TECHNICAL PAPER

HEALTH WORKFORCE THRESHOLDS FOR SUPPORTING ATTAINMENT OF UNIVERSAL HEALTH COVERAGE IN THE AFRICAN REGION

October 2021

World Health Organization
REGIONAL OFFICE FOR Africa

Health workforce thresholds for supporting attainment of universal health coverage in the African Region

ISBN: 978-929023457-9

Suggested citation. Health workforce thresholds for supporting attainment of universal health coverage in the African Region. Brazzaville: WHO Regional Office for Africa; 2021. Licence: CC BY-NC-SA 3.0 IGO.

Cataloguing-in-Publication (CIP) data. CIP data are available at http://apps.who.int/iris.

Layout and design by TIP/AFRO, Brazzaville, Congo

HEALTH WORKFORCE THRESHOLDS FOR SUPPORTING ATTAINMENT OF UNIVERSAL HEALTH COVERAGE IN THE AFRICAN REGION

TECHNICAL PAPER

October 2021

WORLD HEALTH ORGANIZATION
Regional Office for Africa
Universal Health Coverage – Life Course Cluster
Health Workforce Unit
Brazzaville - Congo

CONTENTS

FOREWORD

To improve health and well-being of populations along the life-course, a resilient health system is needed in countries. Achieving health systems resilience requires adequate numbers of health workers who are fit for purpose, motivated and equitably distributed to improve equity in access to services. This has informed several investments in the health workforce as Member States strive to improve their health systems and achieve the Sustainable Development Goals. A key approach to improving the health system is health workforce planning informed by thresholds of health workers that would catalyse achievement of health goals. Over the years, establishing acceptable, comprehensive and context-relevant planning benchmarks has remained a challenge.

The World Health Organization Regional Office for Africa High-Level Consultative Group on the Health Workforce in November 2019 charged the World health Organization with establishing a health workforce density threshold that is directly linked to existing universal health coverage indicators for the Region. This would guide efforts of countries in planning for adequate numbers of health workers needed for integrated people – centred health service delivery across the life – course.

This technical paper is a product of an exploratory analysis conducted by Health Workforce Unit to obtain a health workforce density threshold for select health workforce cadres in the African Region. The findings complement the previous World Health Organization projections and demonstrate that when the contribution of other cadres (besides doctors, nurses and midwives) are taken into account, the progressive realization of universal health coverage requires a higher density of health workers. The estimated threshold takes into account all health workers needed at all levels of service delivery and in all sectors. One key finding is that a density of 134.23 per 10 000 population of 13 categories of the health workforce is required to attain a UHC service coverage index of at least 70%.

Policy makers, managers, planners and partners are encouraged to consider this technical paper in health workforce planning, management and development interventions. WHO/AFRO remains committed to providing evidence needed by our Member States to improve the health workforce as we make progress towards achieving universal health coverage and the Sustainable Development Goals.

Dr Kasonde Mwinga
Director of Universal Health Coverage - Life Course Cluster
World Health Organization Regional Office for Africa

ACKNOWLEDGEMENTS

This technical paper was developed by the Health Workforce Team of the World Health Organization Regional Office for Africa (WHO/AFRO) to guide and facilitate the implementation and achievement of the goals of the Global strategy on human resources for health: Workforce 2030, the African regional framework for the implementation of the Global strategy on human resources for health: Workforce 2030, the Road map for scaling up the human resources for health for improved health service delivery in the African Region 2012–2025, WHO's Thirteenth General Programme of Work, 2019−2023 and national health workforce goals.

The UHC Life Course Cluster of WHO/AFRO is grateful to the Health Workforce Team: Dr Adam Ahmat, Mr James Avoka Asamani, Ms Jennifer Nyoni, Dr Jean Jacques Millogo, Mr Abdou Ilou Mourtala and Dr Sunny Okoroafor who provided insight and expertise that greatly assisted the conceptualization and the drafting of the manuscript.

We acknowledged Dr Humphrey Cyprian Karamagi, Senior Technical Officer at WHO/AFRO and Dr Christmal Dela Christmals, Senior Lecturer at the Centre for Health Professions Education, North-West University for critically reviewing and providing helpful technical inputs on the manuscripot.We would also like to thank Dr Juliet Nabyonga-Orem and Dr Hilary Kipruto for their critical insights.

ACRONYMS

GRG	generalized reduced gradient
HHFA	harmonised health facility assessments
HLCG-HWF	High-Level Consultative Group on the Health Workforce
HRH	human resources for health
ILO	International Labour Organization
MDGs	Millennium Development Goals
MICE	Multivariate Imputation by Chained Equations
MoHS	Ministry of Health and Sanitation
NCDs	noncommunicable diseases
NHWA	National Health Workforce Account
PHC	primary health care
PMM	predictive mean matching
PPP	purchasing power parity
RMNCH	reproductive, maternal, neonatal and child health
SAD	staff access deficit
SARA	service availability and readiness assessment
SDGs	Sustainable Development Goals
UHC	universal health coverage
UNICEF	United Nations Children's Fund
WHO	World Health Organization
WHO/AFRO	World Health Organization Africa Regional Office for Africa

EXECUTIVE SUMMARY

Background: Although health workforce planning is an essential element in building responsive and efficient health systems, establishing acceptable, comprehensive and context-relevant benchmarks/thresholds which are directly linked to a stated health policy agenda has remained a challenge over the decades. There have been past efforts to develop benchmarks for health workforce needs across countries which have been useful for advocacy and planning. Still, they have neither been country-specific nor disaggregated by cadre – mostly due to data inadequacies. The Global strategy on human resources for health: Workforce 2030, for which the WHO Regional Office for Africa developed an implementation framework, has provided a blueprint for interventions geared at resolving the health workforce crisis in the Region. Nevertheless, capacity and resources to develop staffing norms and standards at country level and to produce robust, need-based projections remain a challenge.

The WHO/AFRO High-Level Consultative Group on the Health Workforce (HLCG-HWF) in November 2019 strongly advised the Regional Office to conduct the necessary exploratory analysis towards an index of health workforce density that is directly linked to, and will support, the realization of universal health coverage. It is also intended to be disaggregated as far as possible for the various cadres of the health workforce.

Methods: Using universal health coverage (UHC) service coverage as the outcome measure, a two-level structural equation model was specified and analysed in STATA 16. In the first level of structural equations, health expenditure per capita (HEC)—one of the cross-cutting inputs for UHC—was used to explain the critical inputs for service delivery/coverage: health workforce density (HWD), health facility density (HFD), essential medicines readiness (EMR) and diagnostic readiness which measures testing capability (DRT). In the second level of the model, the critical inputs for service delivery (that is, HWF, HFD, EMR and DRT) were used to explain the (UHC) service coverage index. The model exhibited a high level of fitness for the data, explaining about 70% of it. Using a non-linear GRG approach, an optimization was conducted using Microsoft Excel Solver® to simulate the most 'optimal' combination of the densities of cadres of the HWF at various targets of the UHC service coverage index. This is attainable when the other variables are controlled. The health workforce data was obtained from the 47 Members States through a regional health workforce survey conducted in 2019. Data on essential medicines readiness and diagnostic readiness were both sourced from various reports of service availability and readiness assessment (SARA) or harmonized health facility assessment (HHFA) reports. For countries where there has not been any or a recent (last five years) SARA or HHFA assessment, multiple imputations were conducted to fill the data gaps. Data on health expenditure per capita, standardized health infrastructure were obtained from the Africa Health Observatory dataset available at the Data Analytics and Knowledge Management Unit of WHO/AFRO, while the UHC service coverage index was extracted from the 2019 UHC Monitoring report jointly published by WHO and the World Bank.

Results: The analysis shows that controlling for the other variables (diagnostic readiness, standardized health facility density and essential medicines readiness), a unit increase in the health workforce density per 10 000 population is positively associated with statistically significant improvements in the UHC

service coverage index (β = *0.127, P <0.001*). Similarly, a positive and statistically significant association was established between diagnostic readiness and the UHC service coverage index (β = *0.243, P = 0.015*). Essential medicines readiness also contributed positively to the model in explaining the UHC service coverage index, although it was not statistically significant (β = *0.053, P = 0.658*). To assess the validity of the resulting prediction equation, it was used to predict the UHC service coverage index for all 47 Member States of the WHO African Region, which yielded an average deviation of 6%. The model predicted an average UHC service coverage index of 56.623 versus an average of 56.440 estimated in the UHC monitoring report of 2019 - a mean absolute deviation (MAD) of 0.183.

Various targets of the UHC service coverage index were used to simulate the plausible threshold of HWF at which their attainment is plausible. For instance, by controlling for the other variables, a density of 134.23 per 10 000 population of 13 categories of the health workforce corresponds to the attainment of a UHC service coverage index of at least 70%. The optimization results show that a mix of 7.82 doctors per 10 000 population alongside 58.98 nurses and midwives per 10 000 is necessary for the attainment of 70% of the UHC service coverage index. It will translate into a doctor to nurse/midwife ratio of one doctor to approximately eight professional and associate nurses. In the mix of health workers is the need for up to 25.34 community health workers per 10 000 population, while the other categories all make up 43.55 per 10 000 population.

Beyond the 70% UHC service coverage index, small proportional increases in HWF density yield a relatively larger return on the marginal improvements of the UHC service coverage index. For instance, between 60% and 70% UHC service coverage, a unit increase in the coverage index is associated with the need to increase HWF density by an average of 9.2%, but from then up to 80%, a unit increase in the index is associated with the need to increase HWF density by an average of 4.7%. Similarly, a UHC service coverage index above 80% up to 90% is associated with an average of 3.2% increase in HWF density, and then an average of 2.4% increase in HWF density for any unit increase in the UHC service coverage index beyond 90%.

Limitations: The estimates are guided rough estimates only for national-level analysis. It is not a planning target for countries and in any case, not appropriate for health facility, programmatic or operational planning. The model explained up to 70% of the UHC service coverage index, leaving some 30% which can be explained by variables not measured in this model. A seemingly sizeable statistical noise from the unobserved variables (especially issues of governance) should be considered a limitation and efforts must be made to take them into account in future updates when such data become available.

1. INTRODUCTION

1.1 Background

All Member States of the World Health Organization (WHO) in the African Region have subscribed to the global sustainable development agenda which aims at socioeconomic development that leaves no one behind. Goal 3 of the Sustainable Development Goals (SDGs) is aimed at ensuring healthy lives and well-being for people of all ages. Enshrined in this aspiration is the concept of attaining universal health coverage (UHC)—the pivot of all the targets within SDG 3 and other SDGs with health implications. In pursuit of this goal, it is recognized that building the responsiveness and resilience of health systems through strengthened primary health care (PHC) is a sine qua non for UHC (WHO and UNICEF, 2018).

However, the strength of every health system is a reflection of the capacity and adequacy of its health workforce, as it designs and manages the system, and also provides the necessary services to address population health needs. Therefore, to be effective, a health system must have adequate numbers of health workers who are fit for purpose, motivated to perform and equitably distributed across the subnational levels to enhance equity in access to their services by the population in need. In cognizance of this, SDG 3c sets a target to substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries. However, many countries are faced with numerous health workforce challenges that have been partly attributed to poor or inadequate planning which, in turn, results in insufficient investments in the health workforce (Cometto and Campbell, 2016; Cometto and Witter, 2013).

Thus, although health workforce planning is an essential element in building responsive and efficient health systems, establishing acceptable, comprehensive and context-relevant planning benchmarks/thresholds which are directly linked to the stated health policy agenda has remained a challenge over the decades. Past efforts to develop a one-size-fits-all benchmark for health workforce needs across countries (Bustreo et al., 2013; ILO, 2014; WHO, 2006, 2016a) have not necessarily addressed all the challenges, although they have largely been successful in propelling advocacy and positive momentum that brought health workforce shortages into the limelight of health policy. The Global strategy on human resources for health: Workforce 2030 (WHO, 2016a) for which the Regional Committee of Health Ministers in 2017 adopted a regional implementation framework (WHO/AFRO, 2020) has provided a blueprint for interventions geared towards resolving the health workforce crises in the Region. Nevertheless, capacity and resources to develop staffing norms and standards at country level and to produce robust needs-based projections remain a challenge. Therefore, countries continue to rely on established normative benchmarks and population ratios for planning. However, these are often neither country-specific nor disaggregated by cadre. It has thus become imperative to address these gaps and to explicitly link the benchmarks to a routinely or periodically tracked measure of UHC which is a subject of keen interest in all spheres of health policy and strategy discourse.

1.2 Review of health workforce density thresholds, 2006–2016

The World Health Report of 2006 provided an impetus to the global health workforce discourse and advocacy as it highlighted the stock, distribution and disparities in the health workforce globally (WHO, 2006). It also presented an important metric; the threshold density of 23 doctors, nurses and midwives per 10 000 population, deemed necessary for countries to attain at least 80% of skilled birth attendance—a key target of the agenda of the Millennium Development Goals (MDGs) (WHO, 2006). The threshold significantly influenced health workforce policies and planning in many countries and became a target in WHO/AFRO's regional road map for scaling-up the health workforce (WHO, 2013). However, as a threshold that was based on a single outcome variable, its limitations have been highlighted as the focus of global health policy shifted to the more ambitious SDGs, with UHC as the pivot of the health agenda. Consequently, there have been several efforts (see summary in Table 1) to determine an 'optimal' threshold at which the attainment of crucial health targets is plausible across countries (Bustreo et al., 2013; ILO, 2014; WHO, 2016b).

Besides the 2006 World Health Report, three landmark reports have shaped the global discourse on health workforce requirements. In 2014 the International Labour Organization (ILO) established the 'staff access deficit' (SAD) indicator, a minimum threshold density of 34 doctors, nurses and midwives per 10 000 population (later revised to 41 per 10 000) for ensuring social protection (ILO, 2014). The ILO describes SAD as a measure of the relative difference between a country's health workforce density as compared to the population-weighted median health workforce density of a set of countries having low vulnerability in terms of social protection (Scheil-Adlung, 2013). This approach has, however, been faulted for an insufficient empirical link to health service coverage (WHO, 2016b). Also, the report of the global initiative for ending maternal mortalities by 2035 determined that 59 midwives, nurses and physicians per 10 000 population are needed in countries to achieve lower than 50 maternal deaths per 100 000 live births (Bustreo et al., 2013). However, the lack of a clear policy linkage with the broader agenda of attaining UHC and the SDGs probably rendered this benchmark less popular under the current global health policy agenda.

In 2016 a 'need-based' methodology was developed by WHO known as the SDG-index which seeks the attainment of the targets of at least 25% of some 12 SDG tracer indicators (WHO, 2016b). "Need" in this threshold was defined as the numbers of health workers required to achieve the median level of attainment (25%) for a composite index of 12 tracer health and health-related indicators. The approach yielded a benchmark of 44.5 physicians, nurses and midwives per 10 000 population as the minimum that corresponds to the attainment of the selected tracer indicators of the SDGs. This threshold, by far, represents the most sophisticated analysis with clear SDG linkage for health workforce density threshold. Its main drawback, however, is that it does not disaggregate the specific densities of the different cadres of health workers to allow a more nuanced analysis and planning at the country level. Also, it is understood that in developing the SDG-index, the "decision to define need using the median level of attainment was made by an advisory committee" (Scheffler et al., 2018, p. 2) for which the empirical basis has not been clearly explained.

The Regional Committee of Health Ministers in the WHO African Region in 2017 adopted an implementation framework for operationalizing the Global strategy on human resources for health, which includes the SDG index as a milestone for countries. Since the attainment of 25% of the tracer indicators will by no means represent the attainment of the objectives of UHC and the SDGs, it is imperative to explore complementary ways by which the outcome and target of the health workforce density threshold could be more intuitive, useful at country level, and specific as regards the densities needed for the different cadres of health workers.

Table 1: Health workforce density thresholds, 2006–2016

Measure	Defined health workforce density threshold	Source
Health workforce threshold for 80% of skilled birth attendance	23 doctors, nurses/midwives per 10 000 population.	WHO, 2006
Health workforce requirement for the Ending Preventable Maternal Deaths, 2035	59 skilled health professionals (midwives, nurses and physicians) per 10 000 population	Bustreo et al., 2013
Minimum density threshold for UHC in the context of social protection.	34.5 skilled health workers per 10 000 (revised to 41 per 10 000) population	ILO, 2014
Health workforce density threshold for the attainment of median ranked (25%) of 12 SDG tracer indicators.	44.5 doctors, nurses/midwives per 10 000 population.	WHO, 2016

1.3 Rationale for an African health workforce density threshold towards UHC

Data inadequacies have been cited as the main drawback in the past which undermined efforts to determine disaggregated health workforce density thresholds for requirements of specific cadres of the health workforce – hence single threshold density for doctors, nurses and midwives were adopted (Anand and Bärnighausen, 2004; WHO, 2016b, 2006). In the context of Africa, the contribution of the other cadres (besides doctors, nurses and midwives) tends to be rather substantial given the chronic shortage of doctors and nurses/midwives (Liu et al., 2017; Scheffler et al., 2009). With improved data on most of the cadres that hitherto had an extreme paucity of data—which were submitted by national governments—it has become imperative to include these cadres in a health workforce needs index that better reflects the reality and UHC aspirations of the Region.

It is against this background that the WHO/AFRO High-Level Consultative Group on the Health Workforce (HLCG-HWF) in November 2019 strongly advised the Regional Office to conduct the necessary exploratory analysis to establish a health workforce density threshold that is directly linked to existing UHC indicators (WHO/AFRO, 2020). It is also intended to be disaggregated as far as possible for the various cadres of the health workforce. The HLCG-HWF noted in its report of 27 November 2020:

> *"…the global threshold accounts for physicians, nurses and midwives, but in the context of Africa, there are other cadres (for example, clinical officers/medical assistants/physician assistants, community health workers, allied health professionals, administrative and support staff) who contribute immensely to service delivery in one way or the other. Hence, [it is the] considered view of the HLCG-HWF that there was an urgent need to … develop a fit-for-purpose index or threshold for the African Region that takes into account the different cadres".*

1.4 Overview of conceptual approach

In any health system, overall health expenditure is undertaken across different investment areas including: (1) health workforce education and employment; (2) health infrastructure and equipment; (3) medical and diagnostic products; (4) information systems; (5) governance processes; (6) financial management systems; and (7) service delivery systems. Undoubtedly, the outcomes from these investments transcend health service coverage (or UHC) and include areas that are measured less often, such as improved health security and resilience and citizen service satisfaction among others. However, testing the complex relationships between these constructs has been rarely done (if at all), partly due to challenges in measurement and data quality.

WHO, in collaboration with the World Bank and other partners, has, since 2015, been tracking a set of indicators as markers of progress towards UHC across countries. The UHC monitoring reports analyse datasets from various sources, and a composite UHC index is being produced for all countries (WHO and World Bank, 2017). The UHC index which is a summary statistic comprises fourteen (14) indicators across four components: reproductive, maternal, neonatal and child health (RMNCH); infectious diseases; noncommunicable diseases (NCDs); and service capacity and access (see Table 2 for the constituent indicators for each domain of the UHC service coverage index). The attainment of higher scores of the UHC service coverage index by a country is an important proxy measure for the progressive realization of UHC (SDG 3.8) – and is used as a proxy outcome of health investments (Jordi et al., 2020).

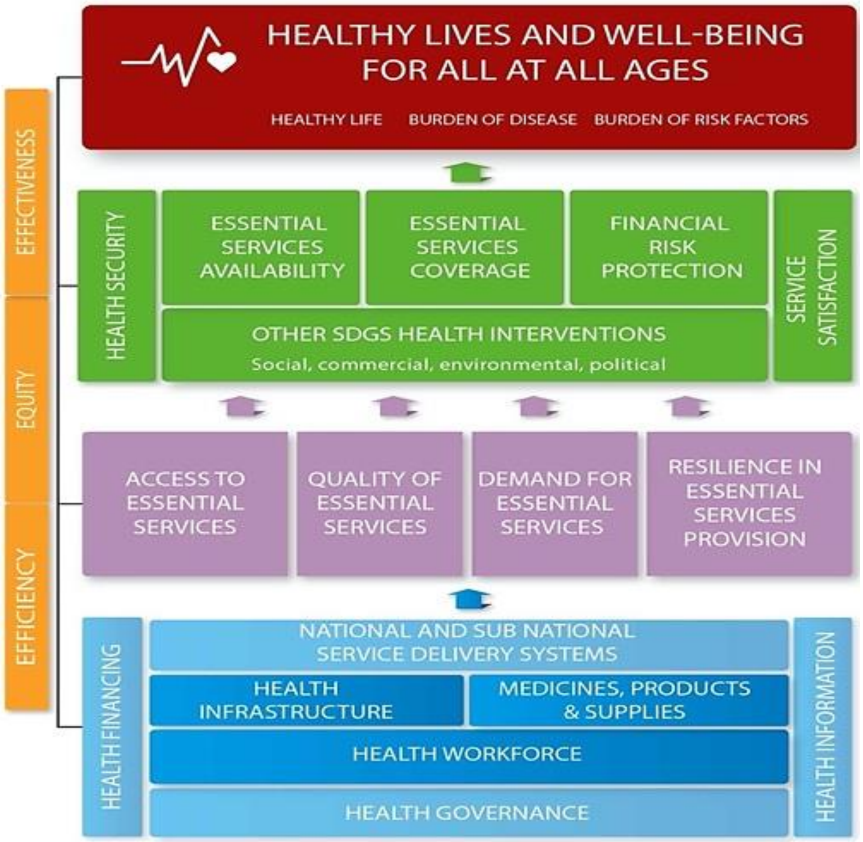
Table 2: Indicators of the UHC index by WHO and the World bank

UHC Index component	The indicator used as a proxy
RMNCH	Family planning demand satisfied with modern methods
	Antenatal care, 4+ visits
	Child immunization (DPT3)
	Care-seeking behaviour for child pneumonia
Infectious diseases	Tuberculosis effective treatment
	HIV antiretroviral treatment
	Insecticide-treated net for malaria prevention
	At least basic sanitation
NCDs	Normal blood pressure
	Mean fasting plasma glucose
	Tobacco non-smoking
Service capacity and access*	Hospital bed density
	Health worker density
	International Health Regulations core capacity Index

**Removed from the UHC service coverage index (outcome variable) for this analysis because two of the constituent variables entered the current model as covariates which will unduly inflate the correlation if they are maintained as part of the outcome variable.*

Robust health systems are a prerequisite for attaining UHC. This relates to availability, functionality and equitable distribution of the health workforce; health infrastructure (health facilities); medicines, health products; as well as diagnostic capacity. These must also be underpinned by strong governance and efficient health financing mechanisms (WHO, 2010; WHO, 2000; WHO, 2010). Consistent with this well-known view, the Regional Committee for Africa adopted a Framework of actions in 2017, which is a harmonized approach to guide health investments towards UHC. The framework identifies health workforce; health infrastructure; health governance; essential medicines, supplies and health products as critical inputs for outputs and intermediate outcomes of health systems. These inputs are also influenced by the level and type of health financing mechanism, health information capacity as well as the national and subnational service delivery systems (see Figure 1 for the Framework of actions).

Figure 1: Framework of actions



Source: WHO, 2017

This analysis was guided by the input-side constructs of the WHO/AFRO Framework of actions and by the UHC index as the proxy outcome variable of interest. As this analysis primarily was aimed at partialling out the health workforce contribution to health outcome to provide insights into the probable threshold for achieving different targets of universal health coverage, we considered the UHC index as the most appropriate outcome indicator for improved access to skilled health workforce. However, out of the four components of the UHC index (described in Table 1 above), the service capacity and access component has two of its constituent variables - hospital bed density and health worker density - included in this analysis as covariates or predictors. Therefore, to avoid including these as predictors and outcome variables at the same time, the service capacity and access subcomponent of the UHC index was removed, leaving the service coverage components (RMNCH, infectious diseases and NCD coverage) which we subsequently refer to as UHC service coverage index.

Also, data were available for 13 categories of health workforce (see Table 3 for list of cadres); a standardized marker of access to health facilities (health infrastructure), diagnostic readiness of countries and the availability of medicines/medical products as well as health expenditure per capita. There was no routine and systematically collected data on some elements of the conceptual framework including health governance, information systems, financial management systems and national/subnational service delivery systems across the countries. Hence, while these constructs are essential, they could not be included in the empirical model. Additionally, structural equation modelling which is most suitable for analysing complex relationships of the nature being analysed in this paper requires large sample size, conservatively, in a ratio of at least ten to one variable included (Barrett, 2007; Hooper et al., 2008; Kline, 2015). However, given that the WHO African Region has only 47 countries (the 'sample'), it allowed for only a few variables to be included.

Table 3: List of health worker groups included in the analysis

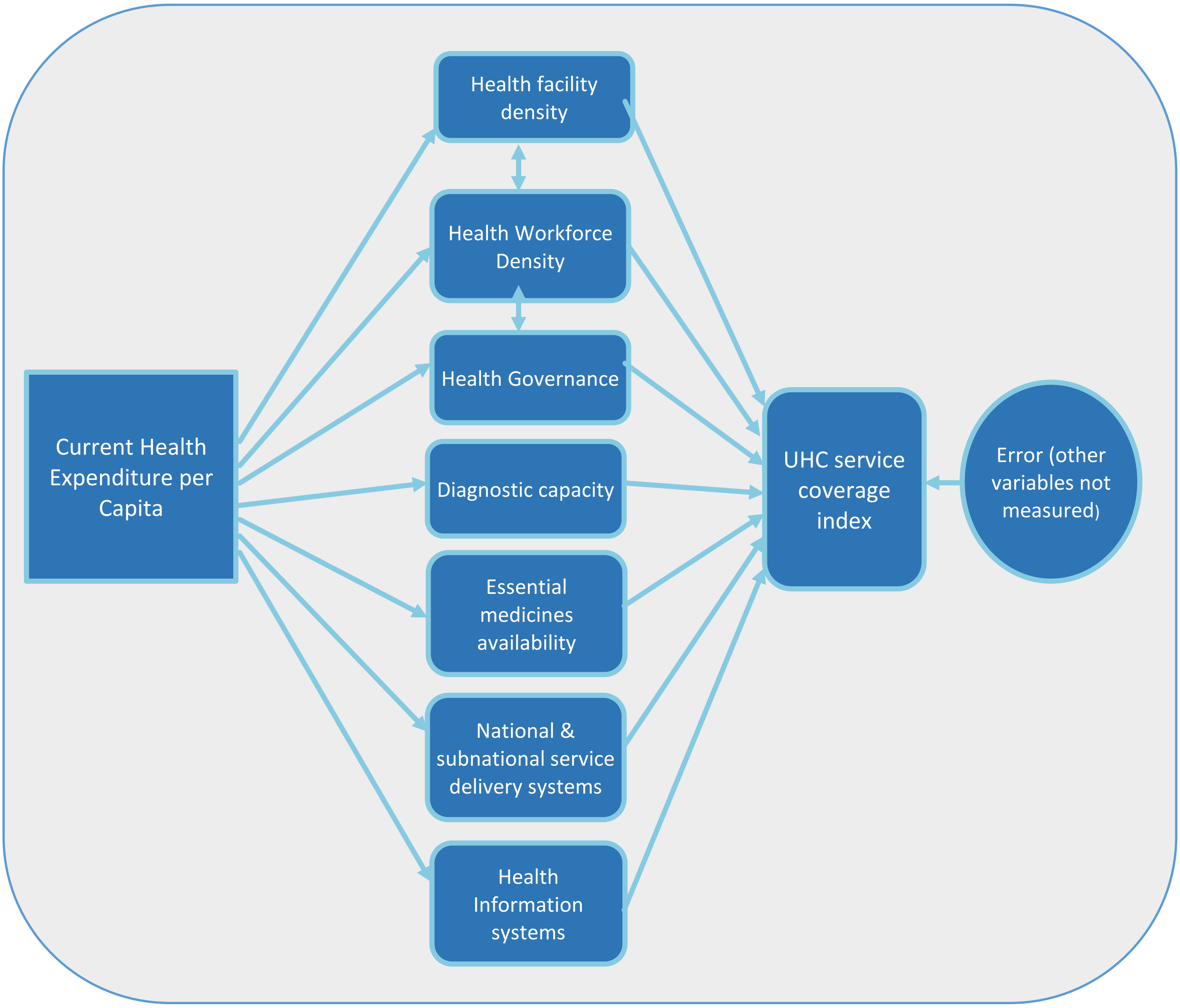
ISCO-08 Code	Health worker group
2211 & 2212	Medical doctors (generalist and specialist medical practitioners)
2221& 2222, 3221 & 3222	Nursing and midwifery professionals (nursing and midwifery associate professionals)
2261 & 3251	Dentists and dental assistants and therapists
2262 & 3213	Pharmacists, pharmaceutical technicians and assistants
3256	Medical assistants
3212	Medical and pathology laboratory technicians
3211	Medical imaging and therapeutic equipment technicians
2264 & 3255	Physiotherapists and physiotherapy technicians and assistants
2267 & 3254	Optometrists and dispensing opticians
2240	Paramedical practitioners
2265	Dieticians and nutritionists
2263 & 3257	Environmental and occupational health and hygiene professionals
3253	Community health workers

Source: International Standard Classification of Occupations, ISCO-08 (ILO, 2008)

The distribution and ability of health workers to optimally function in any country are primarily influenced by the availability and equitable distribution of health infrastructure, and the capacity to diagnose and manage patients/clients with the available essential medicines and health products. Thus, although the focus of this analysis was to determine a density threshold for health workers toward UHC, it was deemed imperative to include these other inputs as covariates in the model and be able to control for them in the estimation (Pituch et al., 2013).

The conceptual relationships described were tested empirically based on the available data from the 47 countries of the WHO African Region using a structural equation modelling procedure in STATA version 16. The resulting structural equations were assessed for fitness of the data and then used in a generalized reduced gradient optimization model to determine the threshold at which the aggregate health workforce density contributes to the attainment of any given level of the UHC service coverage index, by controlling for the other covariates (the other health service inputs). This approach appears intuitive, relatively simple and linked to a regularly tracked metric of UHC which will, in turn, allow a relatively effortless future update of the analysis as may be required.

Figure 2: Conceptual/structural equation model for UHC service coverage index.



2. STATISTICAL PROCEDURES

Based on the described conceptual approach (Figure 2), three steps of: (1) specifying the structural equations; (2) determining the aggregate threshold; and (3) simulating the optimal mix of health workers were used to model the health workforce threshold index at which various targets of the UHC service coverage index is likely attainable, all things being equal.

2.1 Description of the study variables

The primary outcome variable and independent variables used in the empirical model are defined as follows:

- **UHC service coverage Index:** This is a proxy measure of the coverage of essential health services. It is defined as the average coverage of essential services based on tracer interventions that include reproductive, maternal, newborn and child health, infectious diseases, noncommunicable diseases and service capacity and access. The indicator is an index reported on a unitless scale of 0 to 100, which is computed as the geometric mean of 14 tracer indicators of health service coverage (WHO and World Bank, 2017). However, in this analysis, the component on service capacity and access has two of its constituent variables included as explanatory variables and were hence removed (see Table 1 for the modifications made).
- **Health workforce density:** This refers to the number of health workers from a list of 13 categories (defined in Table 3) per 10 000 people in a country.
- **Current health expenditure per capita in PPP:** the average expenditure on health per person measured in the purchasing power of national currencies against the international dollar. It contributes to understanding the health expenditure relative to the population size, thus facilitating international comparison (WHO, 2020).
- **Essential medicines availability:** the proportion of medicines/products listed on the national essential medicines list that are available in surveyed health facilities during harmonized health facility assessments (HHFA) or service availability and readiness assessment (SARA). HHFA/SARA are based on national representative samples of health facilities, and are undertaken less regularly and less frequently in most countries. Hence, data timepoints substantially vary for different countries (MOHS, Ministry of Health and Sanitation, 2018).
- **Diagnostic capacity:** the proportion of needed diagnostic equipment and products listed in the national guidelines that are available in surveyed health facilities during harmonized health facility assessments (HHFA) or service availability and readiness assessment (SARA) (MOHS, Ministry of Health and Sanitation, 2018).
- **Health facility density:** the number of health facilities (of all types) that exist in a country per 1000 population (WHO, 2020).

2.2 Data sources

All data used for the analysis were either obtained from governments directly, from WHO databases or from publicly available sources. The health workforce data were collected from the ministries of health of Member States through a regional health workforce survey conducted by the WHO Regional Office for Africa. For four countries (Botswana, Kenya, South Sudan and Comoros), data from the national health workforce account (NHWA) database of WHO were used, since the official survey questionnaire was yet to be submitted at the time of analysis.

Data on essential medicines readiness and diagnostic readiness were both sourced from various reports of service availability and readiness assessment (SARA) or the harmonized health facility assessments (HHFA), which are publicly available reports. However, for countries where there has not been any or a recent (last five years) SARA or HHFA assessment, the missing data were handled through a multiple imputation procedure.

Data on health expenditure per capita, standardized health infrastructure were obtained from the Africa Health Observatory dataset for 2018 and 2019 (or most recent year) available at the Data Analytics and Knowledge Management Unit of WHO/AFRO. The UHC service coverage index was extracted from the 2019 UHC Monitoring report jointly published by WHO and the World Bank.

2.3 Method of multiple imputations for missing data

We implemented Multivariate Imputation by Chained Equations (MICE) using R software to impute for the missing data (Van Buuren and Groothuis-Oudshoorn, 2011); the methodology is implemented under the assumption that, given the variables we used in the imputation procedure using the variable (UHC service coverage index 2019, overall HRH Density, Health facility density and diagnostic readiness), the missing data are Missing at Random (MAR). This implies that the probability that a value is missing depends only on observed values and not on unobserved values (Raghunathan et al., 2001; Van Buuren, 2007; Schafer and Graham, 2002).

We used the regression equation with the relationship that UHC service coverage index 2019 is explained by the variables of overall HRH density, health facility density and diagnostic readiness. Based on this relationship, the missing variables were imputed using predictive mean matching (PMM), a procedure implemented within the MICE package in R software. PMM produces imputed values that resemble the observed values better than methods based on the normal distribution (White et al. 2011). This methodology ensures that if the original variable is right-skewed, PMM will then produce imputed values that follow the same distributional pattern. With the imputation procedure we implemented, we generated 10 000 complete datasets from which we proceeded to estimate the regression model parameters on each of the datasets and combine the estimates to one combined result which is the resulting final dataset which was utilized in the analysis.

2.4 The modelling/estimation procedure

Step 1: Specifying the structural equations for predicting the UHC service coverage index

Based on the structural relationships illustrated in Figure 1, two-level structural equations were specified in STATA 16 Structural Equation Model (SEM) builder. The choice of the SEM approach in this paper is explained by its ability to take into account a range of complex factors and relationships (Kline, 2015). First, it is best indicated in the context of building indices based on an *a priori* conceptual framework, for which there are no predefined, tested and validated models for the exercise. Second, it adapts well to the investigation of causal inference hypotheses, calling for the use of several variables linked together by functional or structural relationships (Bowen and Guo, 2011). It thus makes it possible to capture the direct and indirect effects of several types of variables, observable or latent. Finally, the SEM approach also offers the possibility of sequential or multi-level modelling, as proposed in the conceptual framework for this analysis.

In the first level of structural equations, health expenditure per capita (HEC) was used to explain the level of some of the critical inputs for service delivery/coverage: health workforce density (HWF), health facility density (HFD), essential medicines readiness (EMR) and diagnostic readiness which measures testing capability (DRT). These are illustrated in Box 1.

Box 1: Generic equations for the relationship between HEC and four input variables

$$HWF = \alpha_i + \beta_i \times HEC + \varepsilon_i \quad \ldots \quad (1)$$
$$HFD = \alpha_{ii} + \beta_{ii} \times HEC + \varepsilon_{ii} \quad \ldots \quad (2)$$
$$EMR = \alpha_{iii} + \beta_{iii} \times HEC + \varepsilon_{iii} \quad \ldots \quad (3)$$
$$DRT = \alpha_{iv} + \beta_{iv} \times HEC + \varepsilon_{iv} \quad \ldots \quad (4)$$

Where:

- α_i is the intercept (constant) for the relationship between HEC and HWF.
- α_{ii} is the intercept (constant) for the relationship between HEC and HFD.
- α_{iii} is the intercept (constant) for the relationship between HEC and EMR.
- α_{iv} is the intercept (constant) for the relationship between HEC and DRT.
- β_i is the slope of the regression line for the relationship between HEC and HWF.
- β_{ii} is the slope of the regression line for the relationship between HEC and HFD.
- β_{iii} is the slope of the regression line for the relationship between HEC and EMR.
- β_{iv} is the slope of the regression line for the relationship between HEC and DRT.
- ε_i is the error term or noise associated with equations 1.
- ε_{ii} is the error term or noise associated with equations 2.
- ε_{iii} is the error term or noise associated with equations 3.
- ε_{iv} is the error term or noise associated with equations 4.

In the second level of structural equations, the four inputs (health workforce density, standardized health facility density, essential medicines readiness and diagnostic readiness) were used as covariates to explain the UHC service coverage index (a standardized measure of 11 out of 14 tracer indicators of

UHC across RMNCH, infectious diseases and NCDs); the other indicators which constitute the service capacity and access component of the original UHC index were excluded because they were entered in the empirical model as covariates and could unduly inflate the degree of correlation if retained as part of the outcome variable. The model was specified, as shown in equation 5. The coefficients of these equations are reported in Table 3.

Box 2: Equations for the relationship between the four input variables and UHC service coverage index (UHC SCI)

$$\text{UHC service coverage index} = \alpha_v + \beta_{vi} \times HWF + \beta_{vii} \times EMR + \beta_{viii} \times DRT + \beta_{iv} \times HFD + \varepsilon_v \quad \ldots \quad (5)$$

- α_v is the intercept (constant) of the equation
- β_{vi} is the slope of the regression line for the relationship between HWF and UHC SCI
- β_{vii} is the slope of the regression line for the relationship between EMR and UHC SCI
- β_{viii} is the slope of the regression line for the relationship between DRT and UHC SCI
- β_{iv} is the slope of the regression line for the relationship between HFD and UHC SCI
- ε_v is the error term or statistical noise associated with equations 5.

Step 2: Determining the aggregate threshold density

After assessing the fitness of the model, which was satisfactory, equation 5 was used to simulate the population-weighted density of health workers that corresponds to various targets of the UHC service coverage index while controlling for the other covariates of health facility density, essential medicines readiness and diagnostic readiness. The regional average of the health workforce density threshold at which various levels of the UHC service coverage index is attainable is presented in Table 5 together with country-specific estimates for the 47 countries in the WHO African Region in Table 7.

Step 3: Determining the disaggregated densities for various cadres

Using a non-linear GRG model, an optimization was conducted using Microsoft Excel Solver® to simulate the most 'optimal' combination of the densities of cadres of HWF that are included in the analysis to attain various levels of the UHC service coverage index when the other variables are controlled.

3. RESULTS, IMPLICATIONS AND LIMITATIONS

3.1 Examining the extent to which the structural equation model fitted the data

Following the structural equation analysis in STATA 16, the model was assessed to examine the extent to which the model fitted the data. First, a model chi-square (χ^2) test was used to evaluate the magnitude of discrepancy between the sample and the fitted covariance matrices (with the assumption that there will not be a statistically significant difference if there is a good model fit). The test was statistically insignificant ($X^2 = 4.58, P = 0.599$), indicating a good model fit. The modelling literature suggests that a good model fit would provide a statistically insignificant chi-square result at a 0.05 alpha threshold (Barrett, 2007); hence the chi-square statistic demonstrates how bad a model fits data or the lack of fit of the model to the data when it is statistically significant. However, one of the known limitations of this test is its low power to detect meaningful levels of model misspecification in small samples (West et al., 2012) such as the sample size used in the current analysis. Therefore, the root mean square error of approximation (RMSEA) was conducted, which demonstrates how well a model contains the optimal parameters and fits the population's covariance matrix (Hooper et al., 2008). It is regarded as one of the critical fit indices due to its sensitivity to the number of estimated parameters in the model (Barrett, 2007; Hooper et al., 2008). The current model yielded an RMSEA value of 0.000 which shows that the model is a near-perfect fit for the data. As a rule of thumb, RMSEA "values less than 0.03 represent excellent fit" (Hooper et al., 2008, p. 58). The probability of a close fit for the current model is 0.70. Thus, the model explains 70% of the data.

3.2 Exploring the contribution of the covariates (inputs) to the UHC service coverage score.

As shown in Table 4, an analysis of the first level equations of the model shows that a country's current health expenditure per capita has a statistically significant positive relationship with the health workforce density per 10 000 population ($\beta = 0.033, P=0.003$). Thus, a US$ 1 increase in current health expenditure per capita is associated with 0.033 improvements in the density of the health workforce per 10 000 population. Albeit statistically not significant, current health expenditure per capita also shows a positive influence on diagnostic readiness ($\beta = 0.005, P = 0.536$), essential medicines readiness ($\beta = 0.014, P = 0.104$), and the number of health facilities per capita ($\beta = 0.00015, P = 0.075$). This result implies that a US$ 1 increase in health expenditure per capita is associated with improvements in diagnostic readiness, essential medicines readiness, and the health facilities per capita at the rates of 0.005, 0.014 and 0.00015 respectively. This association is intuitive and consistent with current knowledge but statistically insignificant in the present analysis, probably due to sample size limitation and data quality relating to these indicators, which were mostly outdated or inputted.

The second path analysis shows that controlling for the other variables (diagnostic readiness, standardized health facility density and essential medicines readiness), a unit increase in the health workforce density per 10 000 population is positively associated with statistically significant improvements in the UHC service coverage index ($\beta = 0.127, P < 0.001$). Similarly, there is a positive and statistically significant association between diagnostic readiness ($\beta = 0.243, P = 0.015$) and the UHC service coverage index. Also, essential medicines readiness contributed positively to the model in explaining the UHC service coverage index ($\beta = 0.053$, $P = 0.658$) although not statistically significant. A higher strength of contribution to UHC service coverage index is shown in the positive relationship between standardized health facility density and the UHC service coverage index ($\beta = 2.235$, $P = 0.634$). The contribution of this covariate in the model was, however, not statistically significant. Only the health workforce density per 10 000 population and diagnostic readiness made statistically significant contributions in explaining the variations in UHC service coverage index across the countries. Nevertheless, the focus of this analysis was intended to partial out the contribution of the health workforce density to the UHC service coverage index. The model is overall, reasonably fitting to the data with an average of 6% deviation; hence the model was deemed appropriate in extrapolating a threshold of health workforce density that corresponds to the attainment of various levels of the UHC service coverage index.

Table 4: Empirical relationships between the variables

					95% Confidence Interval of β	
Structural	**Coefficient (β)**	**Std. Err.**	**Z**	**P-value**	**Lower**	**Upper**
Health workforce density per 10 000 population						
Current health expenditure per capita	0.033	0.011	2.930	0.003	0.011	0.055
Constant	19.731	5.145	3.830	0.000	9.647	29.816
Health facility density per 1000 population						
Current health expenditure per capita	0.00015	0.00008	1.780	0.075	-0.00001	0.00031
Constant	0.329	0.039	8.520	0.000	0.253	0.404
Essential medicines readiness						
Current health expenditure per capita	0.014	0.009	1.620	0.104	-0.003	0.031
Constant	37.726	3.276	11.520	0.000	31.305	44.146
Diagnostic readiness						
Current health expenditure per capita	0.005	0.008	0.620	0.536	-0.011	0.022
Constant	39.296	3.426	11.470	0.000	32.582	46.011
UHC service coverage index (2019)						
Diagnostic readiness	***0.243***	***0.100***	***2.430***	***0.015***	***0.047***	***0.438***
Health workforce density per 10 000 population	***0.127***	***0.033***	***3.870***	***0.000***	***0.063***	***0.192***
Health facility density per 1000 population	2.235	4.694	0.480	0.634	-6.965	11.435
Essential medicines readiness	0.053	0.119	0.440	0.658	-0.180	0.286
Constant	39.762	5.587	7.120	0.000	28.811	50.714

Fitting the intercept and coefficients in Table 4 into equation 5, the UHC service **coverage** index may be predicted for a WHO/AFRO Member State using equation 6, where the diagnostic readiness, health workforce density, standardized health facility density and essential medicines readiness of the country is known – as illustrated in Box 3.

Box 3: Structural equation for predicting UHC service coverage index in the WHO African Region

UHC service coverage index = 39.762 + (Diagnostic readiness x 0.243) + (health workforce density per 10 000 population x 0.127) + (standardized health facility density x 2.235) + (essential medicines readiness x 0.053) .... (6).

To assess the validity of the prediction equation, it was used to predict the UHC service coverage index for all 47 Member States of the WHO African Region, which yielded an average deviation of 6%. The model predicts an average UHC service coverage index of 56.62 for the African Region as against the actual value in the UHC monitoring report of 2019, which was 56.44 – thus showing a mean absolute deviation (MAD) of 0.183 which represents only 0.32% of the value reported in the 2019 UHC monitoring report. However, the model is sensitive to inconsistent, outdated or lack of data for the input variables. For instance, in countries with no recent estimates of essential medicines readiness and diagnostic readiness from SARA or HHFA, the model deviation has been considerable, ranging between -15% and +13%. Thus, updating the estimates as new and reliable data on the input variables become available is essential.

3.3 The derived health workforce threshold density for various minimum targets of UHC service coverage index

To estimate the aggregate health workforce index (density) at which a given UHC service coverage index may be attainable, the parameters were held constant in equation 6, and only the health workforce density varied to determine the threshold at which the given UHC target (for example, 60%, 70%, 80%, etc.) is achieved. This simulation was conducted using the Solver add-in of Microsoft Excel® version 2019, adopting a non-linear GRG optimization. With this, the gradient or slope of the objective function is used as the input values (or decision variables) which are changed across a plausible range until the desired point of the outcome variable is achieved. An optimum solution is reached when the partial derivatives equal to zero (Harmon, 2012; Walsh and Diamond, 1995). In this approach, Solver is only efficient and less time-consuming but yields the same results if manually calculated by making HWF the subject in equation 6 while keeping the UHC index at any desired target.

Table 5 shows a simulation of the HWF threshold at which, holding the other variables constant, various targets of UHC service coverage, ranging from 60% to 100%, are attainable using this model. The analysis shows that between 60% and 70% of UHC service coverage, a unit increase in the coverage index is associated with the need to increase HWF density by an average of 9.2%. For a UHC service coverage index above 70% and up to 80%, a unit increase in the coverage index is associated with the need to increase HWF density by an average of 4.7%. Similarly, a UHC service coverage index above 80% and up to 90% is associated with an average 3.2% increase in HWF density, and then an average of 2.4% increase in HWF density for any unit increase in the UHC service coverage index beyond 90%. The above analysis suggests that massive increases in HWF density are needed to attain a minimum of 70% of the UHC service coverage index, a critical point after which marginal proportional increases in HWF density have an even higher rate of marginal return on UHC service coverage levels. However, given a larger denominator (the HWF numbers), the marginal proportional increases required for each unit increase in UHC service coverage index beyond 70% may represent substantial jumps in the actual number of HWF. From the foregoing, the rest of this analysis assumes 70% of UHC service coverage as a critical point or milestone from the viewpoint of establishing a benchmark index of HWF needs.

Table 5: Simulated targets of UHC service coverage index and the associated HWF index per 10 000 population

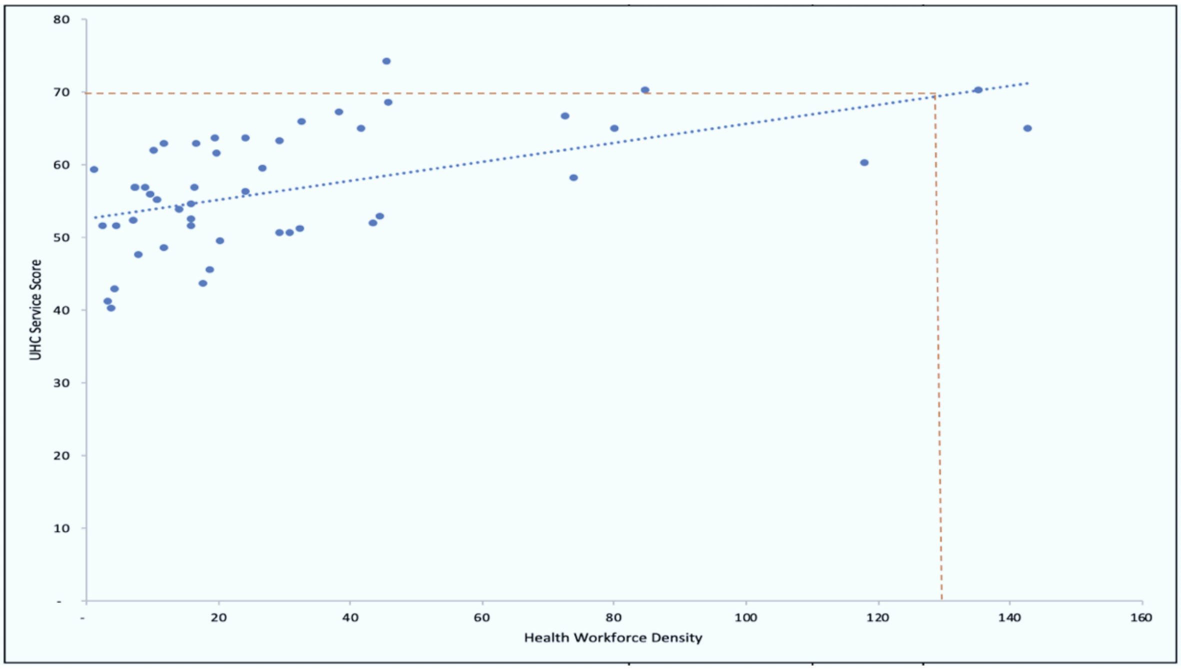
Various levels (targets) of UHC service coverage index	HWF index (density) per 10 000 pop.	Marginal increase in HWF need	The average marginal increase in HWF density for various UHC milestones
56	29.31	Baseline data	
60	55.77		
61	63.62	14.1%	
62	71.46	12.3%	
63	79.31	11.0%	
64	87.15	9.9%	
65	95.00	9.0%	
66	102.85	8.3%	
67	110.69	7.6%	
68	118.54	7.1%	
69	126.38	6.6%	
70	134.23	6.2%	9.2%
71	142.07	5.8%	
72	149.92	5.5%	
73	157.76	5.2%	
74	165.61	5.0%	
75	173.46	4.7%	
76	181.30	4.5%	
77	189.15	4.3%	
78	196.99	4.1%	
79	204.84	4.0%	
80	*212.68*	*3.8%*	*4.7%*
81	220.53	3.7%	
82	228.38	3.6%	
83	236.22	3.4%	
84	244.07	3.3%	
85	251.91	3.2%	
86	259.76	3.1%	
87	267.60	3.0%	
88	275.45	2.9%	
89	283.29	2.8%	
90	*291.14*	*2.8%*	*3.2%*

3.4 The health workforce density threshold for at least 70% UHC service coverage index

As explained above (section 4.3), the attainment of 70% UHC service coverage is assumed as a critical milestone after which small proportional improvements in HWF density tend to yield relatively better returns in terms of the marginal improvements in the UHC service coverage index. Therefore, the attainment of at least 70% UHC service coverage index was considered a critical turning point for analytical purposes. By controlling for the other covariates, a health workforce density of 134.23 per 10 000 population corresponds to the attainment of UHC service coverage of at least 70%. In other words, taking into account the 13 categories of the health workforce included in this analysis, the countries in the WHO African Region on average require an aggregate of 13.42 health workers per 1000 population to enable the progressive realizations of at least 70% of the UHC service coverage targets (see Table 5 for details). However, excluding community health workers, the threshold is 10.9 health workers (comprising 12 categories) per 1000 population.

As a cross-check of the estimated threshold, the UHC service coverage indices of the countries were plotted against their current aggregate health workforce densities (comprising the 13 categories included). In this single predictor analysis, a UHC service coverage index of 70 also corresponded to approximately 136 health workers per 10 000 population (see Figure 2).

Figure 2: Density of 13 cadres of HWF per 10 000 pop. vs UHC service coverage index



3.5 Simulating the optimal mix of health workforce cadres

Using Solver add-in in Microsoft® Excel and maintaining a non-linear GRG model, the model covariates were controlled, the UHC service coverage index constrained at 70% and the various categories of health workers included in the analysis were simultaneously varied to examine an 'optimum mix' at which the UHC target is attainable. The results (Table 6) show that a mix of 7.82 doctors per 10 000 (or 0.782

doctors per 1000) population alongside 58.98 nurses and midwives per 10 000 (or 5.9 per 1000) is necessary for the attainment of at least 70% of the UHC service coverage

index. It will translate into a doctor to nurse/midwife ratio of one doctor to approximately seven to eight nurses (both professionals and associates/auxiliaries). In the mix of the HWF is the need for up to 25.34 community health workers per 10 000 (or 2.534 per 1000) population while the other categories all make up 43.55 per 10 000 (or 4.355 per 1000) population. Table 6 provides details of the density threshold of the various groups of health workers that together correspond to 70% of the UHC service coverage index.

Table 6: Mix of the health workforce threshold by health worker occupational group

ISCO-08 Code	Health worker group	Average regional density per 10 000 population	Density 10 000 population for at least 70% UHC service coverage index	Proportion of the aggregate threshold
2211 & 2212	Medical doctors (generalist and specialist medical practitioners)	3.29	7.77	5.8%
2221& 2222, 3221 & 3222	Nursing and midwife professionals (nursing and midwifery associate professionals)	13.99	58.64	43.7%
2261 & 3251	Dentists and dental assistants and therapists	0.74	5.28	3.9%
2262 & 3213	Pharmacists, pharmaceutical technicians and assistants	1.28	14.72	11.0%
3256	Medical assistants	0.28	0.90	0.7%
3212	Medical and pathology laboratory technicians	1.25	14.00	10.4%
3211	Medical imaging and therapeutic equipment technicians	0.25	0.78	0.6%
2264 & 3255	Physiotherapists and physiotherapy technicians and assistants	0.28	0.91	0.7%
2267 & 3254	Optometrists and dispensing opticians	0.13	0.27	0.2%
2240	Paramedical practitioners	0.52	2.74	2.0%
2265	Dieticians and nutritionists	0.06	0.09	0.1%
2263 & 3257	Environmental and Occupational Health & Hygiene workers	0.54	2.92	2.2%
3253	Community Health Workers	6.69	25.20	18.8%
Health Workforce Density per 10 000 population		**29.31**	**134.23**	-

3.6 Discussion

In 2016, the WHO Global Strategy on HRH: Workforce 2030, on the basis of 12 SDG tracer indicators and their contribution to the global burden of disease (Scheffler et al., 2018), determined that countries needed about 44.5 doctors, nurses and midwives per 10 000 population to be able to attain the median of the target of the SDG tracer indicators. Compared with the current analysis, an even higher density (about threefold) is required when the contribution of other categories of health workers is taken into consideration. Even when only doctors, nurses and midwives are used, the current estimate is roughly 49% higher (66.41 vs 44.5). Besides the methodological differences between the previous work (SDG-index) and the current one, the present analysis is based on only 47 countries in the WHO African Region whereas the previous one was based on all countries where data was available. Thus, whereas the current analysis may suffer from sample size limitations, the former also had to deal with considerable heterogeneity in country contexts, especially between high-, middle- and low-income countries across different continents.

Furthermore, the current analysis included a basket of 13 categories of health workers as compared to three main cadres (doctors, nurses and midwives) included in the previous study. Thus, the current analysis complements the prior work of WHO in that it demonstrates that when the contribution of other cadres (besides doctors, nurses and midwives) is taken into account, the progressive realization of UHC requires an even higher density of health workers.

Furthermore, the work of Bustreo et al., (2013) showed that to reduce maternal deaths down to 50 per 100 000 live births, countries needed a minimum of 59 midwives, nurses and doctors per 10 000. This is a demonstration that, depending on the methodology (model specification and variables included) and the target outcome, varying thresholds are likely to be produced. The current analysis focuses on the progressive attainment of UHC, which is broader than only reducing maternal mortality and also sets a minimum of 70% of the UHC service coverage index, which is more ambitious than the 25% attainment of the SDG tracer indicators used for benchmarking in the SDG index of 2016. Hence, the higher HWF index (or threshold) estimated in the current analysis may not be entirely surprising.

It is also important to note that, depending on contextual factors, some countries may require much more than the threshold density while others may require less to attain the same level of UHC service coverage. There is scope to improve the precision of the estimated health workforce density threshold if the data quality is improved. Importantly, there is also the need to explore opportunities to measure and include other contextual factors such as health system governance and leadership, efficiency and distributional equity to improve the empirical and theoretical linkage.

3.7 Implications of the index/threshold at the country level

This analysis represents the first attempt to include most categories of health workers in developing a threshold and for disaggregating the threshold for the various cadres. It is so far the only attempt (at least within the African Region) to directly derive a health workforce index from the regularly calculated and reported UHC service coverage index. It also further simulates a country-by-country threshold using country-specific data to populate the estimated empirical model from the data.

The estimated threshold density or index of HWF needed for UHC is from a comprehensive or holistic perspective of planning comprising all health workers needed at all levels of service delivery and in all sectors of the health industry—public, private and others.

Despite the positives from this analysis, sample size and data limitations are its drawbacks. Hence, the threshold densities should be used only as a rough guide rather than planning targets at the country level. It may be useful for analytical comparison between subnational levels and across countries. In a country with enhanced analytical capacity, a needs-based health workforce projection that is explicitly linked with the country's health policy objective and predicted workloads from disease burden, essential health service package, and economic capacity might be necessary.

3.8 Limitations

The approach used in this paper represents one of the first attempts to use SEM to model the 'optimal' density of different categories of health workers for the attainment of UHC service coverage targets. However, it has some inherent limitations from both methodological and data perspectives. First, the relatively small sample size (47 countries) with some missing data constrained the extent to which sophisticated analysis and number of variables could be included in the model. However, others have argued that a sample size of more than 30 could yield acceptable statistical estimates, more so, when the current analysis is based on an all-inclusive sampling approach, with data from all 47 Member States of the WHO African Region. Secondly, the exclusion of other variables known to influence the attainment of UHC is a noteworthy shortcoming of the analysis. In this respect, the model explained roughly 70% of the UHC service coverage index, leaving some 30% which can be explained by variables that were not measured in this model. For example, it is widely known that essential concepts such as leadership and governance, equity and efficiency, among others, are a necessary catalyst for attaining UHC. However, at the time of analysis, there were no reliable datasets with metrics that measure these critical elements of health systems across most or all countries within the WHO African Region. The exclusion of these variables should be considered a limitation and efforts must be made to take them into account in future updates when such data become available. Also, accounting for other outcomes beyond UHC such as health security, leadership capacity, health system efficiency, etc., was challenging to incorporate mainly due to the lack of systematically collected data on these variables across the countries.

Finally, in terms of the scope and utility of analysis, it should be deemed as guided rough estimates only for national-level analysis. It is not appropriate for health facility or programmatic, operational planning (and indeed not a planning target).

4. CONCLUSION

This analysis was done in response to WHO/AFRO's HLCG-HWF recommendation for an exploratory analysis to be conducted to establish a health workforce density threshold that is directly linked to existing UHC indicators, taking into consideration the various cadres of the health workforce.

This analysis is so far the only one in the African Region to directly derive a health workforce index from the regularly calculated and reported UHC service coverage index. The estimated threshold density for UHC provides information needed for holistic planning fo all cadres of the health workforce needed for service delivery at all levels of care and in all sectors.

The findings are relevant for holistic health workforce planning, management and development in the African Region.

5. REFERENCES

Anand, S., Bärnighausen, T., 2004. Human resources and health outcomes: cross-country econometric study. The Lancet 364, 1603–1609.

Barrett, P., 2007. Structural equation modelling: Adjudging model fit. Personal. Individ. Differ. 42, 815–824.

Bowen, N.K., Guo, S., 2011. Structural equation modeling. Oxford University Press.

Bustreo, F., Say, L., Koblinsky, M., Pullum, T.W., Temmerman, M., Pablos-Méndez, A., 2013. Ending preventable maternal deaths: the time is now. Lancet Glob. Health 1, e176–e177.

Cometto, G., Campbell, J., 2016. Investing in human resources for health: Beyond health outcomes. Hum. Resour. Health 14, 51. https://doi.org/10.1186/s12960-016-0147-2

Cometto, G., Witter, S., 2013. Tackling health workforce challenges to universal health coverage: Setting targets and measuring progress. Bull. World Health Organ. 91, 881–885. https://doi.org/10.2471/BLT.13.118810

Harmon, M., 2012. Step-By-Step Optimization With Excel Solver-The Excel Statistical Master. Excel Master Series.

Hooper, D., Coughlan, J., Mullen, M.R., 2008. Structural equation modelling: guidelines for determining model fit. Electron J Bus Res Methods 6: 53–60.

ILO, 2014. World Social Protection Report 2014/15. International Labour Organisation, Geneva, Switzerland.

Jordi, E., Pley, C., Jowett, M., Abou Jaoude, G.J., Haghparast-Bidgoli, H., 2020. Assessing the efficiency of countries in making progress towards universal health coverage: a data envelopment analysis of 172 countries. BMJ Glob. Health 5, e002992. https://doi.org/10.1136/bmjgh-2020-002992

Kline, R.B., 2015. Principles and practice of structural equation modeling. Guilford publications.

Liu, J.X., Goryakin, Y., Maeda, A., Bruckner, T., Scheffler, R., 2017. Global Health Workforce Labor Market Projections for 2030. Hum. Resour. Health 15, 11. https://doi.org/10.1186/s12960-017-0187-2

MOHS, Ministry of Health and Sanitation, 2018. Service Availability and Readiness Assessment Plus (SARA+). Ministry of Health and Sanitation, Freetown.

Pituch, K.A., Whittaker, T.A., Stevens, J.P., 2013. Intermediate statistics: A modern approach. Routledge.

Scheffler, R.M., Campbell, J., Cometto, G., Maeda, A., Liu, J., Bruckner, T.A., Arnold, D.R.,

Evans, T., 2018. Forecasting imbalances in the global health labor market and devising policy responses. Hum. Resour. Health 16, 5. https://doi.org/10.1186/s12960-017-0264-6

Scheffler, R.M., Mahoney, C.B., Fulton, B.D., Dal Poz, M.R., Preker, A.S., 2009. Estimates Of Health Care Professional Shortages In Sub-Saharan Africa By 2015. Health Aff. (Millwood) 28, w849–w862. https://doi.org/10.1377/hlthaff.28.5.w849

Scheil-Adlung, X., 2013. Health workforce benchmarks for universal health coverage and sustainable development. Bull. World Health Organ. 91, 888–888. https://doi.org/10.2471/BLT.13.126953

Walsh, S., Diamond, D., 1995. Non-linear curve fitting using Microsoft Excel Solver. Talanta 42, 561–572.

West, S.G., Taylor, A.B., Wu, W., 2012. Model fit and model selection in structural equation modeling. Handb. Struct. Equ. Model. 1, 209–231.

WHO, 2020. Indicator Metadata Registry Details [WWW Document]. Glob. Health Obs. URL https://www.who.int/data/maternal-newborn-child-adolescent/monitor (accessed 11.3.20).

WHO, 2016a. Global strategy on human resources for health: Workforce 2030. World Health Organ.

WHO, 2016b. Health workforce requirements for universal health coverage and the Sustainable Development Goals.(Human Resources for Health Observer, 17). Hum. Resour. Health Obs. Ser. No 17 17, 40.

WHO, 2013. Road Map for Scaling Up the Human Resources for Health for Improved Health Service Delivery in the African Region 2012–2025. Afr. Reg. Off.

WHO, 2006. The world health report: 2006: working together for health.

WHO, UNICEF, 2018. Declaration of Astana: From Alma-Ata towards universal health coverage and the Sustainable Development Goals.

WHO, WH (Ed.), 2010. Health systems financing: the path to universal coverage, The world health report. Geneva.

WHO, WH, World Bank, 2017. Tracking Universal Health Coverage: 2017 Global Monitoring Report (No. ISBN 978-92-4-151355-5).

WHO, WHO, 2018. WHO guideline on health policy and system support to optimise community health worker programmes. World Health Organization.

WHO, WHO, 2010. Monitoring the building blocks of health systems: a handbook of indicators and their measurement strategies. World Health Organization.

WHO, WHO, 2000. The world health report 2000: health systems: improving performance. World Health Organization.

WHO/AFRO, 2020. Report of the first meeting of the high-level consultative group on the health workforce, 27–29 November 2019, Kigali, Rwanda. Brazzaville. Brazzaville.

WHO/AFRO, WHORO for, 2020. The African regional framework for the implementation of the global strategy on human resources for health: workforce 2030. World Health Organization. Regional Office for Africa.