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The landscape of team-based care to manage hypertension: Results from two surveys in 23 low- and middle-income countries and in-country regions

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Summary

Objectives

Team-based care is essential for improving hypertension outcomes in low-resource settings. We assessed perceptions of country representatives and health care workers (HCWs) on team-based hypertension care in low- and middle-income countries.

Methods

We administered two cross-sectional surveys guided by a team-based hypertension care framework, comprising administrative, basic- and advanced-clinical tasks. The first survey (Country Profile Survey), administered to representatives from 23 countries/regions assessed country-level use of team-based care for hypertension management. The second survey (HCW Survey), administered to HCWs in Bangladesh, China, Ethiopia, Nigeria, explored current practices of different HCW cadres, perspectives on team-based management of hypertension, barriers and facilitators. We summarized data by WHO regions (Country Profile Survey) and by participating countries (HCW Survey).

Findings:

In the Country Profile Survey, all (23/23, 100%) countries/regions surveyed integrated team-based care for basic clinical hypertension management tasks, less for advanced tasks (7/23, 30%). In the HCW Survey, 854 HCWs participated, 47% worked in rural settings. Most HCWs acknowledged the value of team-based hypertension care. Although there were slight variations by country, overall, barriers to team-based hypertension care were identified as inadequate training (83%); regulatory issues (76%); resistance by patients (56%), physicians (42%), nurses (40%). Facilitators were use of treatment algorithms (94%), telehealth/m-health technology (92%), and adequate compensation for HCWs (80%).

Conclusion:

These surveys revealed key lessons for health systems and governments regarding team-based care implementation. Specifically, policies to facilitate additional training, optimize HCWs roles within care teams, use of hypertension treatment protocols, and telehealth/m-health technology will be essential to promote team-based care.

Keywords: Hypertension; LMIC; Team-Based Care, Task Shifting, Task Sharing, Blood Pressure Control

Word count: 3,319
Tables: 1
Figures: 3
Reference count: 30

Key Questions

What is already known on this topic

Approximately 75% of people with hypertension reside in low-and middle-income countries (LMICs) with suboptimal rates of hypertension awareness, treatment, and control. Although there is strong evidence from high-income countries that team-based care is a cost-effective approach to equitably improve hypertension control, data from LMICs are limited. Prior to this study, we conducted a systemic review on team-based hypertension care in LMICs. We identified 233 relevant studies. Several studies demonstrated evidence from pilot interventions on the effectiveness of team-based hypertension care, and other studies focused on systematic review of available evidence on team-based care or task redistribution for hypertension care. The remainder were consensus documents, and review papers on approaches to hypertension control in LMICs. In addition, the World Health Organization (WHO) published a technical package for cardiovascular disease management in primary health care on team-based care. However, this document did not contain specific information on the current state of team-based care for hypertension management in multiple countries. To our knowledge, this is the first multi-country survey on system-level approaches and healthcare workers' perceptions regarding team-based hypertension care.

What this study adds

In these multi-country surveys, we found that the performance of advanced clinical hypertension management tasks by HCWs was limited in LMICs. Most HCW respondents acknowledged that team-based care increases patient care capacity and improves healthcare resource efficiency. However, these respondents noted several barriers that hamper the implementation of team-based care, including inadequate staffing, lack of standardized treatment algorithms, and weak health information technology. Adequate compensation, use of technology such as telehealth/m-health, and use of hypertension algorithms were identified as facilitators of team-based hypertension care.

How this study might affect research, practice or policy

These surveys of country representatives and HCWs revealed opportunities in human resource allocation and policy interventions to promote team-based hypertension care in LMICs. To address barriers and enhance the adoption of team-based care in LMICs, training of non-physicians, and updated scope of practice regulations should be prioritized to enable them to acquire the requisite knowledge and skills to perform basic and advanced clinical tasks for hypertension management. In addition, integrating hypertension treatment protocols and algorithms, use of telehealth/m-health technology into hypertension care in LIMCs, multilevel system-based interventions to improve hypertension outcomes, and professional discourse is important. This could encourage more favorable acceptance of team-based care by HCWs and may further foster the reception and implementation of team-based hypertension care in LMICs.

Introduction

Low- and middle-income countries (LMICs) are undergoing an epidemiological transition with a double burden of communicable and non-communicable diseases (NCDs), particularly cardiovascular disease (CVD).[1] Hypertension is a major risk factor for CVD, such as myocardial infarction, stroke, and kidney disease, globally.[2] In addition, LMICs are experiencing an increased burden of hypertension.[3] Despite knowledge and availability of evidence-based treatment of hypertension, the prevalence of controlled blood pressure (BP) is extremely low (<10%) in LMICs, especially for countries in Africa, central and south Asia, and eastern Europe.[4,5]

Tackling the burden of hypertension requires a robust healthcare workforce to diagnose, treat and control hypertension. However, LMICs commonly have an insufficient workforce, i.e., few physicians[6], which presents a major barrier in efforts to control hypertension. There is also a shortage of other healthcare workers (HCWs), such as nurses and pharmacists.[6] The World Bank estimates that there were 0.9 physicians and 2.4 nurses and midwives per 1000 people in India, while in Nigeria, there were 0.4 physicians and 1.5 nurses and midwives per 1000 people.[6] These estimates are in stark contrast to the higher ratios in the United States (2.6 physicians and 15.7 nurses and midwives per 1000 people) and the United Kingdom (5.8 physicians and 10.3 per 1000 people).[6] The COVID-19 pandemic has further strained the healthcare workforce, which was already limited in these countries. The World Health Organization (WHO) projects that 18 million HCWs will be needed in LMICs by 2030. Team-based care which is defined as a health systems-level, and organizational intervention that relies on multidisciplinary teams to improve the quality of hypertension care for patients,[7] has been proposed as a potential solution to workforce shortage challenges in LMICs. Thus, in the WHO HEARTS Team-based care technical package "T" (team-based care) Module, the organization advocated for implementation of team-based care intervention in its member countries.[8]

Teams can include patients, primary care physicians, and other HCWs such as nurses, pharmacists, counselors, social workers, nutritionists, community health workers, or others.[9] In team-based care, these cadres share tasks to manage patients with hypertension (e.g., community health workers measuring BP and nurses refilling antihypertensive medications).[10] Randomized controlled trials and meta-analyses of team-based hypertension care involving nurse or pharmacist intervention have demonstrated reductions in systolic (5.4mmHg reduction) and diastolic BP (1.8mmHg reduction) and greater achievement of BP goals (12% increase) when compared with usual care.[7,11,12] There is also strong evidence that team-based care is a cost-effective strategy, which is relevant to resource-constrained settings. Despite a body of evidence,[13-15] uptake of team-based care is still limited, particularly in LMICs, and barriers and facilitators of team-based care have not been systematically studied in LMICs.[16]

Resolve to Save Lives (RTSL) is a global non-profit organization that supports countries in their efforts to reduce morbidity and mortality from hypertension.[17] To assist LMICs with developing strategies to implement team-based hypertension care, this study aims to understand the current landscape of team-based care from the perspective of healthcare administrators and healthcare workers currently practicing in LMICs. The first survey (Country Profile Survey) assessed country-level use of team-based care for hypertension management. The second survey (HCW Survey), administered to explored current practices of different HCW cadres, perspectives on

team-based management of hypertension, including barriers and facilitators to implementation of team-based hypertension care for hypertension management.

Methods

Two anonymous online surveys with different objectives, questions, and sampling frames were administered from September 2020 – October 2021 (Country Profile Survey) and July 2021 – December 2021 (HCW Survey). The first survey (Country Profile Survey) aimed at understanding the current tasks of HCWs and was administered to country representatives from 23 countries and in-country regions. The second survey (HCW Survey) aimed to understand their perspectives on team-based management of hypertension, and the barriers they face and facilitators, was administered to HCWs currently practicing in four RTSL priority LMICs (Bangladesh, China, Ethiopia, and Nigeria). The surveys collected sociodemographic and employment characteristics of respondents, current roles and responsibilities of HCWs, HCWs' perceptions of team-based hypertension care, and barriers and facilitators to team-based hypertension care. The surveys were developed with contributions from hypertension, epidemiology and health systems experts at Johns Hopkins and RTSL, including its leaders and its country representatives who live or work in LMICs.

The Johns Hopkins Medicine Institutional Review Board (IRB) approved the study at the Johns Hopkins coordinating site, and IRB approval was obtained from each participating country for the HCW Survey. Written informed consent was obtained from all participants. The study conduct and reporting of findings followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cross-sectional studies.

Data Collection

The first survey was administered in English between September 2020 – October 2021 through RTSL-supported programs and the LINKS community,[18] a global community for cardiovascular health that consists of 1061 individuals from 94 countries. Members belong to over 600 different organizations, including ministries of health, academic institutions, non-governmental organizations (NGOs)/civil society organizations, RTSL's partner organizations such as World Health Organization (WHO) and NCD Alliance, private practices, and government hospitals. The inclusion criteria for this survey were persons that are country representatives of hypertension management programs within RTSL, WHO, or persons employed by an academic organization, government, health care organization, or public health organizations in LMICs.

The second survey administered between July 2021 – December 2021 was translated into Chinese, Bangla, and four Ethiopian languages (Amharic, Somali, Sidama, and Oromo) and was administered to HCWs employed as physicians, nurses, pharmacists, and community health workers in Bangladesh, China, Ethiopia, and Nigeria. The back translation of the surveys was done to ensure accuracy of translation and was approved by the principal investigator (YCM).

The two surveys were constructed and administered via Research Electronic Data Capture (REDCap). Two unique links were created, and RTSL disseminated the online survey links to potential respondents for both surveys. Where RTSL was not the main hypertension program implementer, the survey was disseminated through RTSL's in-country implementation partners.

Where internet connectivity was limited for the HCW survey, paper copies of the surveys were administered in person, followed by manual data entry into REDCap by a data clerk.

Study Population and Sample Size

A convenience sample of country representatives and HCWs was used to complete this survey. There was no target recruitment goal for country representatives in the first survey, as the goal was to collect responses from as many LMICs as possible. The recruitment targets for HCWs in the second survey in each country were established based on the size of the HCW workforce in each country (**Supplemental Material table 1**).

Statistical Analysis

All survey data were exported from REDCap and analyzed using Stata®I/C 16.1 (StataCorp, College Station, Texas, USA). A two-sided $p < 0.05$ was considered statistically significant. Missing data were excluded from the analysis. Continuous and categorical variables were summarized using mean (±standard deviation) and frequencies and percentages, respectively. Responses on hypertension management task assignment were presented using graphs for visualization and stratified by WHO regions and participating countries. Chi-square, Fisher's exact, Wilcoxon rank-sum, and Student's t-tests were used as appropriate to compare HCWs' perceptions of team-based care across the LMICs. Tasks of HCWs related to hypertension management were summarized using descriptive analysis summary techniques and categorized based on the Team-Based Hypertension Care conceptual framework the research team developed (**Figure 1**).[19] In this framework, hypertension tasks are categorized into three task complexity levels: 1. Administrative tasks that can be completed with limited clinical knowledge and involve a low level of decision-making (e,.g. scheduling); 2. Basic clinical tasks that require a higher degree of clinical knowledge and decision-making capacity, but that can be performed mostly independently from direct physician supervision (e,.g. taking patients' history), and 3. Advanced clinical tasks that require the highest level of clinical knowledge, decision-making capacity, and support such a standard treatment protocol, or phone call with a physician (,e.g. initiating treatment). For the first survey, data were grouped according to WHO regions and then reported at the level of individual countries.

Figure 1: Team-based care conceptual framework for hypertension management[19]

Patient and Public Involvement statement

Hypertension experts in the participating countries were invited to provide their opinions during the initiation of the project. They were also involved in the pilot phase of the surveys, and they provided feedback on results interpretation.

Reflexivity

The first author, an early career researcher (OO), and the senior author (YCM) are both originally from a lower middle-income country. Majority of the collaborators and co-authors (ZH, LT, GAS, AW, SRC, SJ, MRB, SI, KO, JO, OCE, OD) who assisted with coordinating translations, recruitment and data collection from participating countries were from low and middle-income countries. Research team members from high-income countries were involved (DC, AEM, DN, CDH, AE, GWP, LJA, KM, MDH) in project implementation and contributed

to data interpretation. All authors contributed to the design, results interpretations, and critical revision of the manuscripts. All authors approved the final version for submission.

Results

Team-Based Hypertension Care Country Profile Survey (1st Survey)

Respondents of the Country Profile Survey represented 17 countries and 8 in-country regions across six WHO regions (i.e., Algeria, Bangladesh, Burundi, Chile, China (Beijing, Henan, Shandong), Cuba, Ethiopia, India (Kerala, Madhya Pradesh, Maharashtra, Punjab, Telangana), Nepal, Nigeria, Philippines, Saint Lucia, Sri Lanka, Thailand, Turkey, Uganda, and Vietnam) (**Supplemental Material table 2**). Most country representatives had at least a Masters degree, and had primary affiliations in hospitals or health centers, NGOs or the WHO Country Office. According to the country representatives, health insurance was mandatory in 5 (21.7%) countries and opt-in insurance in 13 (56.5%) of the countries. There was evidence of published hypertension guidelines in 20 countries/regions, and in 10 countries/regions there was team-based care recommendations or guidelines. Telehealth was used in 12 countries/regions and 6 of these had existing guidelines for telehealth use in primary care.

Hypertension Management Task Assignment in Participating Countries

Most countries had evidence of team-based care for basic clinical tasks in which community health workers, nurses and pharmacists measured blood pressure, refilled medication, and counseled patients (**Table 1**). Some countries indicated that team-based care existed at the advanced clinical tasks level such that nurses, pharmacists could perform tasks of diagnosing hypertension, initiating and titrating hypertension treatment. This was evident in Burundi, Ethiopia, Chile, Saint Lucia, India (Madhya Pradesh), Nepal, Nigeria. In fewer countries, Community-health workers performed these advanced-level tasks, namely, China (Beijing and Shandong), India (Madhya Pradesh), and Nigeria.

Table 1. Hypertension Management Task Allowed by Countries, Level of Task Complexity, and Type of Health Care Provider

Tasks Level	Administrative Tasks																Basic Clinical Tasks												Advanced Clinical Tasks											
	Scheduling				Retrieving Patients				Medication Delivery				Registry Management				Taking Patient History				BP Measurement				Refilling Medications				Counseling Patients				Initiating Treatment*				Titrating Treatment*				Diagnosing Hypertension			
HCW Cadre	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C
Africa																																								
Algeria	•	•	•	•	•	•		•	•	•		•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•					•				•			
Burundi	•	•			•				No one				•				•				•	•			•				•								•	•			•	•		
Ethiopia	•	•				•		•	No one				•	•			•	•			•	•			•	•											•	•			•			
Nigeria	•	•	•	•	•	•	•	•		•	•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•		•		•	•	•		•	•	•	•	•
Uganda	•				No one				No one					•				•				•			•					•							•				•			
Americas																																								
Chile	•	•			No One				Non-clinicians				•	•		•	•	•			•	•			•				•	•							•	•			•			
Cuba	•	•			•	•					•		•				•				•	•		•			•		•	•							•				•			
Saint Lucia	•	•			No one				Non-clinicians				•	•		•	•	•			•	•					•		•	•							•	•			•			
Europe																																								
Turkey	•	•			•	•					•		•	•			•	•			•	•			•	•			•								•				•			
Southeast Asia																																								
Bangladesh		•				•			No one					•				•			•	•				•			•	•							•				•			
India																																								
Kerala		•						•				•	•	•			•	•			•	•			•				No one								•				•			
Madhya Pradesh	•	•	•	•	•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•		•		•	•	•	•	•	•	•	•	•
Maharashtra	•	•				•		•		•		•		•	•	•		•	•	•		•	•	•	•		•				•					•				•			
Punjab	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•					•				•			
Telangana	•	•				•		•				•		•		•		•				•		•		•		•		•		•					•				•			
Nepal	No one				No one				No one				•	•		•	•	•			•	•			•	•	•	•	•	•	•					•	•	•		•	•	•		
Sri Lanka		•			No one							•		•			•				No one				•	•		•	No one							•				•			

Western Pacific																																												
China																																												
Beijing	•	•		•	•	•		•	**No one**				•			•	•				•	•		•	•			•	•	•		•	•			•	•			•	•			•
Henan	•	•	•	•	•	•		•	•	•	•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•				•				•			
Shandong				•	•			•				•	•			•	•			•	•			•	•			•	•		•	•	•			•	•			•	•			•
Philippines	•				•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•				•				•			
Thailand	•	•			•	•				•	•	•	•	•			•				•	•		•	•	•			•	•		•	•				•				•			
Vietnam	•	•				•		•		•	•		•	•			•				•	•		•	•				•	•		•	•				•				•			

LEGENDS
HCW: Health Care Workers
P – Physicians, including General and Specialists Medical Practitioners
N – Nursing Professionals
Ph – Pharmacists
C – Community Health Workers
No one – No One Performed this Task
*Initiating and Titrating Treatment Per protocol

Definitions
Administrative Tasks
Scheduling: Scheduling return to the clinic for patients diagnosed with hypertension
Retrieving patients: Retrieving and bringing back to clinic hypertension patients who missed appointments
Medication Delivery: Delivering medications to a patient's home, or the community
Registry Management: Entering new patient information into a registry and updating as necessary
Basic Clinical Tasks
Taking Patient History: Taking patient history or assessing cardiovascular risk
Measuring Blood Pressure: Measuring blood pressure with an automated device
Refilling Medications: Refilling prescriptions of antihypertensive medications without adjusting dosage or medication type
Counseling Patients: Counseling patients about lifestyle changes and medication adherence
Advanced Clinical Tasks
Initiating treatment per protocol: Initiating hypertension treatment based on a treatment protocol
Titrating treatment per protocol: Adjusting a patient's dosage of antihypertensive medication based on a treatment protocol
Diagnosing hypertension: Diagnosing hypertension based on blood pressure measured or clinical examination

Team-Based Hypertension Care Survey among Health Care Workers (2nd Survey)

In the HCW survey, 854 HCWs from four countries completed the survey; 274 were from Bangladesh, 268 from China, 63 from Ethiopia (limited responses due to social unrest), and 249 from Nigeria. Most respondents from China were from Beijing (98%), and most respondents from Bangladesh were from Sylhet Division (49%). The mean (±SD) age was 34.9 (10.2) years, 67% were females, 23% were general medical practitioners, and 31% were nursing professionals (**Supplemental Material table 3**). Many worked in rural areas (47%), hospitals or health centers (83%), and 38% held a managerial role.

Characteristics of HCW Survey Respondents

The mean (±SD) age of HCWs respondents by country was 31.7 (5.9) years in Bangladesh, 34.9 (12.4) years in China, 30 (5.8) years in Ethiopia, and 33.8 (9.8) years in Nigeria (**Supplemental Material table 3**). Across the countries, most respondents were females, except for Ethiopia, where 57% of HCW respondents were males. In terms of HCW cadre, many respondents from Bangladesh were nursing professionals (36%), general medical practitioners for China (37%), nursing professionals for Ethiopia (32%), and community health workers for Nigeria (41%). Report of use of telehealth was highest in China (74%), while less than half of respondents indicated use of telehealth in Bangladesh (46%), Ethiopia (29%), and Nigeria (11%).

Perspectives on Team-Based Hypertension Care, Facilitators, and Barriers

Barriers to team-based care were identified, this included inadequate training of HCWs such as nurses, pharmacists, and community health workers (83%), regulatory issues such as the scope of practice laws and practice standards (76%), resistance by patients (56%), and professional opposition by physicians (42%) or nurses (40%, **Figure 2A**). Most HCWs from China, Ethiopia, and Nigeria listed regulatory issues as a main barrier (75%, 87%, 79%, respectively). Majority of the HCWs in Bangladesh identified inadequate training as major barrier (88%). Healthcare worker respondents indicated that team-based hypertension care could be improved by the following: use of hypertension treatment algorithms (94%), use of technology such as telemedicine and mobile health technology to ease management of hypertension, (92%), and adequate compensation for HCWs who are not physicians (80%) (**Figure 2B**).

Most HCWs acknowledged the value of team-based hypertension care (**Figure 2C**). Specifically, they revealed that team-based hypertension care can quickly increase patient care capacity (96%), improve health care coverage and human resource efficiency (92%), result in similar patient outcomes (88%), reduce the cost of care for patients (87%), is necessary for their country (94%). They also indicated that team-based hypertension care should be included in the hypertension training curriculum of HCWs (94%), and there should be compensation for any additional responsibilities taken on by HCWs (88%).

Figure 2: (A) Perceived Barriers (B) Perceived Facilitators (C) Health Care Workers Perspectives on Team-Based Hypertension Care

Hypertension Management Task Assignment

Task assignments related to hypertension management for HCWs differed across countries. HCWs were asked to identify which HCW cadre performed the advanced hypertension management in practice (**Figure 3**). The task assignment was classified according to the

hypertension task-sharing conceptual framework (**Figure 1**):[19] Advanced clinical tasks which include initiating and titrating hypertension treatment and diagnosing hypertension, were mostly performed by physicians in Bangladesh and China, by nurses in Ethiopia, and by community health workers (including community nurses and community health extension workers) in Nigeria.

Figure 3. Advanced Clinical Tasks Assignment in Practice by Participating Country

Discussion

We undertook this study to examine team-based care for hypertension care in LMICs. Guided by a team-based care conceptual framework for hypertension management[19], we observed similarities as well as heterogeneity in the practice of team-based care across the 6 WHO regions and 19 countries that were represented in the Country Profile Survey. Overall, country representatives indicated that administrative and basic clinical tasks but not advanced tasks were performed by non-physicians in their respective countries and that nurses and pharmacists engaged in advanced clinical tasks in just seven countrin-countryntry regions (Burundi, Ethiopia, Chile, Saint Lucia, India [Madhya Pradesh], Nepal, Nigeria), and community health workers in only four countries/in-country regions (China [Beijing and Shandong], India [Madhya Pradesh], and Nigeria). In the HCW survey, advanced clinical tasks were mostly performed by physicians in Bangladesh and China, by nurses in Ethiopia, and by community health workers. HCWs noted that inadequate training of HCWs, regulatory issues such as the scope of practice laws and practice standards and possible resistance by patients, were barriers related to the implementation of team-based care. Our survey of country representatives and HCWs revealed key lessons that may inform future interventions to implement team-based care in LMICs.

Importantly, barriers to team-based care implementation identified by HCW participants present implementation opportunities for countries, health organizations, and health systems. Although HCWs overwhelmingly perceived that team-based care increases patient care capacity and improves healthcare resource efficiency, barriers such as professional opposition by nurses and physicians, and regulatory, and inadequate training may significantly hamper this process. The benefits of team-based care are well-established, and prior studies have shown that lack of ready acceptance by physicians remains a major obstacle,[9,20] while other studies have found that physicians and non-physicians embrace team-based care.[21]

To address these barriers and enhance the adoption of team-based care in LMICs, ongoing and in-service training of non-physicians should be prioritized to enable them to acquire the requisite knowledge and skills to perform basic and advanced clinical tasks. The effectiveness of these kinds of training has been demonstrated, for instance, in rural districts of northwest Ethiopia, where a three-day training for the health extension workers and other HCWs improved their BP measurement technique.[22] The WHO Team-Based Care Module of the HEARTS technical package[8] provides training materials on team-based care, including steps in implementation, and sample workflow charts that may be tailored to different settings. Other resources include "Fundamentals for Implementing a Hypertension Program in Resource-Constrained Settings", a course developed by Johns Hopkins Bloomberg School of Public Health, International Society of Hypertension, and other organizations,[23] which also include open access YouTube training videos.[24-26] The type and duration of training that is provided should be tailored to the specific

tasks that are performed. More experienced HCWs and physicians could be engaged in the training to enhance acceptance of team-based care and optimize the roles of the healthcare team.

To address the barrier of scope of practice laws and practice standards in LMICs, there is a need for increased advocacy for policy and regulatory changes that allow non-physicians to contribute to efforts to improve hypertension control meaningfully. Professional organizations, especially physician organizations, are well-positioned to advocate on behalf of their HCW colleagues for training opportunities and changes to the scope of practice laws to optimize the HCW workforce needed to curb the burden of hypertension.[27-29] Concerns about quality of training can be mitigated through additional training and supervision of non-physician HCWs. In addition, reforms of outdated scope of practice policies are needed to enhance the capacity of non-physicians in LMICs. Advocacy efforts should also include ensuring fair wages, payment for services and safe working conditions for all HCWs who engage in team-based care. This includes primary health care financing reforms that incentivize multidisciplinary team approaches to primary care services.[30] Additionally, the implementation of comprehensive national policies on team-based care across LMICs as part of the national policy on task-sharing and task strengthening may improve hypertension control across all levels of care.

Our study has limitations. First, the two surveys were limited to a non-random sampling of HCWs and country representatives from 23 LMICs and in-country regions, which may not be representative of team-based care practices in all LMICs. Also, due to the non-random sampling, responses could have been biased toward cadres of HCWs that participated in the surveys. In addition, the Country Profile Survey relied on responses from country representatives, and it is difficult to ascertain whether these representatives have complete knowledge of country-level use of team-based care for hypertension management.

Despite these limitations, our study has some strengths. The findings from our study provide evidence from HCWs from multiple LMICs on the state of team-based hypertension care in low-resource settings. Second, our surveys were translated into the different languages of use in participating countries to allow for more nuanced interpretation of contextual factors to be considered when implementing team-based hypertension care. In addition, many HCWs worked in rural settings with severe shortages of physicians, specialists and middle-level HCWs, where team-based care strategies may be most beneficial. Urban areas with higher patient volume are not spared from the physician shortage challenges either, and will greatly benefit from the implementation of team-based care approaches to manage hypertension. Finally, our study provides further evidence and justification for investment in HCW training and remuneration to enhance team-based care implementation, based on interest among HCW groups to ultimately improve hypertension control at the community level.

In summary, although most HCW respondents acknowledged that team-based care increases patient care capacity and improves healthcare resource efficiency, major barriers hamper the implementation of team-based care in LMICs. Indeed, only a few participating countries endorsed the performance of advanced clinical hypertension management tasks by HCWs who were not physicians. Our survey revealed key lessons for health systems and governments regarding team-based care implementation. Comprehensive national policies on team-based care across LMICs may improve hypertension control across all levels of care. Regulatory and

supervision support mechanisms may need to be instituted to support HCWs, including consideration for capitated funds, per-service payments or reimbursements to the facility team rather than one HCW cadre. In addition, training and systematic supervision of non-physician HCWs should be prioritized to enable them to acquire the requisite knowledge and skills to perform basic and advanced clinical tasks for effective hypertension management and control.

Contributorship statement

This work is a result of a multidisciplinary team. YCM, DC, AEM conceived the idea for the study; YCM, DC, OO drafted the protocol and statistical analysis plan. YCM, OO conducted the literature search. DC, ZH, LT, GAS, AW, SRC, SJ, MRB, SI, KO, JO, OCE, OD, assisted with coordinating translations, recruitment and data collection from participating countries. OO managed data and performed data analyses and visualization. OO, DC, AEM, DN, CDH, AE, GWP, LJA, KM, MDH contributed to data interpretation. YCM supervised the study. YCM, DC, OO wrote the original draft. All authors contributed to the design, results interpretations, and critical revision of the manuscripts. All authors approved the final version for submission.

Competing interests

The authors declare no competing interests.

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Data sharing statement

Data will be made available upon request from researchers who provide a methodologically sound proposal, following assessment from the research team, and subject to a data sharing agreement. Data will be de-identified and strictly adhere to participant confidentiality and consent, per Institutional Review Board guidelines for each participating institution. Datasets specific to this study will be made available upon request following publication.

Ethics approval statements

This study involved human participants; Johns Hopkins Medicine Institutional Review Board (IRB00250769) approved the study at the Johns Hopkins coordinating site, and IRB approval was obtained from each participating country for the HCW Survey. Written informed consent was obtained from all participants.

Acknowledgments

We thank the country representatives and healthcare workers who participated in this study. We thank collaborators from the University of Abuja; Fuwai Hospital, Beijing; National Heart Foundation of Bangladesh, Ministry of Health and Family Welfare Bangladesh, Federal Ministry of Health Ethiopia, Regional Health Bureaus, Ethiopia, Kano State Ministry of Health and State Primary Health care Development Agency, and Ogun State Ministry of Health and State Primary Health care Development Agency. We would also like to thank colleagues from Resolve To Save Lives China (Cao Ying), Resolve To Save Lives Ethiopia (Mentwab Gebreegz). Specifically, we thank the following collaborators:

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15. Kano State Ministry of Health
16. Ogun State Ministry of Health
17. Kano State Primary Health care Development Agency
18. Ogun State Primary Health care Development Agency

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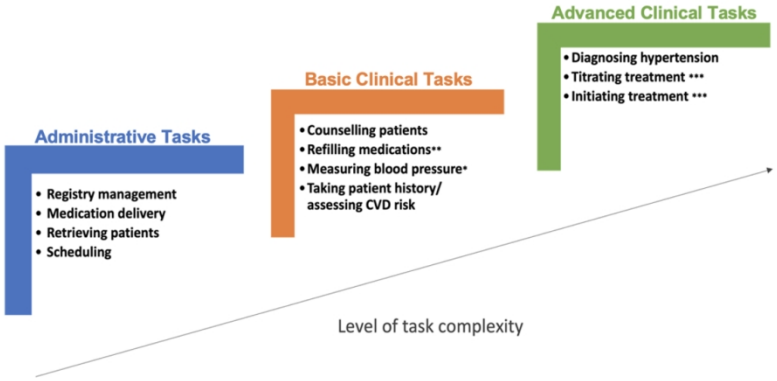

** with an automated device;** without change in dose or medications;*** per protocol; CVD: Cardiovascular disease*

Definitions

Administrative Tasks

Scheduling: Scheduling return to clinic for patients diagnosed with hypertension

Retrieving patients: Retrieving and bringing back to clinic hypertension patients who missed appointments

Medication Delivery: Delivering medications to a patient's home, or the community

Registry Management: Entering new patient information into a registry and updating as necessary

Basic Clinical Tasks

Taking Patient History: Taking patient history or assessing cardiovascular risk

Measuring Blood Pressure: Measuring blood pressure with an automated device

Refilling Medications: Refilling prescriptions of antihypertensive medications without adjusting dosage or medication type

Counseling Patients: Counseling patients about lifestyle changes and medication adherence

Advanced Clinical Tasks

Initiating treatment per protocol: Initiating hypertension treatment based on a treatment protocol

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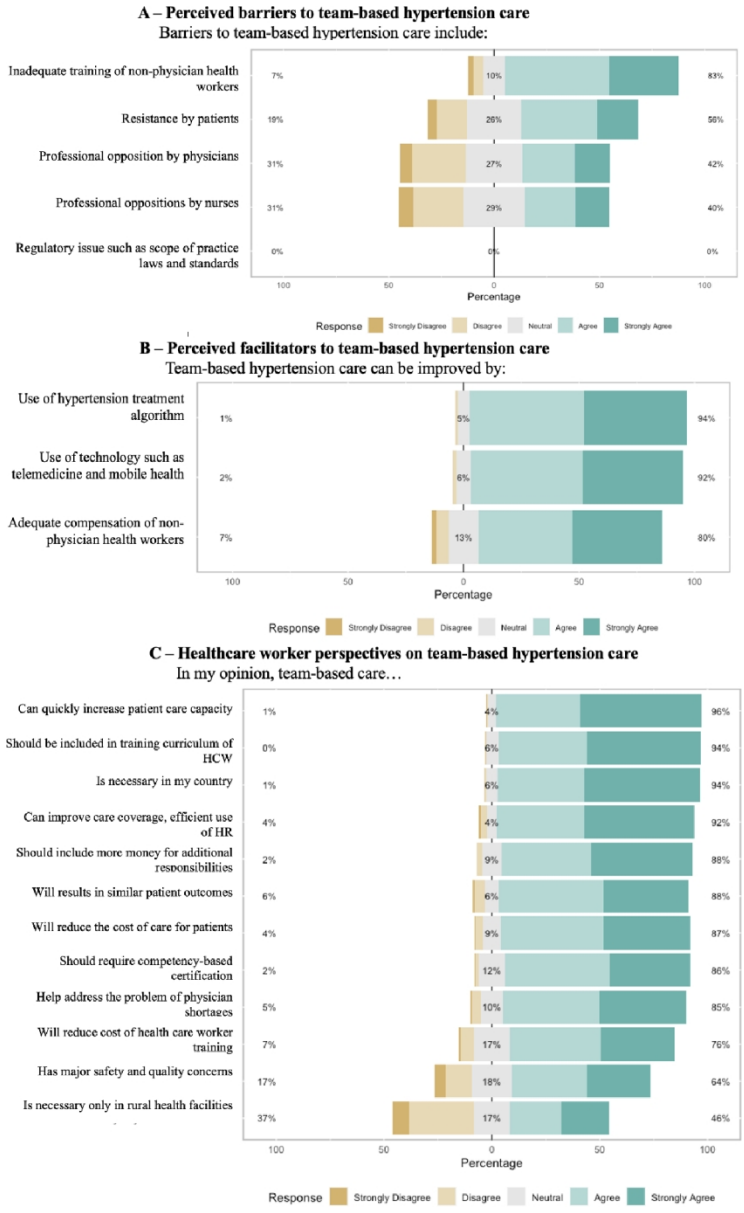

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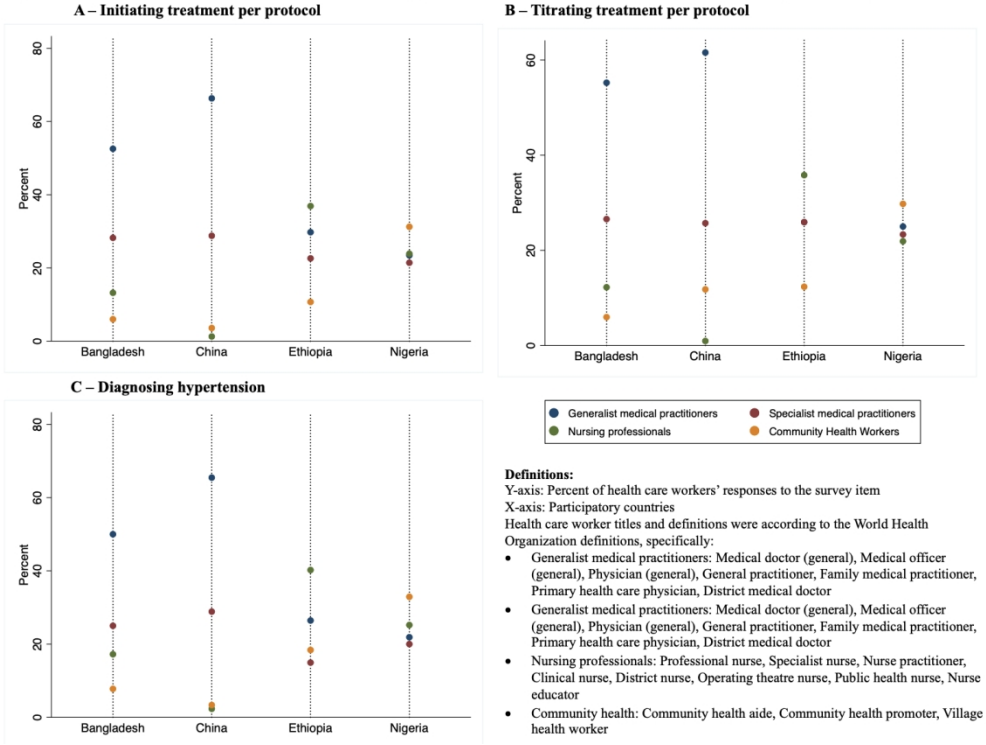
Figure 3. Advanced Clinical Tasks Assignment in Practice by Participating Country



Definitions:
Y-axis: Percent of health care workers' responses to the survey item
X-axis: Participatory countries
Health care worker titles and definitions were according to the World Health Organization definitions, specifically:

- Generalist medical practitioners: Medical doctor (general), Medical officer (general), Physician (general), General practitioner, Family medical practitioner, Primary health care physician, District medical doctor
- Generalist medical practitioners: Medical doctor (general), Medical officer (general), Physician (general), General practitioner, Family medical practitioner, Primary health care physician, District medical doctor
- Nursing professionals: Professional nurse, Specialist nurse, Nurse practitioner, Clinical nurse, District nurse, Operating theatre nurse, Public health nurse, Nurse educator
- Community health: Community health aide, Community health promoter, Village health worker

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Supplemental Material

The landscape of team-based care to manage hypertension: Results from two surveys in 23 low- and middle-income countries and in-country regions

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Supplemental Material Table 1. A priori sample size goal for each participating country

	Occupational Title				**Total**
Country	Generalist medical practitioners (Medical Officers)	Nursing professionals (Graduate nurses, BScN nurses, Registered nurses, Nursing Officers)	Pharmacists	Community Health Workers (Lay Health Workers, Village Health Volunteers,	
1. China	80	100	30	50	260
2. Bangladesh	80	100	30	50	260
3. Nigeria	80	100	30	50	260
4. Ethiopia	40	50	30	40	160
Total	**280**	**350**	**120**	**190**	**N=940**

Supplemental Material Table 2. Characteristics and work settings of country representatives in LMICs (N=23)

Characteristics	Total (N=23)
Years in current position, Mean(±SD)	6.7 (±7.9)
Education/Training, n (%)	
Bachelors	2 (8.7)
Masters	13 (56.5)
Doctorate	8 (34.7)
Primary Affiliation, n (%)	
Hospital/Health Center	1 (4.3)
Public Health Agency	1 (4.3)
Academic Institution	3 (13.0)
Non-governmental Organization	5 (21.7)
Ministry of Health	6 (26.1)
WHO Country Office	7 (30.4)
Health insurance mandate in-country, n (%)	
All citizens automatically have health insurance coverage	3 (13.0)
All citizens are mandated to enroll	5 (21.7)
Health care insurance is optional	13 (56.5)
Health insurance is not available	2 (8.7)
Published national hypertension management guideline, n (%)	
Yes	20 (87.0)
No	2 (8.7)
Unknown	1 (4.3)
National recommendations/guidelines on team-based care, task-sharing, or task-shifting, n (%)	
Yes	10 (43.5)
No	12 (52.2)
Unknown	1 (4.3)
Facility Telehealth Use, n (%)	
Used in primary care	
Yes	12 (52.2)
No	10 (43.5)
Unknown	1 (4.3)
If yes, Existence of Telehealth guideline	
Yes	6 (50.0)
No	3 (25.0)
Unknown	3 (25.0)
WHO Regions, n (%)	
Africa	5
Americas	3
Europe	1

Southeast Asia[#]	4
Western Pacific*	4

SD: Standard Deviation; LMIC-low- and middle-income country
Total number of Respondents: 23
Total number of countries including regional India and China: 23
Total number of countries being represented: 17
[#]Including Regional India; *Including Regional China

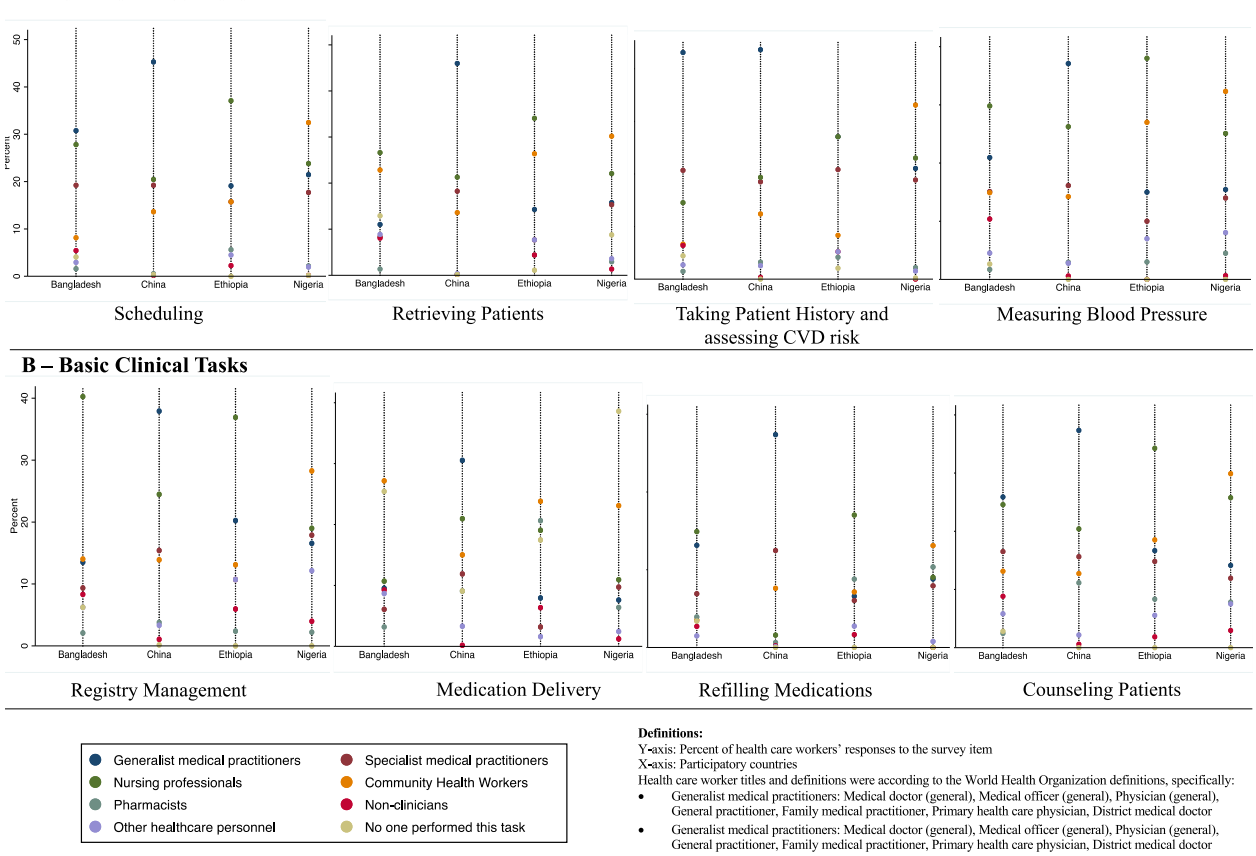
Supplemental Material Table 3. Characteristics and work settings of Health Care Workers respondents from participating countries (Bangladesh, China, Ethiopia, and Nigeria) (N=854)

	Total (N=854)	Countries			
		Bangladesh (274)	China (268)	Ethiopia (63)	Nigeria (249)
Age, m(SD)	34.9 (10.2)	31.7 (5.9)	40.4(12.4)	30.0 (5.8)	33.8 (9.8)
Sex, n(%)					
Male	290 (34.0)	125 (45.8)	48 (17.9)	35 (55.6)	82 (33.1)
Female	562 (67.0)	148 (54.2)	220 (82.1)	28 (44.4)	166 (66.9)
Profession, n(%)					
Generalist medical practitioners	197 (23.1)	79 (28.8)	99 (36.9)	8 (12.7)	11 (4.4)
Specialist medical practitioners	13 (1.5)	1 (0.36)	2 (0.75)	1 (1.6)	9 (3.6)
Nursing professionals	261 (30.6)	99 (36.1)	98 (36.6)	20 (31.8)	44 (17.7)
Nursing associate professionals	41 (4.8)	31 (11.3)	0 (0.0)	2 (3.2)	8 (3.2)
Pharmacist	110 (12.9)	60 (21.9)	33 (12.3)	0 (0.0)	17 (6.8)
Community Health Worker	140 (16.4)	2 (0.7)	21 (7.8)	15 (23.8)	102 (41.0)
Medical Assistants	24 (2.8)	3 (1.1)	2 (0.8)	3 (4.8)	16 (6.4)
Healthcare Administrator	15 (1.8)	1 (0.4)	1 (0.4)	0 (0.0)	13 (5.2)
Other[a]	70 (8.2)	0 (0.0)	17 (6.3)	14 (22.2)	39 (15.6)
Hold Managerial Positions, n(%)	328 (38.4)	172 (62.8)	25 (9.3)	52 (82.5)	328 (38.4)
Education/Training, n(%)					
Secondary School or less	17 (2.0)	2 (0.7)	8 (3.0)	1 (2.4)	6 (2.4)
Post-secondary Diploma	259 (32.3)	104 (38.0)	48 (17.9)	12 (38.2)	95 (38.2)
Bachelors	314 (36.8)	93 (33.9)	118 (44.0)	36 (57.2)	67 (26.9)
Masters	96 (11.2)	58 (21.2)	6 (2.2)	10 (15.9)	22 (8.8)
Doctorate	9 (1.1)	0 (0)	3 (1.1)	2 (3.2)	4 (1.6)
Other Professional Degree/Training	159 (18.6)	17 (6.2)	85 (31.7)	2 (3.2)	55 (22.1)
Work Place Setting, n(%)					
Rural	400 (46.9)	132 (48.2)	139 (51.9)	22 (35.5)	107 (43.0)
Semi-urban	340 (39.8)	104 (38.0)	109 (40.7)	24 (38.7)	103 (41.4)

Urban	113 (13.2)	38 (13.9)	20 (7.5)	56 (25.8)	39 (15.7)
Primary Affiliation, n(%)					
Hospital/Health Center	709 (83.0)	221 (80.7)	245 (91.4)	167 (74.6)	196 (78.7)
Ministry of Health	23 (2.7)	16 (5.8)	0 (0)	2 (3.2)	5 (2.0)
Public Health Agency	41 (5.5)	0 (0)	0 (0)	11 (17.5)	30 (12.1)
Non-governmental Organization	47 (5.5)	31 (11.3)	31 (11.3)	3 (4.8)	10 (4.0)
Faith-based Organization	2 (0.2)	1 (0.4)	1 (0.4)	0 (0)	1 (0.4)
Other[a]	32 (3.8)	5 (1.8)	5 (1.8)	0 (0)	7(2.8)
Facility Type[b], n(%)					
Regional/Tertiary Hospital	20(2.8)	15 (6.8)	3 (1.2)	0 (0)	2 (1.0)
District/General Hospital	21 (3.0)	7 (3.2)	0 (0)	0 (0)	14 (7.1)
Small hospital/Big Health Centers	175 (24.7)	130 (58.8)	1 (0.4)	2 (4.3)	42 (21.4)
Medium Health Centre	134 (18.9)	3 (1.4)	0 (0)	35 (74.5)	96 (49.0)
Small Health Centre	330 (46.5)	41 (18.6)	241 (98.4)	3 (6.4)	45 (23.0)
Aid Posts	37 (5.2)	30 (13.6)	0 (0)	6 (12.8)	1 (0.5)
Facility Telehealth Use, n(%)					
Used in primary care	368 (43.1)	126 (46.0)	197 (73.5)	18 (28.6)	27 (10.8)
Existence of Telehealth guideline	296 (80.4)	78 (61.9)	184 (93.4)	11 (61.1)	23 (85.2)

[a]This includes other community health center, community clinic, community pharmacy workers.
[b]Multiple choice question, answer choices total N=709.
SD: Standard Deviation;

Supplemental Material Figure 1. Hypertension Management Task Assignment (Administrative and Basic Clinical Tasks) in Practice by Participating Country



Definitions:

Y-axis: Percent of health care workers' responses to the survey item

X-axis: Participatory countries

Health care worker titles and definitions were according to the World Health Organization definitions, specifically:

- Generalist medical practitioners: Medical doctor (general), Medical officer (general), Physician (general), General practitioner, Family medical practitioner, Primary health care physician, District medical doctor
- Generalist medical practitioners: Medical doctor (general), Medical officer (general), Physician (general), General practitioner, Family medical practitioner, Primary health care physician, District medical doctor
- Nursing professionals: Professional nurse, Specialist nurse, Nurse practitioner, Clinical nurse, District nurse, Operating theatre nurse, Public health nurse, Nurse educator
- Community health: Community health aide, Community health promoter, Village health worker

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

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
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	6
Bias	9	Describe any efforts to address potential sources of bias	12
Study size	10	Explain how the study size was arrived at	6, **Appendix table 1**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-13
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*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	7-10, Appendix table 2 & 3, Table 1
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A

Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10, Appendix table 2 & 3, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Appendix table 2
Outcome data	15*	Report numbers of outcome events or summary measures	7-10, Appendix table 2, Table 1
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	10-11, Figures 2-3
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Supplemental Material
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
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	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
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	2

*Give information separately for exposed and unexposed groups.

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

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The landscape of team-based care to manage hypertension: results from two surveys in low- and middle-income countries

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The landscape of team-based care to manage hypertension: results from two surveys in low- and middle-income countries

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Abstract

Objectives: Team-based care is essential for improving hypertension outcomes in low-resource settings. We assessed perceptions of country representatives and health care workers (HCWs) on team-based hypertension care in low- and middle-income countries.

Design: Two cross-sectional surveys.

Setting: The first survey (Country Profile Survey) was conducted in 17 countries and eight in-country regions: Algeria, Bangladesh, Burundi, Chile, China (Beijing, Henan, Shandong), Cuba, Ethiopia, India (Kerala, Madhya Pradesh, Maharashtra, Punjab, Telangana), Nepal, Nigeria, Philippines, Saint Lucia, Sri Lanka, Thailand, Turkey, Uganda, and Vietnam. The second survey (HCW Survey) was conducted in four countries: Bangladesh, China, Ethiopia, and Nigeria.

Participants: Using convenience sampling, participants for the Country Profile Survey were representatives from the 17 countries and eight in-country regions, and the HCW Survey was administered to HCWs in Bangladesh, China, Ethiopia, and Nigeria.

Outcome measures: Country-level use of team-based hypertension care framework, comprising administrative, basic- and advanced-clinical tasks. Current practices of different HCW cadres, perspectives on team-based management of hypertension, barriers and facilitators.

Results: In the Country Profile Survey, all (23/23, 100%) countries/regions surveyed integrated team-based care for basic clinical hypertension management tasks, less for advanced tasks (7/23, 30%). In the HCW Survey, 854 HCWs participated, 47% of whom worked in rural settings. Most HCWs in the sample acknowledged the value of team-based hypertension care. Although there were slight variations by country in the study sample, overall, barriers to team-based hypertension care were identified as inadequate training (83%); regulatory issues (76%); resistance by patients (56%), physicians (42%), nurses (40%). Facilitators identified were use of treatment algorithms (94%), telehealth/m-health technology (92%), and adequate compensation for HCWs (80%).

Conclusions: Our findings revealed key lessons for health systems and governments regarding team-based care implementation. Specifically, policies to facilitate additional training, optimize HCWs' roles within care teams, use of hypertension treatment protocols, and telehealth/m-health technology will be essential to promote team-based care.

Keywords: Hypertension; LMIC; Team-Based Care, Task Shifting, Task Sharing, Blood Pressure Control

Word count: 3,570
Tables: 1
Figures: 3
Reference count: 34

Strengths and limitations of this study

- Findings from our study provide evidence from health care workers (HCWs) from multiple low- and middle-income countries (LMICs) on the state of team-based hypertension care in low-resource settings.
- Our surveys were translated into the different languages of use in participating countries to allow for more nuanced interpretation of contextual factors regarding team-based hypertension care.
- Our study provides further evidence and justification for investing in HCW training and remuneration to enhance implementation of team-based care.
- The surveys were limited to a non-random sampling of HCWs and country representatives from LMICs; the sample may not be representative of team-based care practices in these countries, which may impact the generalizability of the findings.
- The Country Profile Survey relied on responses from country representatives, and it is difficult to ascertain whether these representatives have complete knowledge of country-level use of team-based care for hypertension management.

Introduction

Low- and middle-income countries (LMICs) are undergoing an epidemiological transition with a double burden of communicable and non-communicable diseases (NCDs), particularly cardiovascular disease (CVD).[1] Hypertension is a major risk factor for CVD, such as myocardial infarction, stroke, and kidney disease, globally.[2] In addition, LMICs are experiencing an increased burden of hypertension.[3] Despite knowledge and availability of evidence-based treatment of hypertension, the prevalence of controlled blood pressure (BP) is extremely low (<10%) in LMICs, especially for countries in Africa, central and south Asia, and eastern Europe.[4,5]

Tackling the burden of hypertension requires a robust healthcare workforce to diagnose, treat and control hypertension. However, LMICs commonly have an insufficient workforce, i.e., few physicians[6], which presents a major barrier in efforts to control hypertension. There is also a shortage of other healthcare workers (HCWs), such as nurses and pharmacists.[6] The World Bank estimates (2018-2020 data) that there were 0.7 physicians, 1.7 nurses and midwives per 1000 people in India, while in Nigeria, there were 0.4 physicians, 1.5 nurses and midwives per 1000 people.[6] These estimates are in stark contrast to the higher ratios in the United States (2.6 physicians, 15.7 nurses and midwives per 1000 people) and the United Kingdom (3.0 physicians, 7.2 nurses and midwives per 1000 people).[6] The COVID-19 pandemic has further strained the healthcare workforce, which was already limited in these countries. The World Health Organization (WHO) projects that 18 million HCWs will be needed in LMICs by 2030. Team-based care, defined as a health systems-level, and organizational intervention that relies on multidisciplinary teams to improve the quality of hypertension care for patients,[7] has been proposed as a potential solution to workforce shortage challenges in LMICs. The WHO Team-Based Care Module of the HEARTS technical package[8] provides training materials on team-based care, including steps in implementation, and sample workflow charts that may be tailored to different settings. Through the HEARTS technical package, the WHO advocates that its

member countries consider implementing team-based care interventions to improve the accessibility and quality of healthcare services.

Teams can include patients, primary care physicians, and other HCWs such as nurses, pharmacists, counselors, social workers, nutritionists, community health workers, etc.[9] In team-based care, these cadres share tasks to manage patients with hypertension (e.g., community health workers measuring BP and nurses refilling antihypertensive medications).[10] Randomized controlled trials and meta-analyses of team-based hypertension care involving nurse or pharmacist intervention have demonstrated reductions in systolic (5.4mmHg reduction) and diastolic BP (1.8mmHg reduction) and greater achievement of BP goals (12% increase) when compared with usual care.[7,11,12] There is also strong evidence that team-based care is a cost-effective strategy, which is relevant to resource-constrained settings. Despite a body of evidence,[13-15] uptake of team-based care is still limited, particularly in LMICs, and barriers and facilitators of team-based care have not been systematically studied in LMICs.[16]

To assist LMICs with developing strategies to implement team-based hypertension care, this study aims to understand the current landscape of team-based care from the perspective of healthcare administrators and healthcare workers currently practicing in LMICs. The first survey (Country Profile Survey) assessed country-level use of team-based care for hypertension management. The second survey (HCW Survey) explored team-based care management of hypertension through current practices and perspectives of different HCWs, including barriers and facilitators to implementation.

Methods

Two anonymous online surveys with different objectives, questions, and sampling frames were administered from September 2020 – October 2021 (Country Profile Survey) and July 2021 – December 2021 (HCW Survey). The first survey (Country Profile Survey) aimed at understanding the current tasks of HCWs and was administered to country representatives from 23 countries and in-country regions. The second survey (HCW Survey) aimed to understand their perspectives on team-based management of hypertension, and the barriers they face and facilitators, was administered to HCWs currently practicing in four RTSL priority LMICs (Bangladesh, China, Ethiopia, and Nigeria). The surveys collected sociodemographic and employment characteristics of respondents, current roles and responsibilities of HCWs, HCWs' perceptions of team-based hypertension care, and barriers and facilitators to team-based hypertension care. The surveys were developed with contributions from hypertension, epidemiology and health systems experts at Johns Hopkins and RTSL, including its leaders and country representatives who live or work in LMICs.

The Johns Hopkins Medicine Institutional Review Board (IRB) approved the study at the Johns Hopkins coordinating site, and IRB approval was obtained from each participating country for the HCW Survey. Written informed consent was obtained from all participants. The study conduct and reporting of findings followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline for cross-sectional studies.

Data collection

The first survey was administered in English between September 2020 – October 2021 among countries with ongoing Resolve to Save Lives (RTSL) –supported programs. RTSL is a global non-profit organization that supports countries in their efforts to reduce morbidity and mortality from hypertension.[17] The study was also administered among the LINKS community,[18] a global community for cardiovascular health comprising 1061 individuals from 94 countries. Members belong to over 600 organizations, including ministries of health, academic institutions, non-governmental organizations (NGOs)/civil society organizations, RTSL's partner organizations such as World Health Organization (WHO) and NCD Alliance, private practices, and government hospitals. The inclusion criteria for this survey were persons that are country representatives of hypertension management programs within RTSL, WHO, or persons employed by an academic organization, government, healthcare organization, or public health organizations in LMICs. We advised our partners to ensure only one representative per country was selected to participate; if the selected representative was unable to complete the survey, an alternative person was recommended.

The second survey administered between July 2021 – December 2021 was translated into Chinese, Bangla, and four Ethiopian languages (Amharic, Somali, Sidama, and Oromo) and was administered to HCWs employed as physicians, nurses, pharmacists, and community health workers in Bangladesh, China, Ethiopia, and Nigeria. The back translation of the surveys was done to ensure accuracy of translation and was approved by the principal investigator (YCM). Participants were recruited through healthcare facilities and healthcare organizations that have established relationships and existing collaborations with RTSL and the LINKS community within the countries. We distributed the survey link to these organizations, who then distributed the survey to their constituents, encouraging interested HCWs to participate. Due to the convenience sampling strategy, we were unable to pre-specify a response rate because we could not reliably determine those who received a link to the survey and persons who declined to participate.

The two surveys were constructed and administered via Research Electronic Data Capture (REDCap). Two unique links were created, and RTSL disseminated the online survey links to potential respondents for both surveys. Where RTSL was not the main hypertension program implementer, the survey was disseminated through RTSL's in-country implementation partners. Where internet connectivity was limited for the HCW survey, paper copies of the surveys were administered in person, followed by manual data entry into REDCap by a data clerk. The survey instruments are available in the supplemental material.

Study population and sample size

A convenience sample of country representatives and HCWs was used to complete this survey. There was no target recruitment goal for country representatives in the first survey, as the goal was to collect responses from as many LMICs as possible. The recruitment targets for HCWs in the second survey in each country were established based on the size of the HCW workforce in each country (**Supplemental Material Table 1**).

Statistical analysis

All survey data were exported from REDCap and analyzed using Stata®I/C 16.1 (StataCorp, College Station, Texas, USA). A two-sided $p < 0.05$ was considered statistically significant.

Missing data were excluded from the analysis. Continuous and categorical variables were summarized using mean (±standard deviation) and frequencies and percentages, respectively. Responses on hypertension management task assignment were presented using graphs for visualization and stratified by WHO regions and participating countries. Chi-square, Fisher's exact, Wilcoxon rank-sum, and Student's t-tests were used as appropriate to compare HCWs' perceptions of team-based care across the LMICs. Tasks of HCWs related to hypertension management were summarized using descriptive analysis summary techniques and categorized based on the Team-Based Hypertension Care conceptual framework the research team developed (**Figure 1**).[19] In this framework, hypertension tasks are categorized into three task complexity levels: 1. Administrative tasks that can be completed with limited clinical knowledge and involve a low level of decision-making (e.g., scheduling); 2. Basic clinical tasks that require a higher degree of clinical knowledge and decision-making capacity, but that can be performed mostly independently from direct physician supervision (e.g., taking patients' history), and 3. Advanced clinical tasks that require the highest level of clinical knowledge, decision-making capacity, and support such as a standard treatment protocol, or phone call with a physician (e.g., initiating treatment). For the first survey, data were grouped according to WHO regions and then reported at the level of individual countries.

Reflexivity

The first author, an early career researcher (OO), and the senior author (YCM) are both originally from a lower middle-income country. Majority of the collaborators and co-authors (ZH, LT, GAS, AW, SRC, SJ, MRB, SI, KO, JO, OCE, OD) who assisted with coordinating translations, recruitment, and data collection from participating countries were from low and middle-income countries. Research team members from high-income countries were involved (DC, AEM, DN, CDH, AE, GWP, LJA, KM, MDH) in project implementation and contributed to data interpretation. All authors contributed to the design, results interpretations, and critical revision of the manuscripts. All authors approved the final version for submission.

Patient and public involvement

None.

Results

Team-Based Hypertension Care Country Profile Survey (first survey)

Respondents of the Country Profile Survey represented 17 countries and 8 in-country regions across six WHO regions (i.e., Algeria, Bangladesh, Burundi, Chile, China (Beijing, Henan, Shandong), Cuba, Ethiopia, India (Kerala, Madhya Pradesh, Maharashtra, Punjab, Telangana), Nepal, Nigeria, Philippines, Saint Lucia, Sri Lanka, Thailand, Turkey, Uganda, and Vietnam) (**Supplemental Material Table 2**). Most country representatives had at least a Masters degree, and had primary affiliations in hospitals or health centers, NGOs, or the WHO Country Office. According to the country representatives, health insurance was mandatory in 5 (21.7%) countries and opt-in insurance in 13 (56.5%) of the countries. There was evidence of published hypertension guidelines in 20 countries/regions; in 10 countries/regions, there were team-based care recommendations or guidelines. Telehealth was used in 12 countries/regions and 6 of these had existing guidelines for telehealth use in primary care.

Hypertension management task assignment in participating countries

Most countries had evidence of team-based care for basic clinical tasks in which community health workers, nurses and pharmacists measured blood pressure, refilled medication, and counseled patients (**Table 1, Supplemental Material Table 3**). Some countries indicated that team-based care existed at the advanced clinical tasks level such that nurses and pharmacists could diagnose hypertension, initiate and titrate hypertension treatment. This was evident in Burundi, Ethiopia, Chile, Saint Lucia, India (Madhya Pradesh), Nepal, and Nigeria. In fewer countries, Community-health workers performed these advanced-level tasks, namely, China (Beijing and Shandong), India (Madhya Pradesh), and Nigeria.

Table 1. Hypertension management task allowed by countries, level of task complexity, and type of health care provider

Tasks Level	Basic Clinical Tasks																Advanced Clinical Tasks											
	Taking Patient History				BP Measurement				Refilling Medications				Counseling Patients				Initiating Treatment*				Titrating Treatment*				Diagnosing Hypertension			
HCW Cadre	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C
Africa																												
Algeria	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•				•				•			
Burundi	•				•	•			•				•	•			•				•	•			•	•		
Ethiopia	•	•			•	•			•	•						•	•				•	•			•			
Nigeria	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•		•	•	•	•	•
Uganda		•				•			•					•			•				•				•			
Americas																												
Chile	•	•			•	•			•				•	•			•				•	•			•			
Cuba	•				•	•		•			•		•	•		•	•				•				•			
Saint Lucia	•	•			•	•					•		•	•			•				•	•			•			
Europe																												
Turkey	•	•			•	•			•	•			•	•			•				•				•			
Southeast Asia																												
Bangladesh		•			•	•		•		•			•	•		•	•				•				•			
India																												
Kerala	•	•			•	•			•				No one				•				•				•			
Madhya Pradesh	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•				•				•	•	•	•
Maharashtra		•	•	•		•	•	•	•		•				•	•	•				•				•			
Punjab	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•				•				•			

Telangana		•				•		•		•		•		•		•	•				•				•			
Nepal	•	•			•	•			•	•	•	•	•	•	•		•	•	•		•	•	•		•	•	•	
Sri Lanka	•				•				**No one**				•	•		•	**No one**				•				•			
Western Pacific																												
China																												
Beijing	•				•	•		•	•			•	•	•		•	•			•	•			•	•			•
Henan	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•				•				•			
Shandong	•			•	•			•	•			•	•		•	•	•			•	•			•	•			•
Philippines	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•				•				•			
Thailand	•				•	•		•	•	•			•	•		•	•				•				•			
Vietnam	•				•	•		•	•				•	•		•	•				•				•			

LEGENDS
HCW: Health Care Workers
P – Physicians, including General and Specialists Medical Practitioners
N – Nursing Professionals
Ph – Pharmacists
C – Community Health Workers
No one – No One Performed this Task
*Initiating and Titrating Treatment Per protocol

Definitions
Administrative Tasks
Scheduling: Scheduling return to the clinic for patients diagnosed with hypertension
Retrieving patients: Retrieving and bringing back to clinic hypertension patients who missed appointments
Medication Delivery: Delivering medications to a patient's home, or the community
Registry Management: Entering new patient information into a registry and updating as necessary
Basic Clinical Tasks
Taking Patient History: Taking patient history or assessing cardiovascular risk
Measuring Blood Pressure: Measuring blood pressure with an automated device
Refilling Medications: Refilling prescriptions of antihypertensive medications without adjusting dosage or medication type
Counseling Patients: Counseling patients about lifestyle changes and medication adherence
Advanced Clinical Tasks
Initiating treatment per protocol: Initiating hypertension treatment based on a treatment protocol
Titrating treatment per protocol: Adjusting a patient's dosage of antihypertensive medication based on a treatment protocol
Diagnosing hypertension: Diagnosing hypertension based on blood pressure measured or clinical examination

Team-Based Hypertension Care Survey among Health Care Workers (second survey)

In the HCW survey, 854 HCWs from four countries completed the survey; 274 were from Bangladesh, 268 were from China, 63 were from Ethiopia (limited responses due to social unrest), and 249 were from Nigeria. Most respondents from China were from Beijing (98%), and most respondents from Bangladesh were from Sylhet Division (49%). The mean (±SD) age was 34.9 (10.2) years, 67% were females, 23% were general medical practitioners, and 31% were nursing professionals (**Supplemental Material Table 4**). Many worked in rural areas (47%), hospitals, or health centers (83%), and 38% held a managerial role.

Characteristics of HCW Survey respondents

The mean (±SD) age of HCWs respondents by country was 31.7 (5.9) years in Bangladesh, 34.9 (12.4) years in China, 30 (5.8) years in Ethiopia, and 33.8 (9.8) years in Nigeria (**Supplemental Material Table 4**). Across the countries, most respondents were females, except for Ethiopia, where 57% of HCW respondents were males. In terms of HCW cadre, many respondents from

Bangladesh were nursing professionals (36%), general medical practitioners for China (37%), nursing professionals for Ethiopia (32%), and community health workers for Nigeria (41%). Report of use of telehealth was highest in China (74%), while less than half of respondents indicated use of telehealth in Bangladesh (46%), Ethiopia (29%), and Nigeria (11%).

Perspectives on team-based hypertension care, facilitators, and barriers

Barriers to team-based care were identified; this included inadequate training of HCWs such as nurses, pharmacists, and community health workers (83%), regulatory issues such as the scope of practice laws and practice standards (76%), resistance by patients (56%), and professional opposition by physicians (42%) or nurses (40%) (**Figure 2A**). Most HCWs from China, Ethiopia, and Nigeria listed regulatory issues as a main barrier (75%, 87%, 79%, respectively) (**Supplemental Material Figures 1-3**). The majority of the HCWs in Bangladesh identified inadequate training as major barrier (88%) (**Supplemental Material Figure 4)**. Healthcare worker respondents indicated that team-based hypertension care could be improved by the following: use of hypertension treatment algorithms (94%), use of technology such as telemedicine and mobile health technology to ease management of hypertension (92%), and adequate compensation for HCWs who are not physicians (80%) (**Figure 2B**).

Most HCWs acknowledged the value of team-based hypertension care (**Figure 2C**). Specifically, they revealed that team-based hypertension care could quickly increase patient care capacity (96%), improve health care coverage and human resource efficiency (92%), result in similar patient outcomes (88%), reduce the cost of care for patients (87%), is necessary for their country (94%). They also indicated that team-based hypertension care should be included in the hypertension training curriculum of HCWs (94%), and there should be compensation for any additional responsibilities taken on by HCWs (88%).

Hypertension management task assignment

Task assignments related to hypertension management for HCWs differed across countries (**Supplemental Material Figure 5)**. HCWs were asked to identify which HCW cadre performed the advanced hypertension management in practice (**Figure 3**). The task assignment was classified according to the hypertension task-sharing conceptual framework (**Figure 1**):[19] Advanced clinical tasks which include initiating and titrating hypertension treatment and diagnosing hypertension, were mostly performed by physicians in Bangladesh and China, by nurses in Ethiopia, and by community health workers (including community nurses and community health extension workers) in Nigeria.

Discussion

We undertook this study to examine team-based care for hypertension care in LMICs. Guided by a team-based care conceptual framework for hypertension management[19], we observed similarities as well as heterogeneity in the practice of team-based care across the 6 WHO regions and 19 countries that were represented in the Country Profile Survey. Overall, country representatives indicated that non-physicians performed administrative and basic clinical tasks but not advanced tasks in their respective countries and that nurses and pharmacists engaged in advanced clinical tasks in just seven countries and in-country regions (Burundi, Ethiopia, Chile, Saint Lucia, India [Madhya Pradesh], Nepal, Nigeria), and community health workers in only

four countries/in-country regions (China [Beijing and Shandong], India [Madhya Pradesh], and Nigeria). In the HCW survey, advanced clinical tasks were mostly performed by physicians in Bangladesh and China, by nurses in Ethiopia, and by community health workers. HCWs noted that inadequate training of HCWs, regulatory issues such as the scope of practice laws and practice standards and possible resistance by patients, were barriers to implementing team-based care. Our survey of country representatives and HCWs revealed key lessons that may inform future interventions to implement team-based care in LMICs.

Importantly, barriers to team-based care implementation identified by HCW participants present implementation opportunities for countries, health organizations, and health systems. Although HCWs overwhelmingly perceived that team-based care increases patient care capacity and improves healthcare resource efficiency, barriers such as professional opposition by nurses and physicians, regulatory issues, and inadequate training may significantly hamper this process. The benefits of team-based care are well-established, and prior studies have shown that lack of ready acceptance by physicians remains a major obstacle,[9,20] while other studies have found that physicians and non-physicians embrace team-based care.[21]

To address these barriers and enhance the adoption of team-based care in LMICs, ongoing and in-service training of non-physicians should be prioritized to enable them to acquire the requisite knowledge and skills to perform basic and advanced clinical tasks. The effectiveness of these kinds of training has been demonstrated, for instance, in rural districts of northwest Ethiopia, where a three-day training for the health extension workers and other HCWs improved their BP measurement technique.[22] The WHO Team-Based Care Module of the HEARTS technical package[8] provides training materials on team-based care, including steps in implementation, and sample workflow charts that may be tailored to different settings. Other resources include "Fundamentals for Implementing a Hypertension Program in Resource-Constrained Settings", a course developed by Johns Hopkins Bloomberg School of Public Health, International Society of Hypertension, and other organizations,[23] which also include open access YouTube training videos.[24-26] The type and duration of training that is provided should be tailored to the specific tasks that are performed. More experienced HCWs and physicians could be engaged in the training to enhance acceptance of team-based care and optimize the roles of the healthcare team.

To address the barrier of scope of practice laws and practice standards in LMICs, there is a need for increased advocacy for policy and regulatory changes that allow non-physicians to contribute to efforts to improve hypertension control meaningfully. Professional organizations, especially physician organizations, are well-positioned to advocate on behalf of their HCW colleagues for training opportunities and changes to the scope of practice laws to optimize the HCW workforce needed to curb the burden of hypertension.[27-29] Concerns about quality of training can be mitigated through additional training and supervision of non-physician HCWs. In addition, reforms of outdated scope of practice policies are needed to enhance the capacity of non-physicians in LMICs. Advocacy efforts should also include ensuring fair wages, payment for services and safe working conditions for all HCWs who engage in team-based care. This includes primary health care financing reforms that incentivize multidisciplinary team approaches to primary care services.[30] Additionally, the implementation of comprehensive national policies on team-based care across LMICs as part of the national policy on task-sharing and task strengthening may improve hypertension control across all levels of care.

Our study has limitations. First, the two surveys were limited to a non-random sampling of HCWs and country representatives from 23 LMICs and in-country regions, which may not be representative of team-based care practices in all LMICs. The generalizability of study findings is also limited; given the convenience sampling and inability to pre-determine a response rate, the representativeness of the samples in the HCW Survey cannot be determined. Additionally, the survey was administered in only some of the states and provinces in India and China, further limiting the generalization of results within those countries. Also, due to the non-random sampling, responses could have been biased toward cadres of HCWs that participated in the surveys. In addition, the Country Profile Survey relied on responses from country representatives, and it is difficult to ascertain whether these representatives have complete knowledge of country-level use of team-based care for hypertension management. Considering the important role of dieticians in non-pharmacologic management of hypertension, they could have been included as one the healthcare workers of focus involved in team-based hypertension care in the participating countries.[31,32] Although we note that in many of the countries surveyed, there are shortages of registered dieticians and many facilities may not have a registered dietician on staff.[33,34]

Despite these limitations, our study has some strengths. The findings from our study provide evidence from HCWs from multiple LMICs on the state of team-based hypertension care in low-resource settings. Second, our surveys were translated into the different languages of use in participating countries to allow for more nuanced interpretation of contextual factors to be considered when implementing team-based hypertension care. In addition, many HCWs worked in rural settings with severe shortages of physicians, specialists and middle-level HCWs, where team-based care strategies may be most beneficial. Urban areas with higher patient volume are not spared from the physician shortage challenges either, and will greatly benefit from the implementation of team-based care approaches to manage hypertension. Finally, our study provides further evidence and justification for investment in HCW training and remuneration to enhance team-based care implementation, based on interest among HCW groups to ultimately improve hypertension control at the community level.

In summary, although most HCW respondents acknowledged that team-based care increases patient care capacity and improves healthcare resource efficiency, major barriers hamper the implementation of team-based care in LMICs. Indeed, only a few participating countries endorsed the performance of advanced clinical hypertension management tasks by HCWs who were not physicians. Our survey revealed key lessons for health systems and governments regarding team-based care implementation. Comprehensive national policies on team-based care across LMICs may improve hypertension control across all levels of care. Regulatory and supervision support mechanisms may need to be instituted to support HCWs, including consideration for capitated funds, per-service payments, or reimbursements to the facility team rather than one HCW cadre. In addition, training and systematic supervision of non-physician HCWs should be prioritized to enable them to acquire the requisite knowledge and skills to perform basic and advanced clinical tasks for effective hypertension management and control.

Contributors

This work is a result of a multidisciplinary team. YCM, DC, AEM conceived the idea for the study; YCM, DC, OO drafted the protocol and statistical analysis plan. YCM, OO conducted the literature search. DC, ZH, LT, GAS, AW, SRC, SJ, MRB, SI, KO, JO, OCE, OD, assisted with coordinating translations, recruitment and data collection from participating countries. OO managed data and performed data analyses and visualization. OO, DC, AEM, DN, CDH, AE, GWP, LJA, KM, MDH contributed to data interpretation. YCM supervised the study. YCM, DC, OO wrote the original draft. All authors contributed to the design, results interpretations, and critical revision of the manuscripts. All authors approved the final version for submission.

Competing interests

The authors declare no competing interests.

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Data availability statement

Data will be made available upon request from researchers who provide a methodologically sound proposal, following assessment from the research team, and subject to a data sharing agreement. Data will be de-identified and strictly adhere to participant confidentiality and consent, per Institutional Review Board guidelines for each participating institution. Datasets specific to this study will be made available upon request following publication.

Ethics approval

This study involved human participants; Johns Hopkins Medicine Institutional Review Board (IRB00250769) approved the study at the Johns Hopkins coordinating site, and IRB approval was obtained from each participating country for the HCW Survey. Written informed consent was obtained from all participants.

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17. Kano State Primary Health care Development Agency
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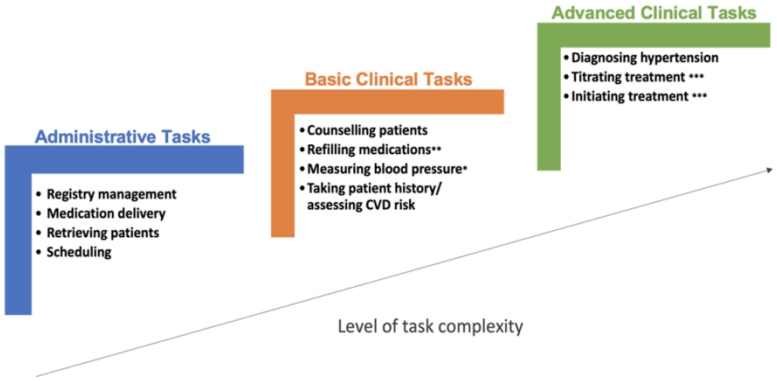
FIGURE TITLES

Figure 1. Team-based care conceptual framework for hypertension management[19]

Figure 2. (A) Perceived barriers, (B) perceived facilitators, (C) health care workers' perspectives on team-based hypertension care

Figure 3. Advanced clinical tasks assignment in practice, by participating country



** with an automated device;** without change in dose or medications;*** per protocol; CVD: Cardiovascular disease*

Definitions

Administrative Tasks

Scheduling: Scheduling return to clinic for patients diagnosed with hypertension

Retrieving patients: Retrieving and bringing back to clinic hypertension patients who missed appointments

Medication Delivery: Delivering medications to a patient's home, or the community

Registry Management: Entering new patient information into a registry and updating as necessary

Basic Clinical Tasks

Taking Patient History: Taking patient history or assessing cardiovascular risk

Measuring Blood Pressure: Measuring blood pressure with an automated device

Refilling Medications: Refilling prescriptions of antihypertensive medications without adjusting dosage or medication type

Counseling Patients: Counseling patients about lifestyle changes and medication adherence

Advanced Clinical Tasks

Initiating treatment per protocol: Initiating hypertension treatment based on a treatment protocol

315x222mm (118 x 118 DPI)

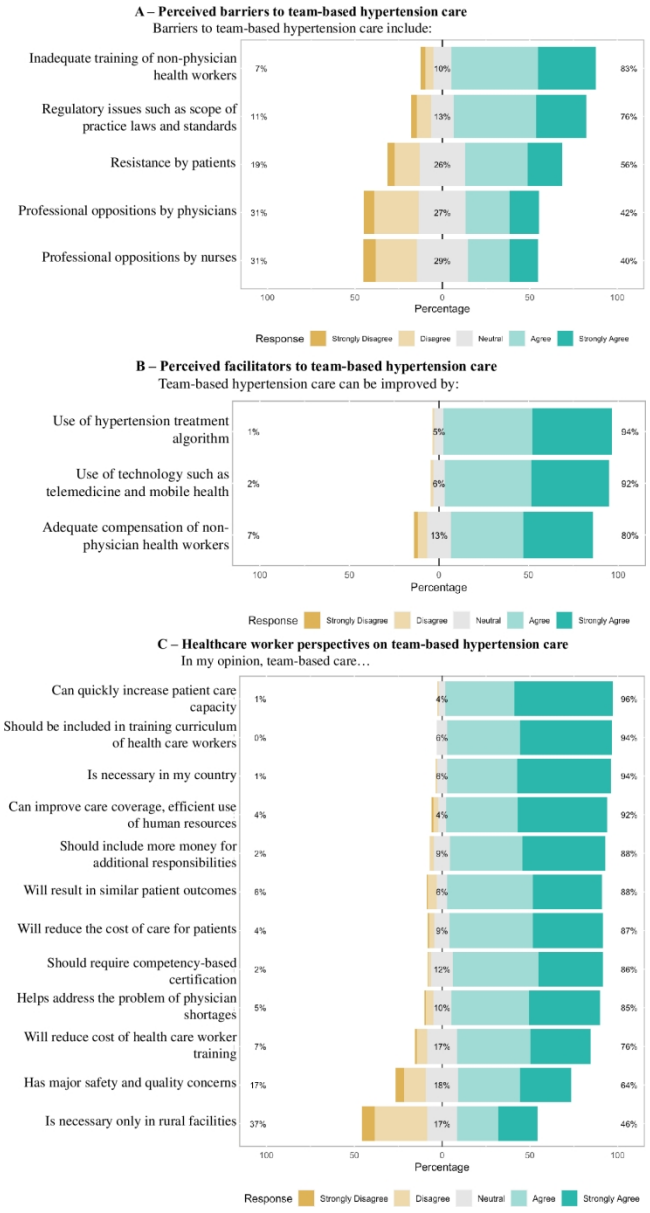


Figure 2: (A) Perceived Barriers (B) Perceived Facilitators (C) Health Care Workers Perspectives on Team-Based Hypertension Care

114x214mm (300 x 300 DPI)

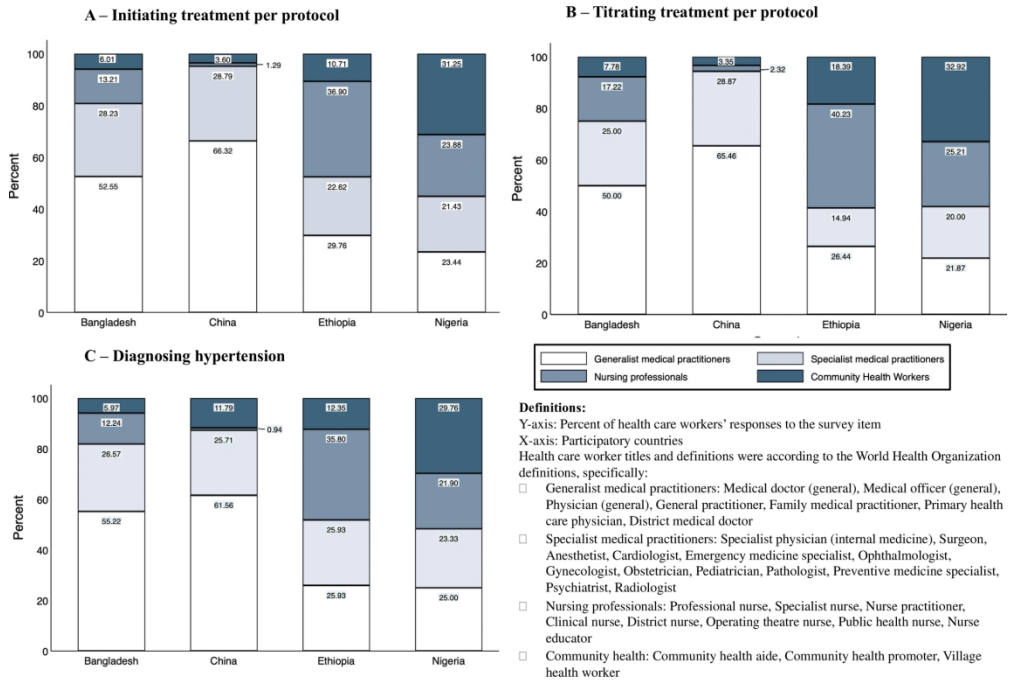


Figure 3. Advanced Clinical Tasks Assignment in Practice by Participating Country

190x127mm (300 x 300 DPI)

Supplemental Material

Supplemental Material Table 1. A priori sample size goal for each participating country

	Occupational Title				Total
Country	Generalist medical practitioners (Medical Officers)	Nursing professionals (Graduate nurses, BScN nurses, Registered nurses, Nursing Officers)	Pharmacists	Community Health Workers (Lay Health Workers, Village Health Volunteers,	
1. China	80	100	30	50	260
2. Bangladesh	80	100	30	50	260
3. Nigeria	80	100	30	50	260
4. Ethiopia	40	50	30	40	160
Total	**280**	**350**	**120**	**190**	**N=940**

Participant Involvement in the Study

The Country Profile survey was piloted among country staff in some of the participating countries. Feedback obtained was mostly related to differences in healthcare worker level terminology in specific countries and was updated to reflect country-specific contexts while remaining aligned with WHO definitions. RTSL country staff was responsible for coordinating the survey among partner organizations within the respective hypertension programs. When survey data was missing or entered incorrectly, RTSL staff would reach back out to partners administering the survey to clarify and correct any inconsistencies.

Supplemental Material Table 2. Characteristics and work settings of country representatives in LMICs (N=23)

Characteristics	Total (N=23)
Years in current position, Mean(±SD)	6.7 (±7.9)
Education/Training, n (%)	
Bachelors	2 (8.7)
Masters	13 (56.5)
Doctorate	8 (34.7)
Primary Affiliation, n (%)	
Hospital/Health Center	1 (4.3)
Public Health Agency	1 (4.3)
Academic Institution	3 (13.0)
Non-governmental Organization	5 (21.7)
Ministry of Health	6 (26.1)
WHO Country Office	7 (30.4)
Health insurance mandate in-country, n (%)	
All citizens automatically have health insurance coverage	3 (13.0)
All citizens are mandated to enroll	5 (21.7)
Health care insurance is optional	13 (56.5)
Health insurance is not available	2 (8.7)
Published national hypertension management guideline, n (%)	
Yes	20 (87.0)
No	2 (8.7)
Unknown	1 (4.3)
National recommendations/guidelines on team-based care, task-sharing, or task-shifting, n (%)	
Yes	10 (43.5)
No	12 (52.2)
Unknown	1 (4.3)
Facility Telehealth Use, n (%)	
Used in primary care	
Yes	12 (52.2)
No	10 (43.5)
Unknown	1 (4.3)
If yes, Existence of Telehealth guideline	
Yes	6 (50.0)
No	3 (25.0)
Unknown	3 (25.0)
WHO Regions, n (%)	
Africa	5
Americas	3
Europe	1

Southeast Asia[#]	4
Western Pacific*	4

SD: Standard Deviation; LMIC-low- and middle-income country
Total number of Respondents: 23
Total number of countries including regional India and China: 23
Total number of countries being represented: 17
[#]Including Regional India; *Including Regional China

Supplemental Material Table 3. Hypertension Management Task Allowed by Countries, Level of Task Complexity, and Type of Health Care Provider

Tasks Level	Administrative Tasks																Basic Clinical Tasks												Advanced Clinical Tasks											
	Scheduling				Retrieving Patients				Medication Delivery				Registry Management				Taking Patient History				BP Measurement				Refilling Medications				Counseling Patients				Initiating Treatment*				Titrating Treatment*				Diagnosing Hypertension			
HCW Cadre	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C	P	N	Ph	C
Africa																																								
Algeria	•	•	•	•	•	•		•	•	•		•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•		•				•				
Burundi	•	•			•				No one				•				•				•	•			•				•	•			•	•			•	•			
Ethiopia	•	•				•		•	No one				•	•			•	•			•	•			•	•							•	•			•				
Nigeria	•	•	•	•	•	•	•	•		•	•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•
Uganda	•				No one				No one					•				•				•			•					•			•				•				
Americas																																								
Chile	•	•			No One				Non-clinicians				•	•		•	•	•			•	•			•				•	•			•	•			•				
Cuba	•	•			•	•					•		•				•				•	•	•				•		•	•			•				•				
Saint Lucia	•	•			No one				Non-clinicians				•	•		•	•	•			•	•					•		•	•			•	•			•				
Europe																																								
Turkey	•	•			•	•					•		•	•			•	•			•	•			•	•			•				•				•				
Southeast Asia																																								
Bangladesh		•				•			No one					•				•			•	•		•		•			•	•			•				•				
India																																								
Kerala		•						•				•	•	•			•	•			•	•			•				No one				•				•				
Madhya Pradesh	•	•	•	•	•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•			•	•	•	•	•	•	•
Maharashtra	•	•				•		•		•		•		•	•	•		•	•	•		•	•	•	•		•				•	•	•			•				
Punjab	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•			•				

Telangana	•	•				•		•				•		•		•		•				•		•		•		•				•				•			
Nepal	**No one**				**No one**				**No one**				•	•		•	•	•			•	•			•	•	•	•	•	•	•		•	•	•		•	•	•	
Sri Lanka		•			**No one**							•		•			•				•				**No one**				•	•		**No one**				•			
Western Pacific																																						
China																																						
Beijing	•	•		•	•	•		•	**No one**				•			•	•				•	•		•	•			•	•	•				•			•	•			•			•
Henan	•	•	•	•	•	•		•	•	•	•	•	•	•		•	•	•		•	•	•	•	•	•	•	•	•	•	•				•						
Shandong				•	•			•				•	•			•	•			•	•			•	•			•	•					•			•	•			•	
Philippines	•				•	•	•	•	•	•	•	•	•	•	•	•	•			•	•	•	•	•	•	•	•	•	•	•				•				•				
Thailand	•	•			•	•				•	•	•	•	•			•				•	•			•	•			•	•				•				•				
Vietnam	•	•				•		•		•	•		•	•			•				•	•			•				•	•				•				•				

LEGENDS
HCW: Health Care Workers
P – Physicians, including General and Specialists Medical Practitioners
N – Nursing Professionals
Ph – Pharmacists
C – Community Health Workers
No one – No One Performed this Task
*Initiating and Titrating Treatment Per protocol

Definitions
Administrative Tasks
Scheduling: Scheduling return to the clinic for patients diagnosed with hypertension
Retrieving patients: Retrieving and bringing back to clinic hypertension patients who missed appointments
Medication Delivery: Delivering medications to a patient's home, or the community
Registry Management: Entering new patient information into a registry and updating as necessary
Basic Clinical Tasks
Taking Patient History: Taking patient history or assessing cardiovascular risk
Measuring Blood Pressure: Measuring blood pressure with an automated device
Refilling Medications: Refilling prescriptions of antihypertensive medications without adjusting dosage or medication type
Counseling Patients: Counseling patients about lifestyle changes and medication adherence
Advanced Clinical Tasks
Initiating treatment per protocol: Initiating hypertension treatment based on a treatment protocol
Titrating treatment per protocol: Adjusting a patient's dosage of antihypertensive medication based on a treatment protocol
Diagnosing hypertension: Diagnosing hypertension based on blood pressure measured or clinical examination

Supplemental Material Table 4. Characteristics and work settings of Health Care Workers respondents from participating countries (Bangladesh, China, Ethiopia, and Nigeria) (N=854)

	Total (N=854)	Countries			
		Bangladesh (274)	China (268)	Ethiopia (63)	Nigeria (249)
Age, m(SD)	34.9 (10.2)	31.7 (5.9)	40.4(12.4)	30.0 (5.8)	33.8 (9.8)
Sex, n(%)					
Male	290 (34.0)	125 (45.8)	48 (17.9)	35 (55.6)	82 (33.1)
Female	562 (67.0)	148 (54.2)	220 (82.1)	28 (44.4)	166 (66.9)
Profession, n(%)					
Generalist medical practitioners	197 (23.1)	79 (28.8)	99 (36.9)	8 (12.7)	11 (4.4)
Specialist medical practitioners	13 (1.5)	1 (0.36)	2 (0.75)	1 (1.6)	9 (3.6)
Nursing professionals	261 (30.6)	99 (36.1)	98 (36.6)	20 (31.8)	44 (17.7)
Nursing associate professionals	41 (4.8)	31 (11.3)	0 (0.0)	2 (3.2)	8 (3.2)
Pharmacist	110 (12.9)	60 (21.9)	33 (12.3)	0 (0.0)	17 (6.8)
Community Health Worker	140 (16.4)	2 (0.7)	21 (7.8)	15 (23.8)	102 (41.0)
Medical Assistants	24 (2.8)	3 (1.1)	2 (0.8)	3 (4.8)	16 (6.4)
Healthcare Administrator	15 (1.8)	1 (0.4)	1 (0.4)	0 (0.0)	13 (5.2)
Other[a]	70 (8.2)	0 (0.0)	17 (6.3)	14 (22.2)	39 (15.6)
Hold Managerial Positions, n(%)	328 (38.4)	172 (62.8)	25 (9.3)	52 (82.5)	328 (38.4)
Education/Training, n(%)					
Secondary School or less	17 (2.0)	2 (0.7)	8 (3.0)	1 (2.4)	6 (2.4)
Post-secondary Diploma	259 (32.3)	104 (38.0)	48 (17.9)	22 (38.2)	95 (38.2)
Bachelors	314 (36.8)	93 (33.9)	118 (44.0)	36 (57.2)	67 (26.9)
Masters	96 (11.2)	58 (21.2)	6 (2.2)	10 (15.9)	22 (8.8)
Doctorate	9 (1.1)	0 (0)	3 (1.1)	2 (3.2)	4 (1.6)
Other Professional Degree/Training	159 (18.6)	17 (6.2)	85 (31.7)	2 (3.2)	55 (22.1)
Work Place Setting, n(%)					
Rural	400 (46.9)	132 (48.2)	139 (51.9)	22 (35.5)	107 (43.0)

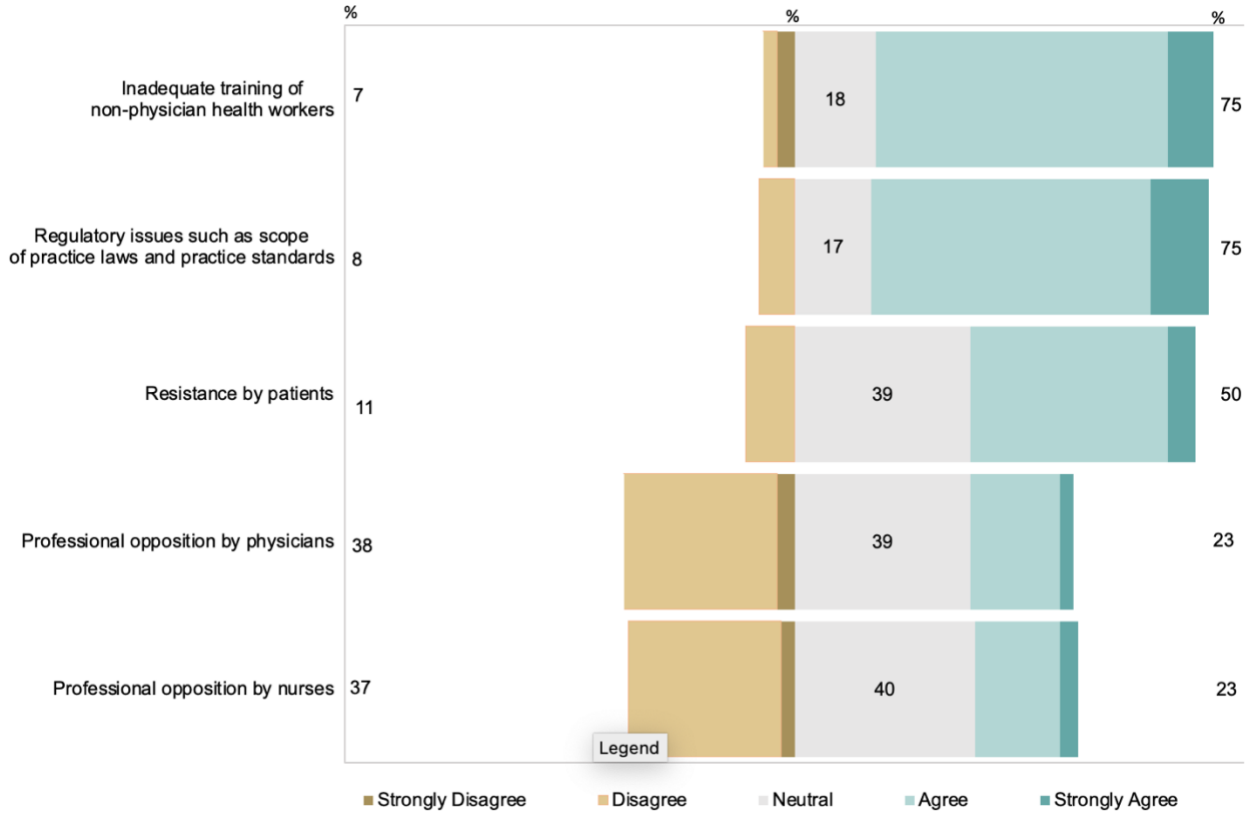
Semi-urban	340 (39.8)	104 (38.0)	109 (40.7)	94 (38.7)	103 (41.4)
Urban	113 (13.2)	38 (13.9)	20 (7.5)	26 (25.8)	39 (15.7)
Primary Affiliation, n(%)					
Hospital/Health Center	709 (83.0)	221 (80.7)	245 (91.4)	77 (74.6)	196 (78.7)
Ministry of Health	23 (2.7)	16 (5.8)	0 (0)	2 (3.2)	5 (2.0)
Public Health Agency	41 (5.5)	0 (0)	0 (0)	11 (17.5)	30 (12.1)
Non-governmental Organization	47 (5.5)	31 (11.3)	31 (11.3)	3 (4.8)	10 (4.0)
Faith-based Organization	2 (0.2)	1 (0.4)	1 (0.4)	0 (0)	1 (0.4)
Other[a]	32 (3.8)	5 (1.8)	5 (1.8)	0 (0)	7(2.8)
Facility Type[b], n(%)					
Regional/Tertiary Hospital	20(2.8)	15 (6.8)	3 (1.2)	0 (0)	2 (1.0)
District/General Hospital	21 (3.0)	7 (3.2)	0 (0)	0 (0)	14 (7.1)
Small hospital/Big Health Centers	175 (24.7)	130 (58.8)	1 (0.4)	2 (4.3)	42 (21.4)
Medium Health Centre	134 (18.9)	3 (1.4)	0 (0)	35 (74.5)	96 (49.0)
Small Health Centre	330 (46.5)	41 (18.6)	241 (98.4)	3 (6.4)	45 (23.0)
Aid Posts	37 (5.2)	30 (13.6)	0 (0)	6 (12.8)	1 (0.5)
Facility Telehealth Use, n(%)					
Used in primary care	368 (43.1)	126 (46.0)	197 (73.5)	8 (28.6)	27 (10.8)
Existence of Telehealth guideline	296 (80.4)	78 (61.9)	184 (93.4)	11 (61.1)	23 (85.2)

[a]This includes other community health center, community clinic, community pharmacy workers.
[b]Multiple choice question, answer choices total N=709.
SD: Standard Deviation;

Supplemental Material Figure 1: (A) Perceived Barriers (B) Perceived Facilitators (C) Health Care Workers' Perspectives on Team-Based Hypertension Care in China

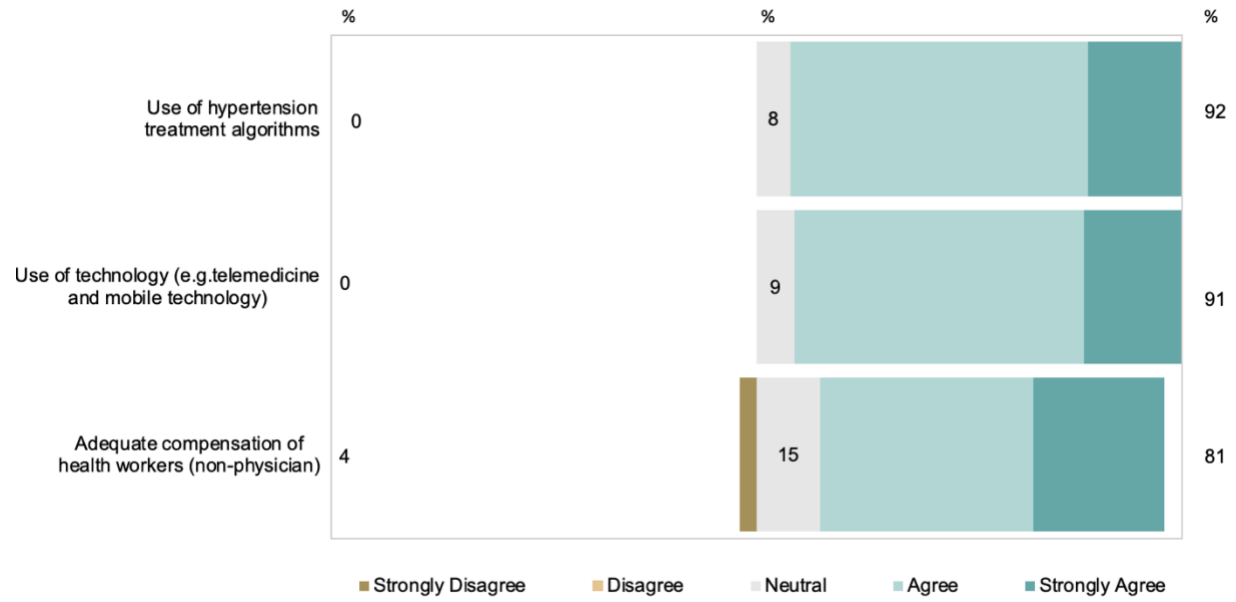
A – Perceived barriers to team-based hypertension care

Barriers to team-based hypertension care include:



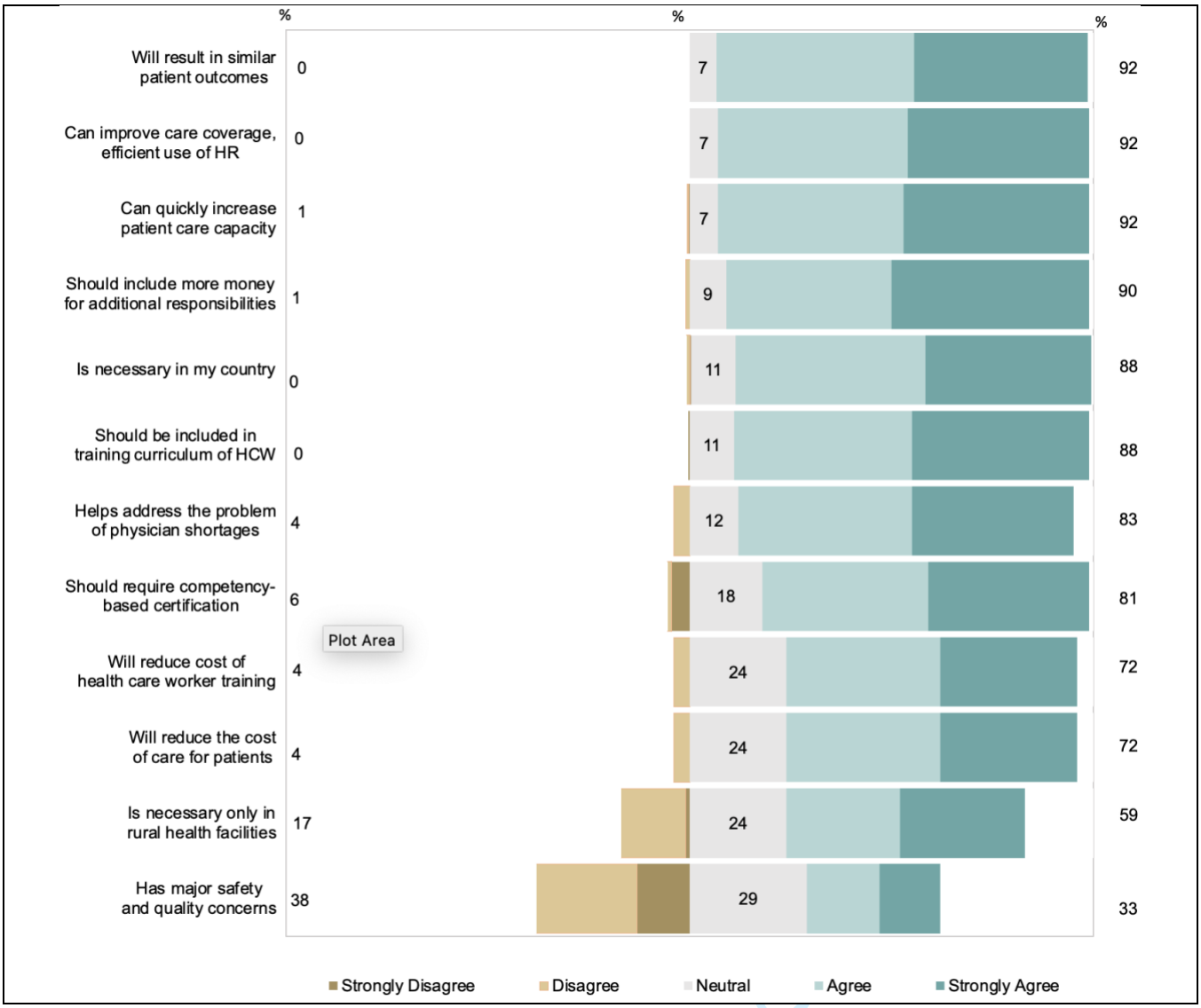
B – Perceived facilitators to team-based hypertension care

Team-based hypertension care can be improved by:

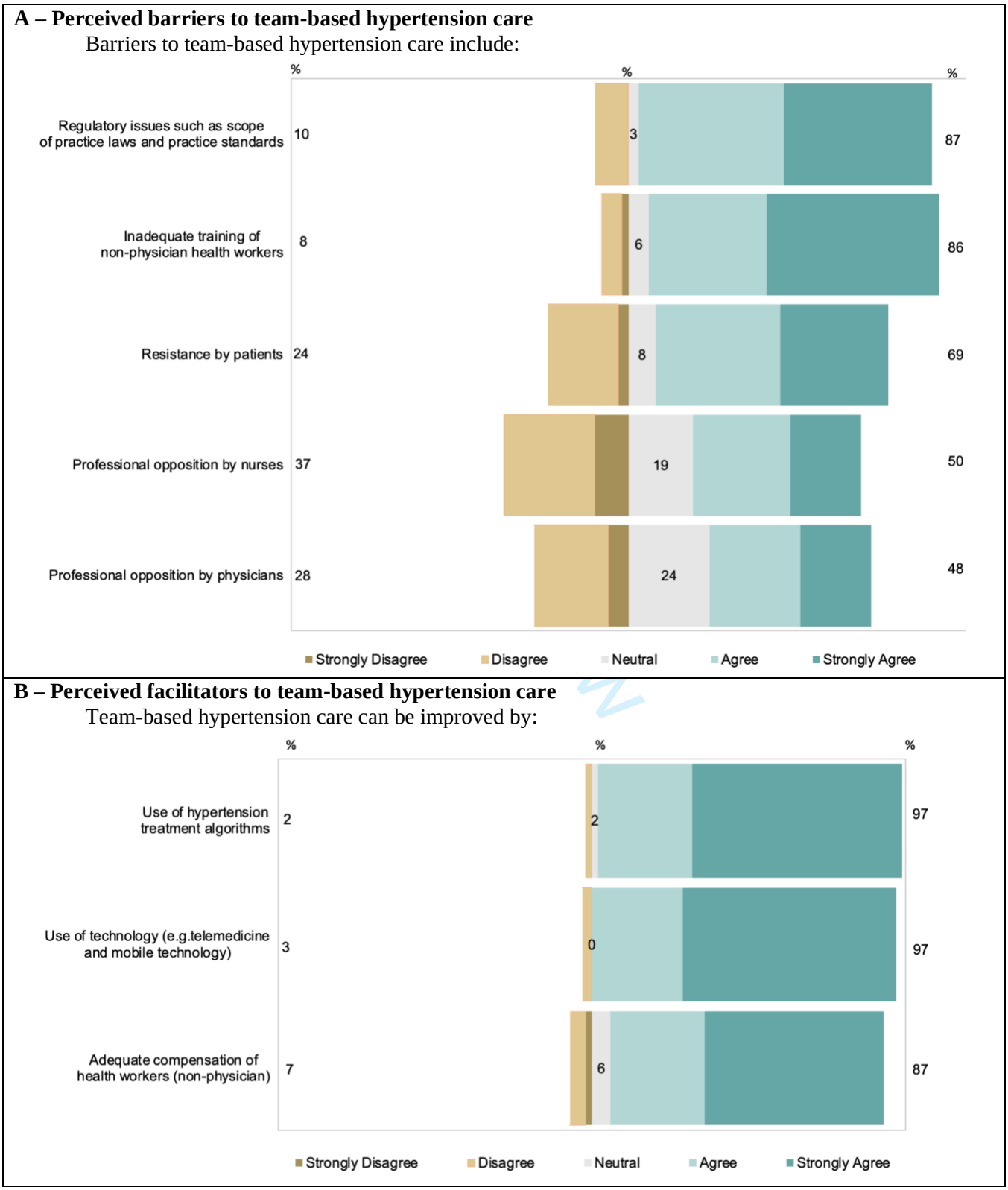


C – Healthcare worker perspectives on team-based hypertension care

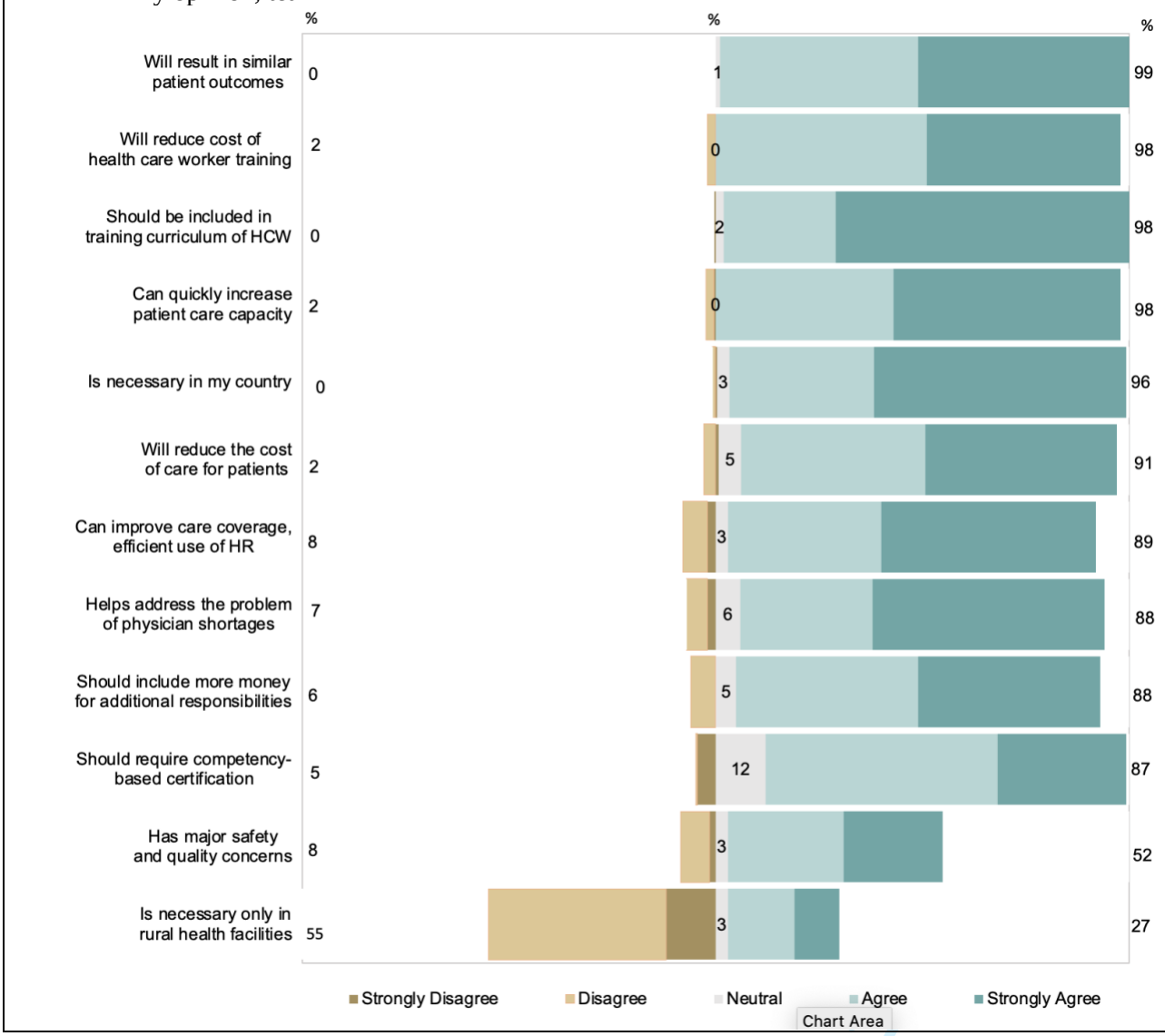
In my opinion, team-based care…



Supplemental Material Figure 2: (A) Perceived Barriers (B) Perceived Facilitators (C) Health Care Workers' Perspectives on Team-Based Hypertension Care in Ethiopia



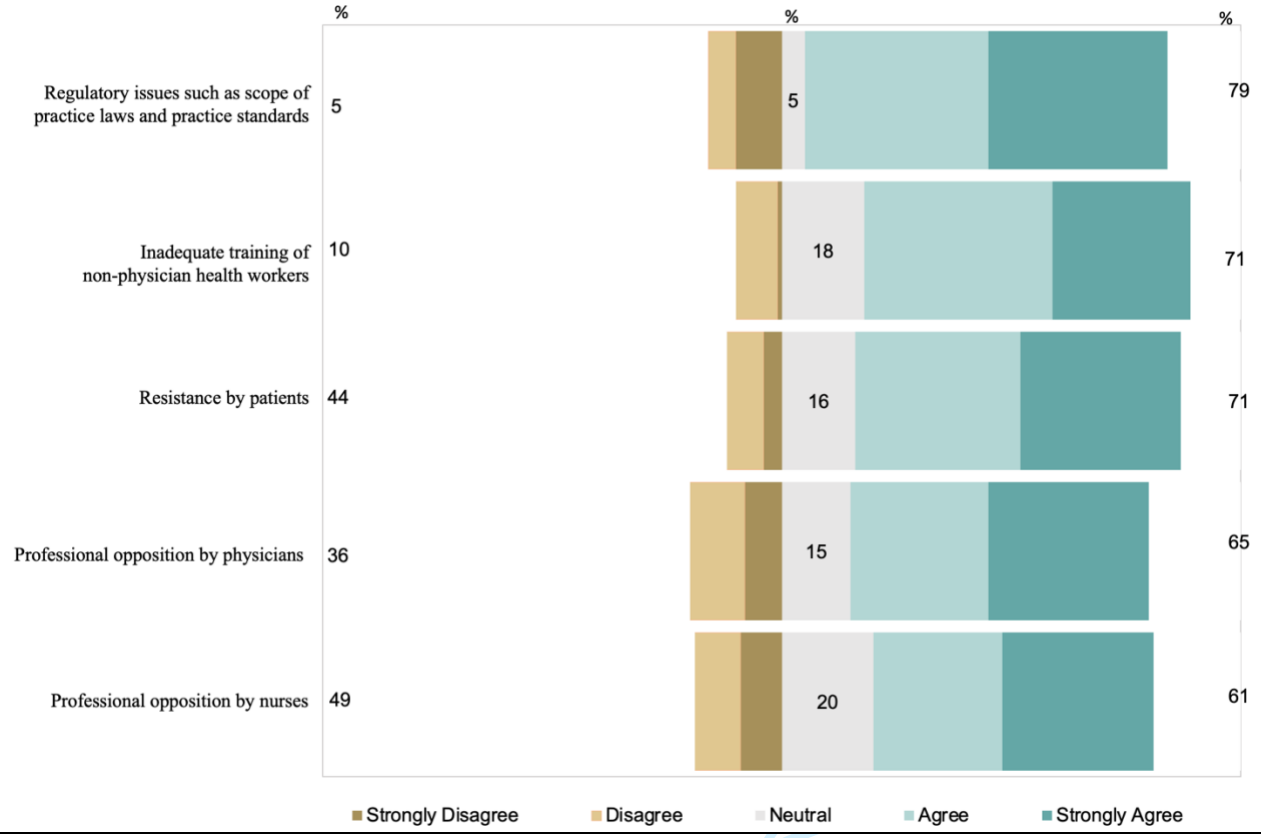
C – Healthcare worker perspectives on team-based hypertension care



Supplemental Material Figure 3: (A) Perceived Barriers (B) Perceived Facilitators (C) Health Care Workers' Perspectives on Team-Based Hypertension Care in Nigeria

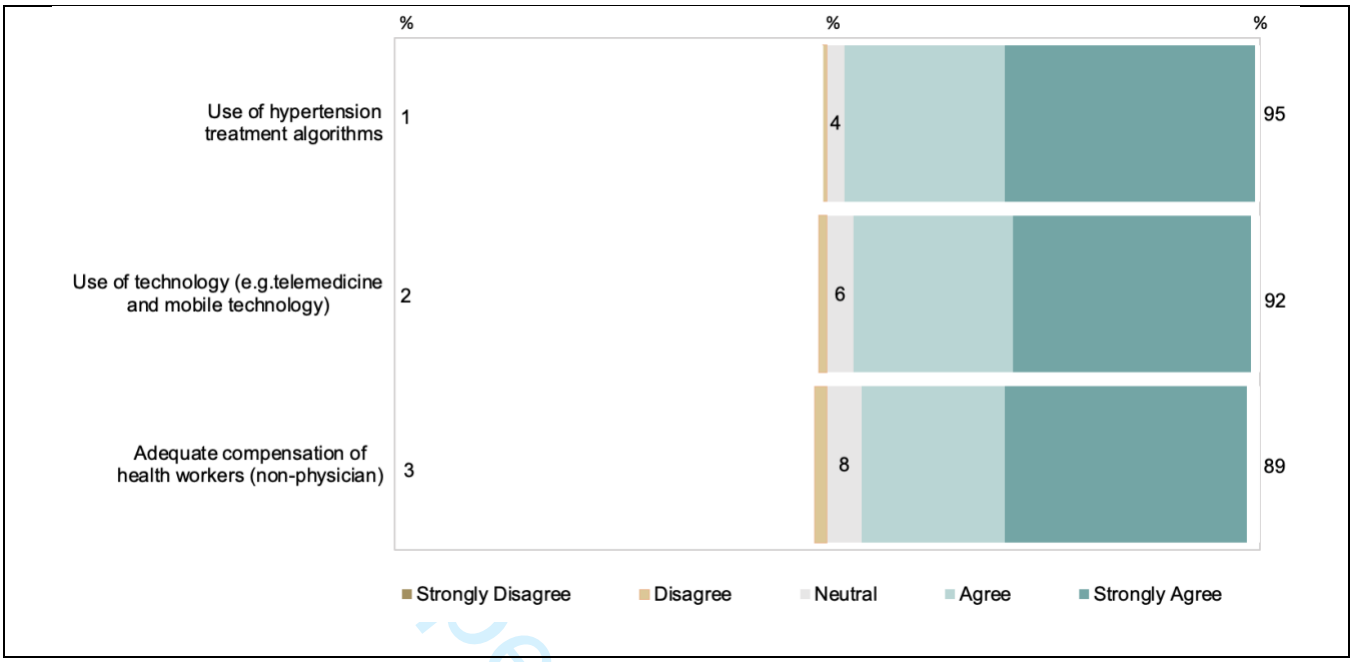
A – Perceived barriers to team-based hypertension care

Barriers to team-based hypertension care include:



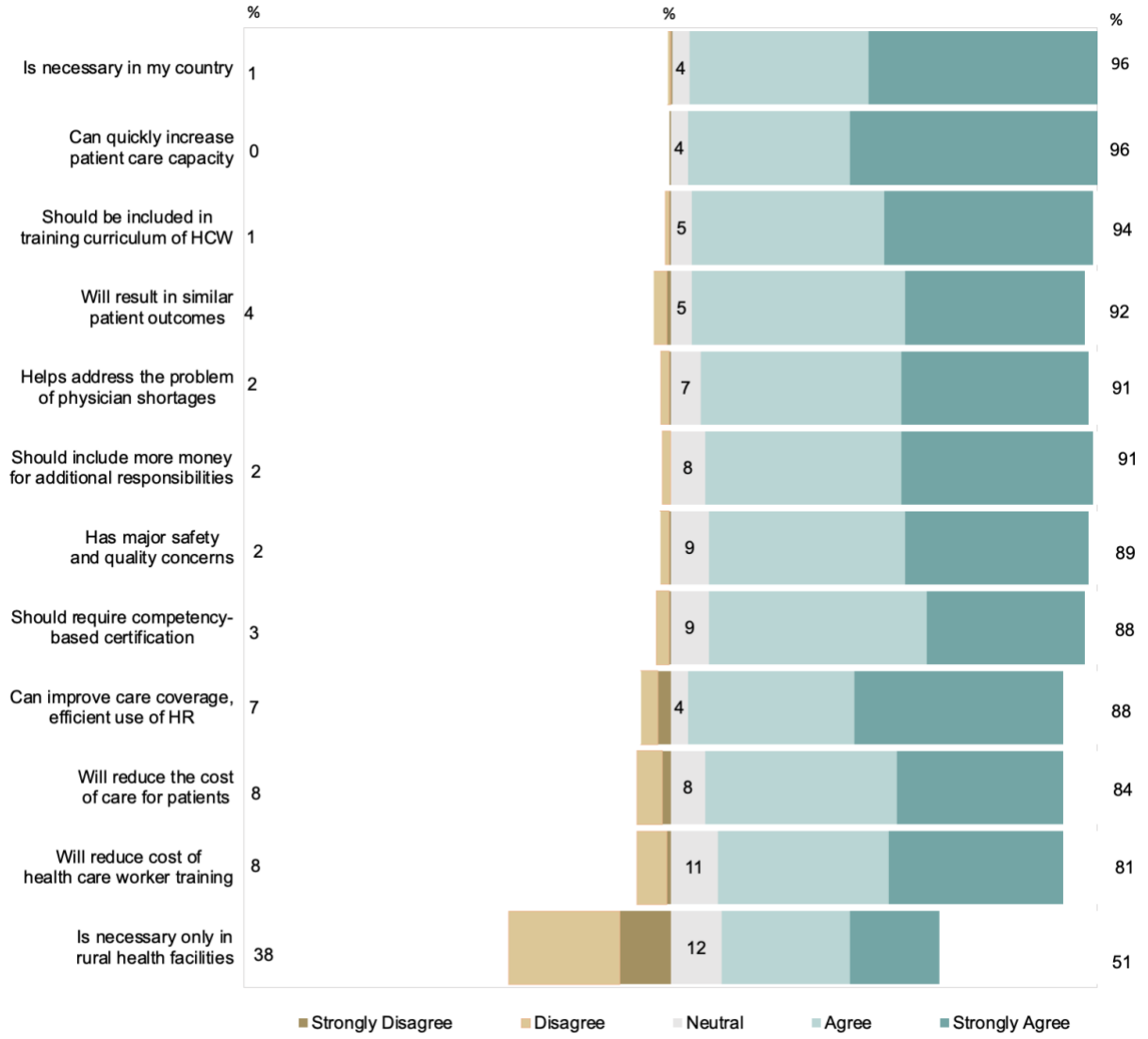
B – Perceived facilitators to team-based hypertension care

Team-based hypertension care can be improved by:

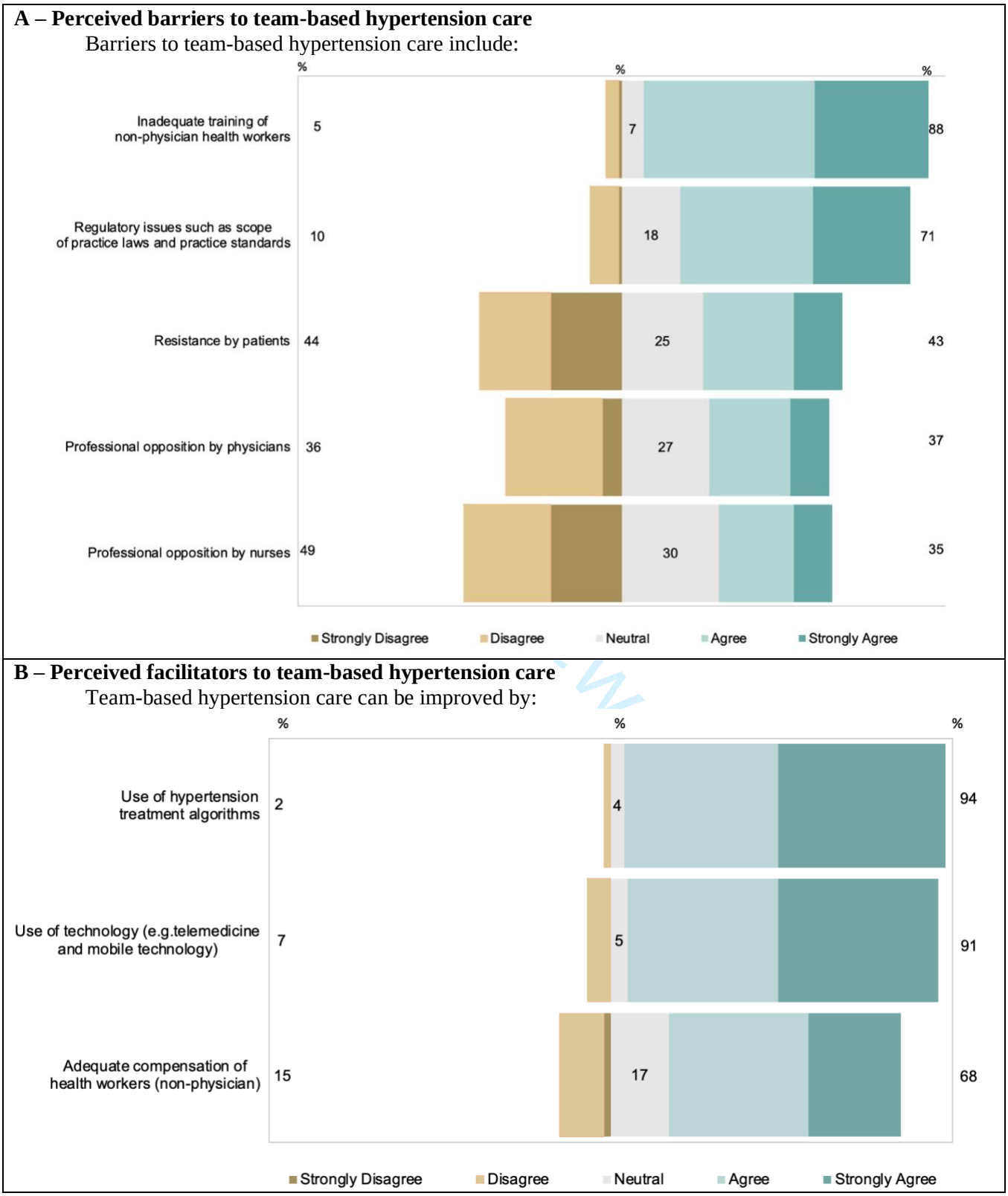


C – Healthcare worker perspectives on team-based hypertension care

In my opinion, team-based care…

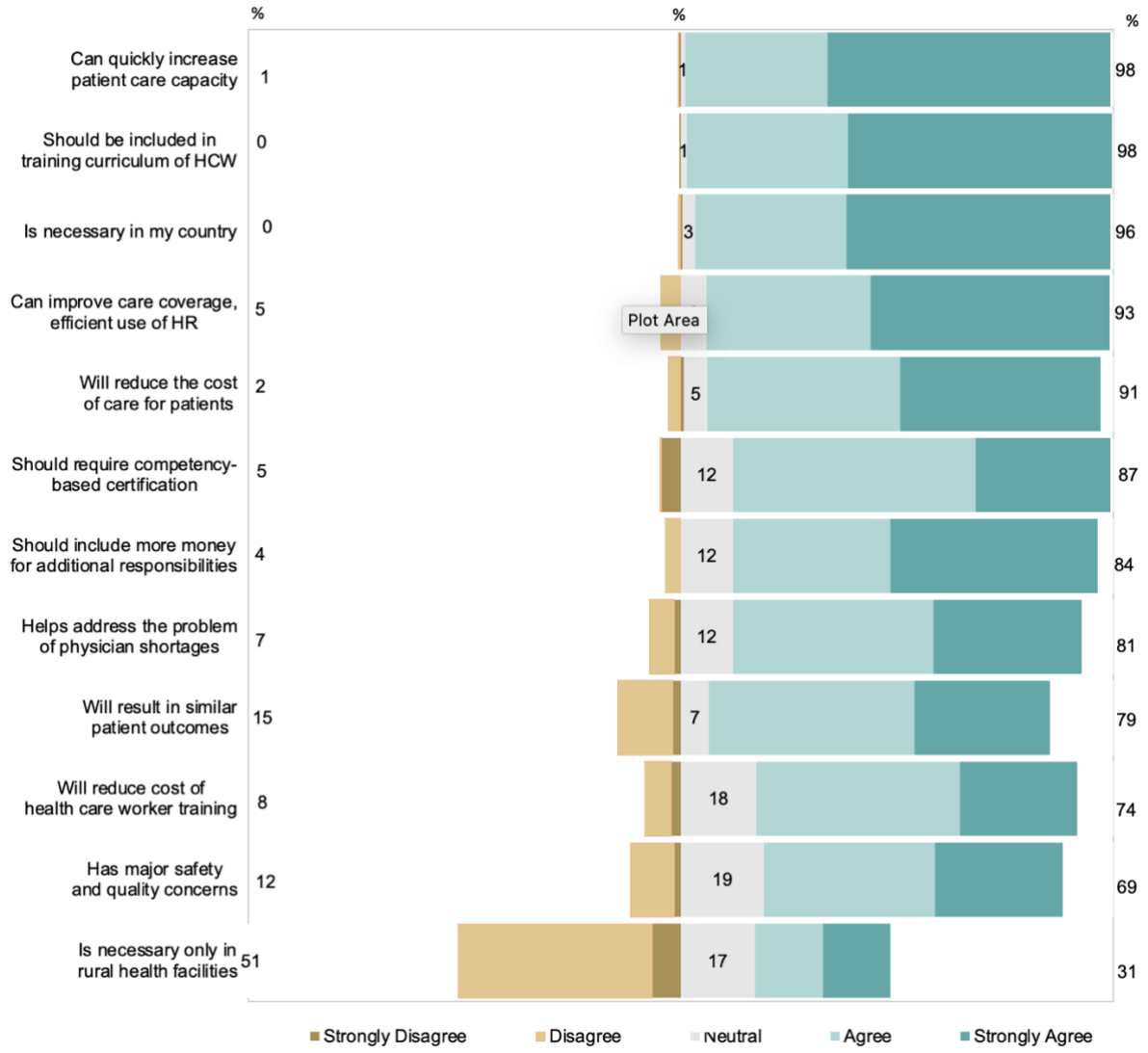


Supplemental Material Figure 4: (A) Perceived Barriers (B) Perceived Facilitators (C) Health Care Workers' Perspectives on Team-Based Hypertension Care in Bangladesh

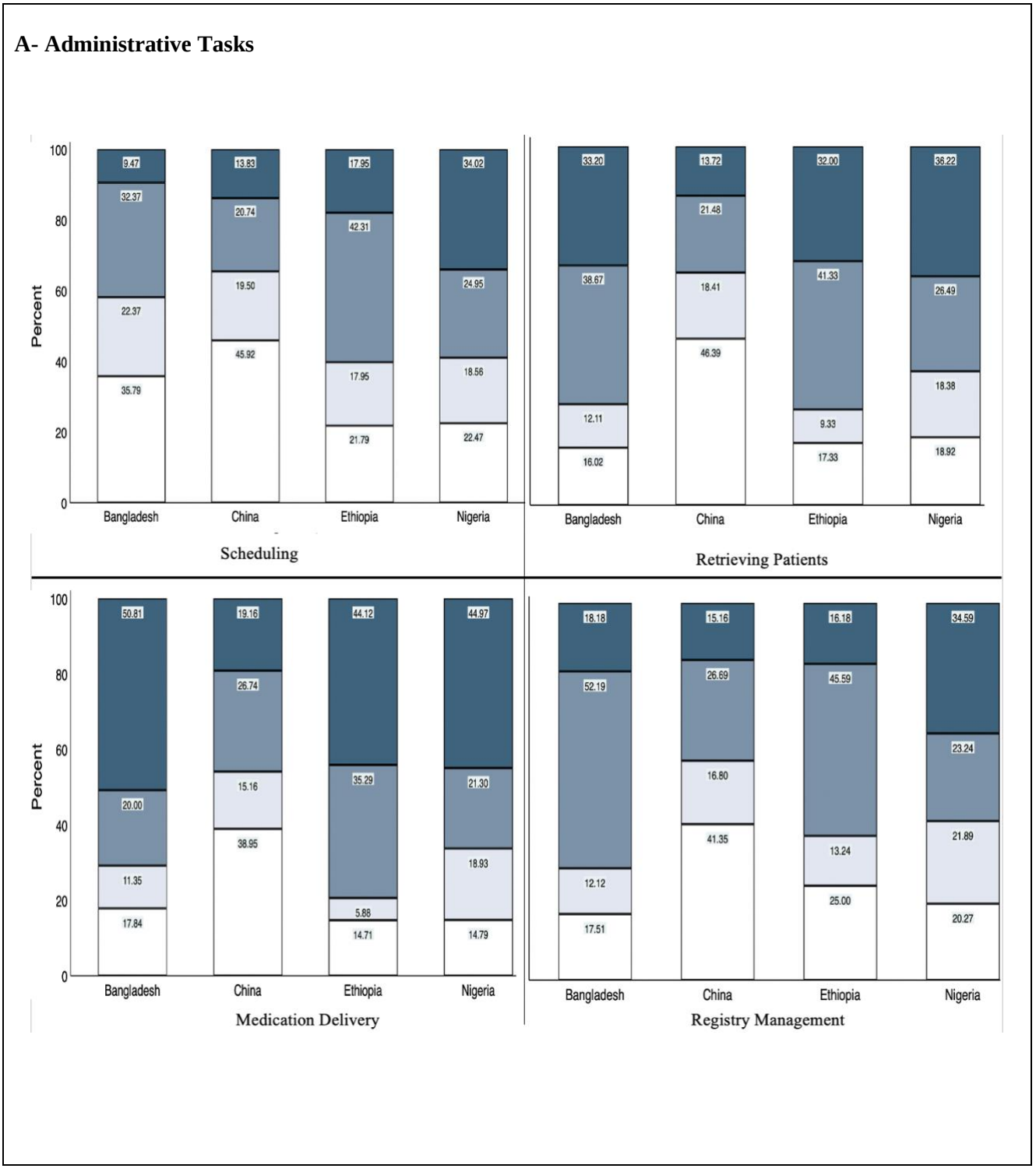


C – Healthcare worker perspectives on team-based hypertension care

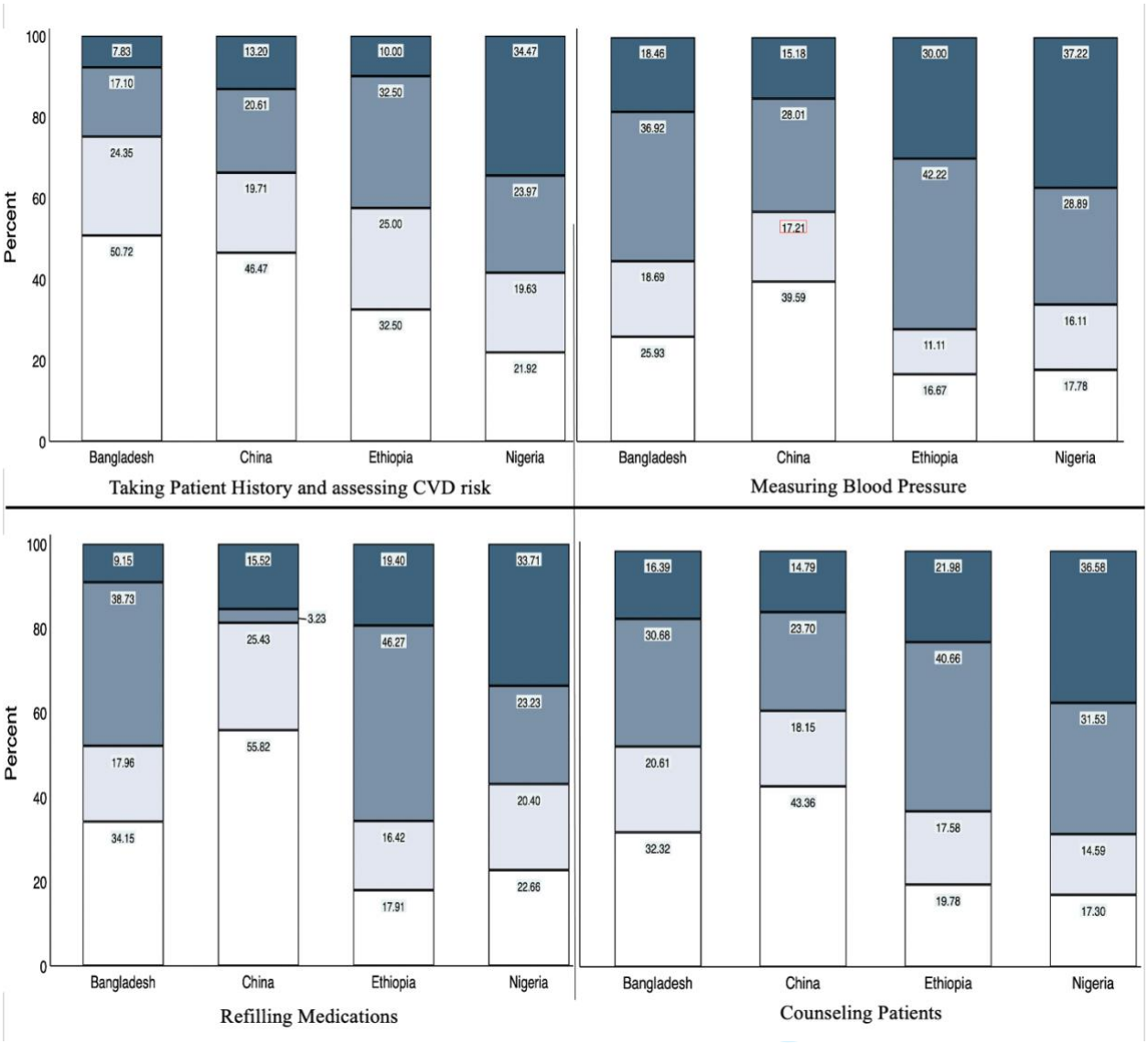
In my opinion, team-based care:



Supplemental Material Figure 5. Hypertension Management Task Assignment (Administrative and Basic Clinical Tasks) in Practice by Participating Country



B- Basic Clinical tasks



Definitions:

Y-axis: Percent of health care workers' responses to the survey item

X-axis: Participatory countries

Health care worker titles and definitions were according to the World Health Organization definitions, specifically:

- Generalist medical practitioners: Medical doctor (general), Medical officer (general), Physician (general), General practitioner, Family medical practitioner, Primary health care physician, District medical doctor
- Specialist medical practitioners: Specialist physician (internal medicine), Surgeon, Anesthetist, Cardiologist, Emergency medicine specialist, Ophthalmologist, Gynecologist, Obstetrician, Pediatrician, Pathologist, Preventive medicine specialist, Psychiatrist, Radiologist
- Nursing professionals: Professional nurse, Specialist nurse, Nurse practitioner, Clinical nurse, District nurse, Operating theatre nurse, Public health nurse, Nurse educator
- Community health: Community health aide, Community health promoter, Village health worker

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

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
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	6
Bias	9	Describe any efforts to address potential sources of bias	12
Study size	10	Explain how the study size was arrived at	6, **Appendix table 1**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-13
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6
		(*b*) Describe any methods used to examine subgroups and interactions	6
		(*c*) Explain how missing data were addressed	6
		(*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	7-10, Appendix table 2 & 3, Table 1
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A

Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-10, Appendix table 2 & 3, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Appendix table 2
Outcome data	15*	Report numbers of outcome events or summary measures	7-10, Appendix table 2, Table 1
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	10-11, Figures 2-3
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Supplemental Material
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
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	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
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	2

*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.