited range of health conditions and
20 potential services for NCDs. We recommend that the WHO continue refining the HHFA survey
21 to enhance the scope and precision of indicators for essential healthcare.
22
23

24 Additionally, the scope of our analysis is limited to service-specific readiness for a few NCDs
25 and does not assess broader dimensions of health facility readiness, like human resources and
26 basic infrastructure. A study by Banda et al.(10) of a smaller number of health facilities
27 assessed other dimensions not included in the HHFA survey, such as whether facilities kept
28 reliable records for NCD patients, supplemented with qualitative interviews to characterize the
29 constraints.
30

31 **CONCLUSION**

32
33 Our analysis reveals that, despite progress since 2015, health facilities in Malawi have a long
34 way to go to ensure universal access to NCD services. Despite being the first point of care and
35 the ideal platform for early detection and long-term management of most NCDs, PHC facilities
36 in Malawi have low NCD service readiness. While health centers and rural/community
37 hospitals may not be expected to perform complete diagnostics or treatment for complicated
38 conditions, these primary care facilities are well-positioned to provide basic services for
39 common NCDs. PHC facilities urgently need additional investment to improve NCD service
40 availability. For other NCDs, a progressive approach to decentralizing NCD care would start
41 by building the capacity of RCH that, over time, could allow for extending a broader range of
42 services to PHC facilities. Our list of bottlenecks and permanently unavailable items provides
43 a starting point to enhance the supply of medicines and equipment. The list can also inform the
44 updating of guidelines to achieve better service readiness for particular conditions sensitive to
45 these identified bottlenecks.
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50 **Contributors**

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53 ZW, YC, and SA led the literature review and wrote the first draft of the manuscript. PT and
54 JC provided data and supporting documents. ZW and LB analyzed the data, and MM replicated
55 the estimates. ZW and MM produced the tables. YS, YC, and SA created the figures. MC, PT,
56 EW, and DW contributed to conceiving the study, refining the methods, and interpreting the
57 results. DW acquired funding for the research. YS led the study design, method development,
58 and result interpretation. All the authors have made significant intellectual or practical
59 contributions, critically revised the manuscript, and approved the final version of this paper.
60

Competing interests

We declare that none of the authors nor coauthors have any financial or non-financial competing interests that may influence the analysis or the interpretation of this paper.

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Data availability statement

The data supporting this study's findings were obtained through the MoH Malawi and are not available in a public repository.

Ethics approval

As this study was an analysis of an existing dataset, review and approval by an IRB was not required.

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FIGURE LEGENDS

Figure 1. Healthcare systems in Malawi

The figure presents the structure of the health system in Malawi and maps the health facilities in the country.

Figure 2. Required items and service readiness relation

The figure presents the relationship between service readiness (water level) and complementary items (bars).

Figure 3. NCD service readiness of the Malawi health system by level

The figure presents the service readiness of chronic and acute NCD conditions, comparing PHC Level to STC Level.

Figure 4. Service functionality for each essential medical component at PHCs and STC

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3 facilities

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5 The figure illustrates the availability of essential equipment and medicines considered in the
6 analysis, categorizing them into equipment and medicine.
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9 **Figure 5.** Permanent unavailability by facility level

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11 The figure presents the items that were never available, comparing the PHC and STC levels.
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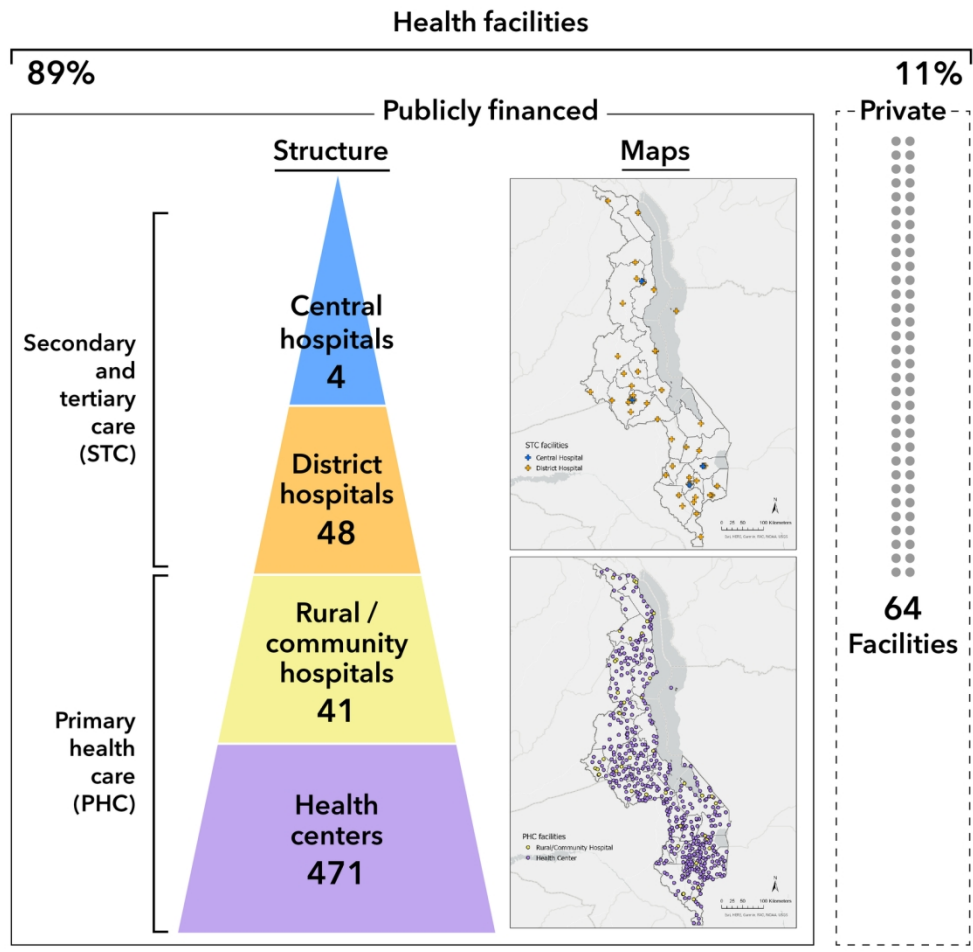


Figure 1. Healthcare system and facilities in Malawi

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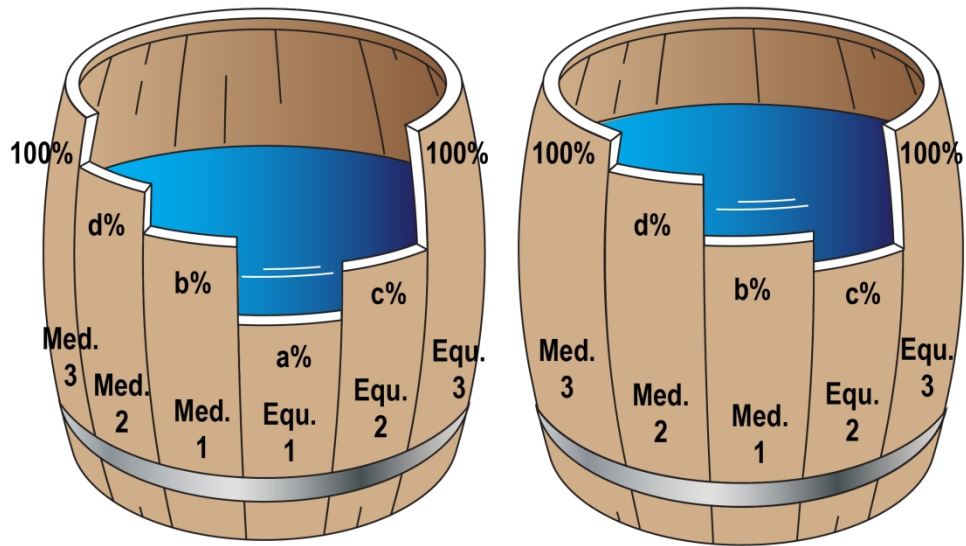
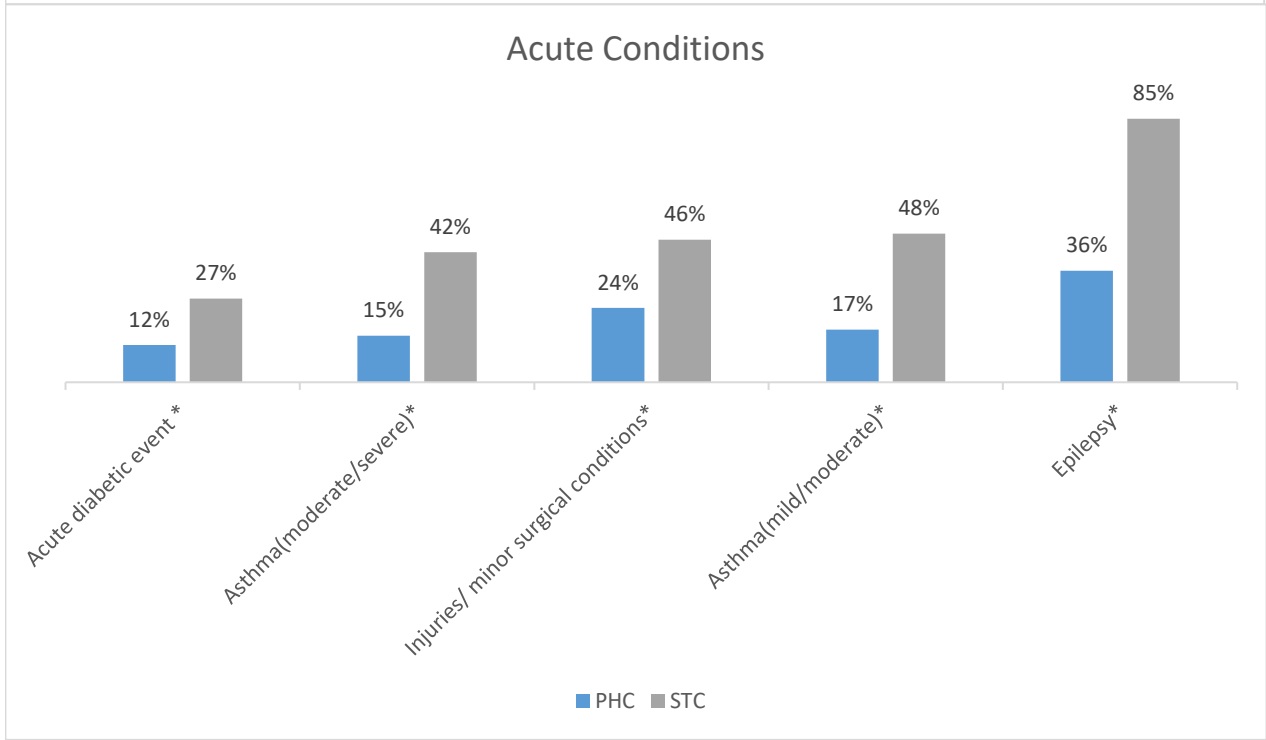
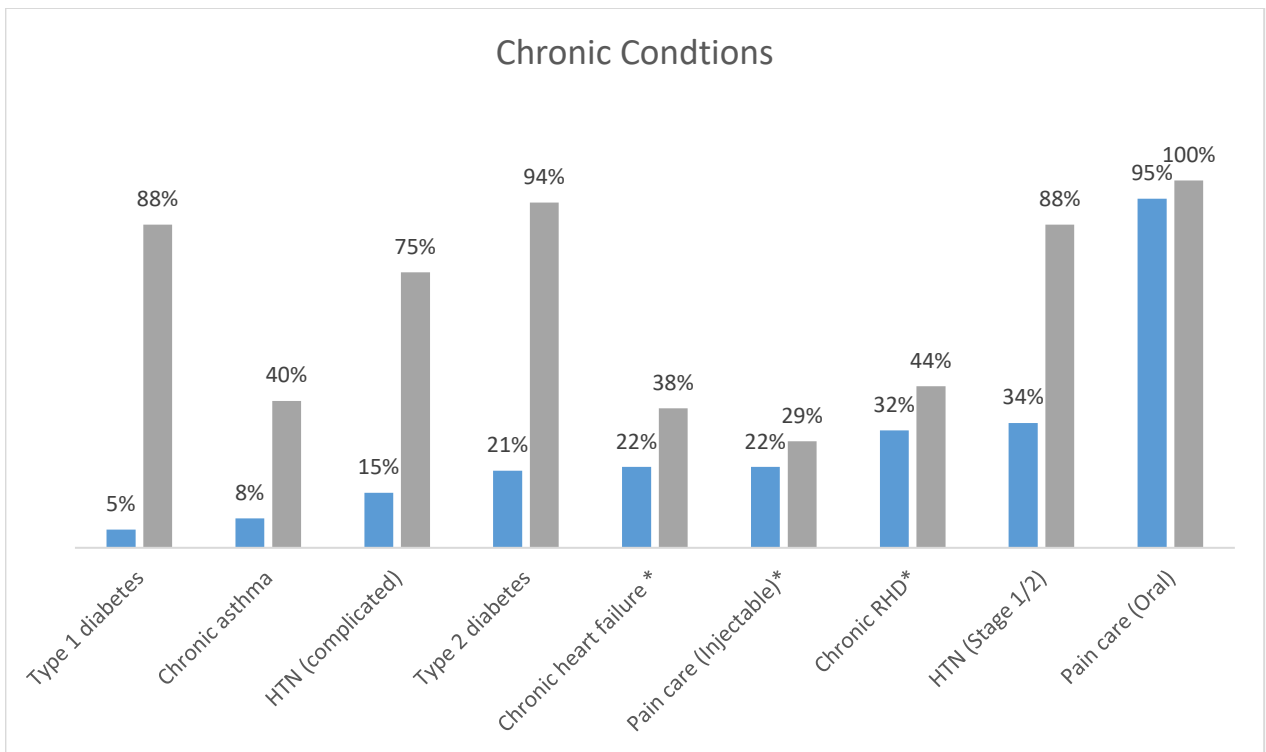


Figure 2: Required items and service readiness relation

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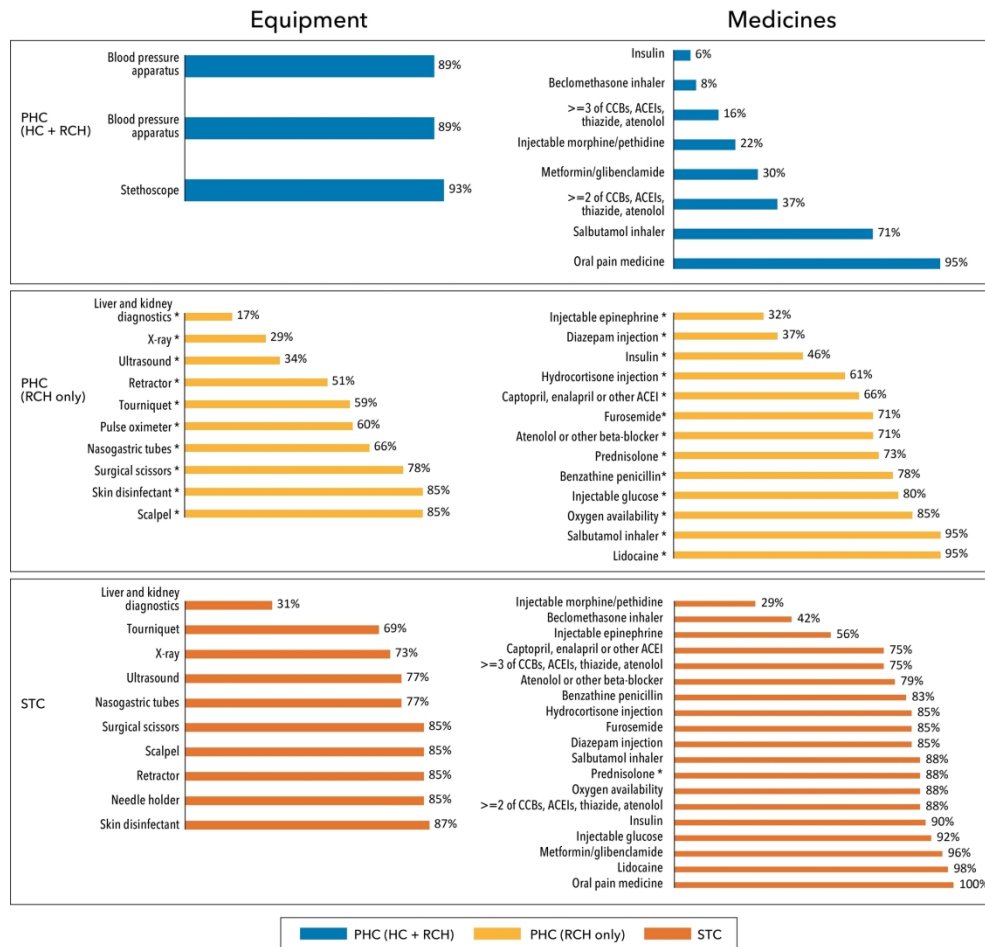


Figure 4: Functionality and stock of essential equipment and medicines at PHCs and STC facilities.

213x202mm (300 x 300 DPI)

Condition		Equipment & Medicines	PHC	STC
Chronic Conditions	Chronic Asthma	Beclomethasone inhaler	74%	29%
		Salbutamol inhaler	8%	0%
	HTN (Stage 1 or 2)	>=2 of: CCB, ACEI, thiazide, atenolol	12%	0%
	Type 1 diabetes	Insulin	81%	2%
	Type 2 diabetes	Metformin/glibenclamide	48%	0%
	Oral pain care	Oral pain medication	0%	0%
	Injectable pain care *	Injectable morphine/pethidine	7%	19%
	Chronic heart failure*	Atenolol or other beta-blocker	24%	6%
		Captopril, enalapril or other ACEI	20%	6%
		Furosemide	12%	2%
	Chronic RHD*	Benzathine penicillin	44%	8%
		Injectable epinephrine	5%	10%
	Acute Conditions	Mild/moderate acute asthma*	Prednisolone	10%
Salbutamol inhaler			0%	0%
Moderate/severe acute asthma*		Prednisolone	10%	0%
		Salbutamol inhaler	0%	0%
		Hydrocortisone injection	32%	8%
Acute diabetic events*		Injectable glucose	0%	2%
		Insulin	49%	2%
Acute epilepsy*		Diazepam injection	0%	0%
Injuries/acute minor surgical conditions*		Lidocaine	2%	0%
		Skin disinfectant	5%	2%
	Sutures	5%	0%	

Appendix Table 1. Summary of publicly financed facility representation in each category

Facility type	Primary health care (PHC) facilities			Secondary and tertiary care (STC) facilities		
	Health centers	Rural/Community hospitals (RCH)	Total	District hospitals	Central hospitals	Total
Total facilities	485	41	526	48	5	53
Non-functional facilities*	14	0	14	0	0	0
HHFA samples	471**	41	512	48	4	52

*We consider the facilities not surveyed by the HHFA as "non-functional" because HHFA is a census survey.

**Three quasi-district hospitals were categorized as "District Hospitals": Ndirande Health Centre, Matawale Health Centre, and Mzuzu Health Centre.

Appendix Table 2: NCD services analyzed by expected level of service

Condition	Primary health care facilities		Secondary and tertiary facilities	
	Health Centers	Rural/Community Hospitals	District Hospitals	Central Hospitals
Controlled chronic conditions				
Chronic asthma	x	x	x	x
Hypertension (stage 1 or 2)	x	x	x	x
Type 1 diabetes	x	x	x	x
Type 2 diabetes	x	x	x	x
Oral pain care	x	x	x	x
Injectable pain care		x	x	x
Hypertension requiring three or more antihypertensive classes	x	x	x	x
Heart failure		x	x	x
Chronic RHD		x	x	x
Acute exacerbations and complications				
Mild/moderate acute Asthma		x	x	x
Moderate/severe acute Asthma		x	x	x
Acute diabetic events		x	x	x
Acute epilepsy		x	x	x
injuries/ acute minor Surgical conditions+		x	x	x

Appendix Table 3: Service Indicators

Part 1: Acute conditions

diseases	Essential equipment and medications	Availability Indicators	Functionality Indicators	“Never Available” Data Availability	Facility Types Surveyed*
Mild/moderate acute Asthma	Functional X-ray machine	T125_01 (Y = 1,2,3; N = 4,NA)	T125_01 (Y = 1; N = 2,4,NA)	No Data	1,2,3
	Oxygen availability (cylinder or concentrator)	HH101__22 (Y = “Yes”, N = “No”, NA) OR HH101__23 (cylinder) (Y = “Yes”, N = “No”, NA)	HH101A22 (Y = “Yes”, N = “No”, NA) OR HH101A23 (Y = “Yes”, N = “No”, NA)	No Data	1,2,3,4
	Peak flow meter in NCD or general outpatient area	No Data (used SPA data for estimation)	No Data	No Data	No Data
	Prednisolone	U103_10 (Y = 1,2; N = 3,4,5,NA)	U103_10 (Y = 1; N = 2,3,4,5,NA)	U103_10 = 5	1,2,3,4
	Pulse oximeter	HH101__8 (Y = “Yes”, N = “No”, NA)	HH101A8 (Y = “Yes”, N = “No”, NA)	No Data	1,2,3,4
	Salbutamol inhaler	U103_21 (Y = 1,2; N = 3,4,5,NA)	U103_21 (Y = 1; N = 2,3,4,5,NA)	U103_21 = 5	1,2,3,4
	Moderate/severe acute Asthma	Functional X-ray machine	T125_01 (Y = 1,2,3; N = 4,NA)	T125_01 (Y = 1; N = 2,4,NA)	No data
Oxygen availability (cylinder or concentrator)		HH101__22 (Y = “Yes”, N = “No”, NA) OR HH101__23 (cylinder) (Y = “Yes”, N = “No”, NA)	HH101A22 (Y = “Yes”, N = “No”, NA) OR HH101A23 (Y = “Yes”, N = “No”, NA)	No data	1,2,3,4
Peak flow meter in NCD or general		No Data (used SPA data for estimation)	No data	No data	No data

	outpatient area				
	Prednisolone	U103_10 (Y = 1, 2; N = 3,4,5,NA)	U103_10 (Y = 1; N = 2,3,4,5,NA)	U103_10 = 5	1,2,3,4
	Pulse oximeter	HH101_8 (Y = "Yes", N = "No", NA)	HH101A8 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
	Salbutamol inhaler	U103_21 (Y = 1,2; N = 3,4,5,NA)	U103_21 (Y = 1; N = 2,3,4,5,NA)	U103_21 = 5	1,2,3,4
	Micro nebuliser in NCD or general outpatient area	No Data (used SPA data for estimation)	No Data	No Data	No Data
	Hydrocortisone injection	U103_11 (Y = 1,2; N = 3,4,5,NA)	U103_11 (Y = 1; N = 2,3,4,5,NA)	U103_11 = 5	1,2,3,4
Acute diabetes	Blood glucose test equipment	T105_01 (Y = 1,2; N = 3,NA)	No Data	No Data	1,2,3,4
	Blood pressure apparatus in NCD or general outpatient area	HH101_15 (Y = "Yes", N = "No", NA)	HH101A15 (Y = "Yes", N = "No", NA)	No Data	1,2,3,4
	Infusion kit for intravenous fluids	M116_161 (Y = "Yes", N = "No")	No Data	No Data	1,2,3,4
	Injectable glucose	U103_03 (Y = 1,2; N = 3,4,5,NA)	U103_03 (Y = 1; N = 2,3,4,5,NA)	U103_03 = 5	1,2,3,4
	Insulin	U103_02 (Y = 1,2; N = 3,4,5,NA)	U103_02 (Y = 1; N = 2,3,4,5,NA)	U103_02 = 5	1,2,3,4
	Liver and kidney function diagnostics (creatinine, electrolytes)	T113_03 (Y = 1,2; N = 3,NA) Or T122_01 (Y = 1,2; N = 3,NA) Or T123_01 (Y = 1,2,3; N = 4,NA)	T123_01 (Y = 1; N = 2,3,4,NA)	T123_01 = 5	1,2,3
Acute epilepsy	Diazepam injection	U125_16 (Y = 1,2; N = 3,4,5,NA) Or U126_05 (Y = 1,2; N = 3,4,5,NA)	U125_16 (Y = 1; N = 2,3,4,5,NA) Or U126_05 (Y = 1; N = 2,3,4,5,NA)	U125_16 = 5 And U126_05 = 5	All facility types AND M103.Yes.Contains(8)

		1,2; N = 3,4,5,NA)	1; N = 2,3,4,5,NA)		
Injuries/ acute minor surgical conditions+	Lidocaine in minor surgical area	U125_12 (Y = 1,2; N = 3,4,5,NA)	U125_12 (Y = 1; N = 2,3,4,5,NA)	U125_12 (Y = 5)	1,2,3,4
	Nasogastric tubes in minor surgical area	RR115_7 (Y = "Yes", N = "No", NA)	RR115A7 (Y = "Yes", N = "No", NA)	No Data	1,2,3
	Needle holder in minor surgical area	RR115_3 (Y = "Yes", N = "No", NA)	RR115A3 (Y = "Yes", N = "No", NA)	No Data	1,2,3
	Oxygen availability (cylinder or concentrator)	HH101_22 (Y = "Yes", N = "No", NA) OR HH101_23 (cylinder) (Y = "Yes", N = "No", NA)	HH101A22 (Y = "Yes", N = "No", NA) OR HH101A23 (Y = "Yes", N = "No", NA)	No Data	1,2,3,4
	Retractor in minor surgical area	RR115_5 (Y = "Yes", N = "No", NA))	RR115A5 (Y = "Yes", N = "No", NA))	No Data	1,2,3
	Scalpel in minor surgical area	RR115_4 (Y = "Yes", N = "No", NA))	RR115A4 (Y = "Yes", N = "No", NA))	No Data	1,2,3
	Skin disinfectant in minor surgical area	U125_05 (Y = 1,2; N = 3,4,5,NA)	U125_05 (Y = 1, N = 2,3,4,5,NA)	U125_05 (Y = 5)	1,2,3,4
	Surgical scissors in minor surgical area	RR115_6 (Y = "Yes", N = "No", NA)	RR115A6 (Y = "Yes", N = "No", NA)	No Data	1,2,3
	Sutures in minor surgical area	U125_09 (Y = 1,2; N = 3,4,5)	U125_09 (Y = 1; N = 2,3,4,5)	U125_09 (Y = 5)	1,2,3,4
	Tourniquet in minor surgical area	RR115_8 (Y = "Yes", N = "No", NA)	RR115A8 (Y = "Yes", N = "No", NA)	No Data	1,2,3

Part 2: Chronic Conditions

Conditions	Availability of complete essential equipment and medications	Availability Indicators	Functionality Indicators	"Never Available" Data Availability	Facility Types Surveyed
Chronic asthma	Beclomethasone	U103_09 (Y = 1,2; N = 3,4,5)	U103_09 (Y = 1; N = 2,3,4,5)	U103_09 (Y = 5)	1,2,3,4

	inhaler	1,2; N = 1; N = 3,4,5,NA	=1; N = 2,3,4,5,NA)	==5	
	Salbutamol inhaler	U103_21 (Y = 1,2; N = 3,4,5,NA)	=U103_21 (Y = 1; N = 2,3,4,5,NA)	=U103_21	1,2,3,4
	Stethoscope	HH101_13 (Y = "Yes", N = "No", NA)	HH101A3 (Y = "Yes", N = "No", NA)	No Data	1,2,3,4
Hypertension (stage 1 or 2)	At least two of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	U103_04, U103_05, U103_06, U103_07 (Y = 1,2; N = 3,4,5)	U103_04, U103_05, U103_06, U103_07 (Y = 1; N = 2,3,4,5)	U103_04 ==5 AND U103_05 ==5 AND U103_06 ==5 AND U103_07 ==5	1,2,3,4
	Blood pressure apparatus	HH101_15 (Y = "Yes", N = "No", NA)	HH101A15 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
	Stethoscope	HH101_13 (Y = "Yes", N = "No", NA)	HH101A3 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
Hypertension requiring three or more antihypertensive classes	At least three of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	U103_04, U103_05, U103_06, U103_07 (Y = 1,2; N = 3,4,5)	U103_04, U103_05, U103_06, U103_07 (Y = 1; N = 2,3,4,5)	U103_04 ==5 AND U103_05 ==5 AND U103_06 ==5 AND U103_07 ==5	1,2,3,4
	Blood pressure apparatus	HH101_15 (Y = "Yes", N = "No", NA)	HH101A15 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
	Stethoscope	HH101_13 (Y = "Yes", N = "No", NA)	HH101A3 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
Heart failure	Adult scale	HH101_1 (Y = "Yes", N = "No", NA)	HH101A1 (Y = "Yes", N = "No", NA)	No Data	1,2,3,4
	Atenolol or other beta-blocker	U103_06 (Y = 1,2; N = 3,4,5,NA)	=U103_06 (Y = 1; N = 2,3,4,5,NA)	=U103_06	1,2,3,4

	Blood pressure apparatus	HH101_15 (Y = "Yes", N = "No", NA)	HH101A15 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
	Captopril, enalapril or other ACE inhibitor	U103_04 (Y = 1,2; N = 3,4,5,NA)	U103_04 (Y = 1; N = 2,3,4,5,NA)	U103_04 = 5	1,2,3,4
	Furosemide	U103_13 (Y = 1,2; N = 3,4,5,NA)	U103_13 (Y = 1; N = 2,3,4,5,NA)	U103_13 = 5	1,2,3,4
	Stethoscope	HH101_13 (Y = "Yes", N = "No", NA)	HH101A3 (Y = "Yes", N = "No", NA)	No data	1,2,3,4
	Ultrasound equipment	T125_02 (Y = 1,2,3; N = 4,NA)	T125_02 (Y = 1; N = 2,3,4,NA)	No Data	1,2,3
chronic RHD	Benzathine penicillin	U106_18 (Y = 1,2; N = 3,4,5,NA)	U106_18 (Y = 1; N = 2,3,4,5,NA)	U106_18 = 5	1,2,3,4
	Injectable epinephrine	U125_20 (Y = 1,2; N = 3,4,5,NA)	U125_20 (Y = 1; N = 2,3,4,5,NA)	U125_20 = 5 AND U103_12 OR U103_12 = 5	1,2,3
Type 1 diabetes	Blood glucose test equipment	T105_01 (Y = 1,2; N = 3,NA)	No data	No data	1,2,3,4
	Insulin	U103_02 (Y = 1,2; N = 3,4,5,NA)	U103_02 (Y = 1; N = 2,3,4,5,NA)	U103_02 = 5	1,2,3,4
Type 2 diabetes	Blood glucose test equipment	T105_01 (Y = 1,2; N = 3,NA)	No data	No data	1,2,3,4
	Metformin or glibenclamide	U103_01 (Y = 1,2; N = 3,4,5,NA)	U103_01 (Y = 1; N = 2,3,4,5,NA)	U103_01 = 5 AND U103_14 OR U103_14 = 5	1,2,3,4
Pain care	Injectable morphine or pethidine	U127_07 (Y = 1,2; N = 3,4,5,NA)	U127_07 (Y = 1; N = 2,3,4,5,NA)	U127_07 = 5	1,2,3

	Oral pain medication (paracetamol, ibuprofen, aspirin or diclofenac)	U103_20 OR U103_17 OR U111_08 OR U103_08; Y = 1,2; N = 3,4,5,NA	U103_20 OR U103_17 OR U111_08 OR U103_08; Y = 1; N = 2,3,4,5,NA	U103_20 OR U103_17 OR U103_17 OR U103_17 OR U103_08; Y = 1; N = 2,3,4,5,NA	1,2,3,4

* Facility types: 1 = central hospitals, 2 = district hospitals, 3 = rural/community hospitals, 4 = health centres

Appendix Table 4: Missingness in HHFA data

		Health Center (n=471)		Rural Community Hospital (n=41)		District Hospital (n=48)		Central Hospital (n=4)	
		Missing data							
Condition	Essential Equipment & Medication	Available Components	Functional Components	Available Components	Functional Components	Available Components	Functional Components	Available Components	Functional Components
Chronic Conditions									
Chronic asthma	Beclomethasone inhaler	0%	0%	0%	0%	0%	0%	0%	0%
	Salbutamol inhaler	0%	0%	0%	0%	0%	0%	0%	0%
	Stethoscope	1%	1%	0%	0%	0%	0%	0%	0%
	At least two of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	0%	0%	0%	0%	0%	0%	0%	0%
Hypertension (stage 1 or 2)	Blood pressure apparatus	1%	7%	0%	0%	0%	0%	0%	0%
	Stethoscope	1%	1%	0%	0%	0%	0%	0%	0%
Type 1 diabetes	Blood glucose	2%	100%	0%	100%	0%	100%	0%	100%

	test equipment								
	Insulin	0%	0%	0%	0%	0%	0%	0%	0%
Type 2 diabetes	Blood glucose test equipment	2%	100%	0%	100%	0%	100%	0%	100%
	Metformin or glibenclamide	0%	0%	0%	0%	0%	0%	0%	0%
Pain care	Oral pain medication	0%	0%	0%	0%	0%	0%	0%	0%
	Injectable morphine or pethidine	99%	99%	15%	15%	17%	17%	0%	0%
Hypertension requiring three or more antihypertensive classes	At least three of: calcium channel blocker, ACE inhibitor, thiazide, atenolol	0%	0%	0%	0%	0%	0%	0%	0%
	Blood pressure apparatus	1%	7%	0%	0%	0%	0%	0%	0%
	Stethoscope	1%	1%	0%	0%	0%	0%	0%	0%
Heart failure	Adult scale	1%	7%	0%	2%	0%	2%	0%	0%
	Atenolol or other beta-blocker	0%	0%	0%	0%	0%	0%	0%	0%
	Blood pressure apparatus	1%	7%	0%	0%	0%	0%	0%	0%

	Captopril, enalapril or other ACE inhibitor	0%	0%	0%	0%	0%	0%	0%	0%
	Furosemide	0%	0%	0%	0%	0%	0%	0%	0%
	Stethoscope	1%	1%	0%	0%	0%	0%	0%	0%
	Ultrasound equipment	99%	99%	15%	15%	17%	17%	0%	0%
chronic RHD	Benzathine penicillin	0%	0%	0%	0%	0%	0%	0%	0%
	Injectable epinephrine	0%	0%	0%	0%	0%	0%	0%	0%
Acute Conditions									
Mild/moderate acute Asthma	Functional X-ray machine	99%	99%	15%	15%	17%	17%	0%	0%
	Oxygen availability (cylinder or concentrator)	1%	75%	0%	12%	0%	13%	0%	0%
	Peak flow meter in NCD or general outpatient area	100%	100%	100%	100%	100%	100%	100%	100%
	Prednisolone	0%	0%	0%	0%	0%	0%	0%	0%
	Pulse oximeter	2%	84%	2%	8%	2%	8%	0%	0%

	Salbutamol inhaler	0%	0%	0%	0%	0%	0%	0%	0%
	Functional X-ray machine	99%	99%	15%	15%	17%	17%	0%	0%
	Oxygen availability (cylinder or concentrator)	1%	75%	0%	12%	0%	13%	0%	0%
	Peak flow meter in NCD or general outpatient area	100%	100%	100%	100%	100%	100%	100%	100%
	Prednisolone	0%	0%	0%	0%	0%	0%	0%	0%
	Pulse oximeter	2%	84%	2%	8%	2%	8%	0%	0%
	Salbutamol inhaler	0%	0%	0%	0%	0%	0%	0%	0%
	Micro nebulizer in NCD or general outpatient area	100%	100%	100%	100%	100%	100%	100%	100%
Moderate/severe acute Asthma	Hydrocortisone injection	0%	0%	0%	0%	0%	0%	0%	0%
Acute diabetes	Blood glucose test equipment	2%	100%	0%	100%	0%	100%	0%	100%

	Blood pressure apparatus in NCD or general outpatient area	1%	7%	0%	0%	0%	0%	0%	0%
	Infusion kit for intravenous fluids	11%	100%	6%	100%	6%	100%	0%	100%
	Injectable glucose	0%	0%	0%	0%	0%	0%	0%	0%
	Insulin	0%	0%	0%	0%	0%	0%	0%	0%
	Liver and kidney function diagnostics (creatinine, electrolytes)	97%	97%	6%	6%	6%	6%	0%	0%
Acute epilepsy	Diazepam injection	99%	99%	15%	15%	17%	17%	0%	0%
Injuries/ acute minor surgical conditions+	Lidocaine in minor surgical area	0%	0%	0%	0%	0%	0%	0%	0%
	Nasogastric tubes in minor surgical area	99%	99%	13%	23%	15%	25%	0%	0%
	Needle holder in minor surgical	99%	99%	13%	15%	15%	17%	0%	0%

	area								
	Oxygen availability (cylinder or concentrator)	1%	75%	0%	12%	0%	13%	0%	0%
	Retractor in minor surgical area	99%	99%	13%	15%	15%	17%	0%	0%
	Scalpel in minor surgical area	99%	99%	13%	15%	15%	17%	0%	0%
	Skin disinfectant in minor surgical area	0%	0%	0%	0%	0%	0%	0%	0%
	Surgical scissors in minor surgical area	99%	99%	13%	15%	15%	17%	0%	0%
	Sutures in minor surgical area	0%	0%	0%	0%	0%	0%	0%	0%
	Tourniquet in minor surgical area	99%	99%	13%	31%	15%	31%	0%	25%

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Appendix Table 5: nebulizer and peak-flow meter availability from SPA data, 2015



































































Medical component	Facility type	Total facilities	Facilities with availability	% availability
Nebulizer	Central hospital	4	3	75.00
	District hospital	24	6	25.00
	Other hospital	47	28	59.25
	Rural / community hospital	41	9	21.95
	Health center	473	24	5.07
	Clinic	317	38	12.02
	Health post	20	NA	NA
	Maternity	4	NA	NA
	Dispensary	47	1	2.00
	Total	977	109	11.09
Peak-flow meter	Central hospital	4	1	25.00
	District hospital	24	1	4.17
	Other hospital	47	13	27.58
	Rural / community hospital	41	2	4.88
	Health center	473	8	1.68
	Clinic	317	12	3.79
	Health post	20	NA	0.00
	Maternity	4	NA	0.00
	Dispensary	47	NA	0.00
	Total	977	37	3.76

Appendix Figure 1: Service readiness and availability of equipment and Medicines by level

Part-1

Category	Condition	Essential Equipment & Medicines	PHC (% functional)		STC (% functional)	
Chronic Conditions	Chronic Asthma	SR	8	8%	40	40%
		Beclomethasone inhaler	8	8%	42	42%
		Salbutamol inhaler	71	71%	88	88%
		Stethoscope	93	93%	100	100%
	HTN (Stage 1 or 2)	SR	34	34%	88	88%
		>=2: CCB, ACEI, thiazide, atenolol	37	37%	88	88%
		Blood pressure apparatus	89	89%	98	98%
		Stethoscope	93	93%	100	100%
	Type 1 diabetes	SR	5	5%	88	88%
		Blood glucose apparatus	43	43%	98	98%
		Insulin	6	6%	90	90%
	Type 2 diabetes	SR	21	21%	94	94%
		Blood glucose apparatus	43	43%	98	98%
		Metformin/glibenclamide	30	30%	96	96%
	Chronic pain (oral)	SR	95	95%	100	100%
		Oral pain medicine	95	95%	100	100%
	Chronic pain (Injectable care)*	SR	22	22%	29	29%
		Injectable morphine/pethidine	22	22%	29	29%
	HTN (complicated)	SR	15	15%	75	75%
		>=3: CCB, ACEI, thiazide, atenolol	16	16%	75	75%
		Blood pressure apparatus	89	89%	98	98%
		Stethoscope	93	93%	100	100%
	Chronic Heart Failure*	SR	22	22%	38	38%
		Adult scale	95	95%	98	98%
		Atenolol or other beta-blocker	71	71%	79	79%
		Blood pressure apparatus	93	93%	98	98%
		Captopril, enalapril or other ACEI	66	66%	75	75%
		FRS	71	71%	85	85%
		Stethoscope	95	95%	100	100%
		Ultrasound equipment	34	34%	77	77%
Chronic RHD*	SR	32	32%	44	44%	
	BPG	78	78%	83	83%	
	Injectable epinephrine	32	32%	56	56%	

Part -2

Category	Condition	Essential Equipment & Medicines	PHC (% functional)		STC (% functional)			
Acute Conditions	Acute Asthma (Mild/moderate)*	SR	17		17%	48		48%
		Oxygen availability	85		85%	88		88%
		Peak flow meter	NA	NA		NA	NA	
		Prednisolone	73		73%	88		88%
		Pulse oximeter	59		59%	88		88%
		Salbutamol inhaler	93		93%	88		88%
		X-ray	29		29%	73		73%
	Acute Asthma (Moderate/severe)*	SR	15		15%	42		42%
		X-ray	29		29%	73		73%
		Oxygen availability	85		85%	88		88%
		Peak flow meter	NA	NA		NA	NA	
		Prednisolone	73		73%	88		88%
		Pulse oximeter	60		60%	88		88%
		Salbutamol inhaler	93		93%	88		88%
		Micro nebuliser	NA	NA		NA	NA	
	Acute diabetic event*	Hydrocortisone injection	61		61%	85		85%
		SR	12		12%	87		87%
		Blood glucose apparatus	95		95%	98		98%
		Blood pressure apparatus	93		93%	98		98%
		IV infusion kit	90		90%	92		92%
		Injectable glucose	80		80%	92		92%
		Insulin	46		46%	90		90%
	Acute epilepsy*	Liver and kidney diagnosis	17		17%	31		31%
		SR	36		36%	85		85%
	Injuries/acute minor surgical conditions*	Diazepam injection	37		37%	85		85%
		SR	24		24%	46		46%
		Lidocaine	95		95%	98		98%
		Nasogastric tubes	66		66%	77		77%
		Needle holder	90		90%	85		85%
		Oxygen availability	85		85%	88		88%
Retractor		51		51%	85		85%	
Scalpel		85		85%	85		85%	
Skin disinfectant		85		85%	87		87%	
Surgical scissors		78		78%	85		85%	
Sutures	90		90%	98		98%		
Tourniquet	59		59%	69		69%		

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For peer review only

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	NA
		(e) Describe any sensitivity analyses	NA
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	NA
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	NA
		(b) Indicate number of participants with missing data for each variable of interest	√
Outcome data	15*	Report numbers of outcome events or summary measures	NA
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	NA

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(b) Report category boundaries when continuous variables were categorized NA

(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period NA

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	√
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.