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Kehinde Ogunyemi November 29, 2023

Developing an Institute for Workforce Development with Multi-communication, Online Training for Global Health Security among the Public Health Workforce in West Africa

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Master of Public Health (Accelerated)

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Abstract

Developing an Institute for Workforce Development with Multi-communication, Online Training for Global Health Security among the Public Health Workforce in West Africa

By Kehinde Ogunyemi

Background: eLearning plays a key role in bridging competency gaps among the public health workforce. However, implementation remains a challenge in resource-limited settings. In this study, we assessed the contextual fit and feasibility of a multi-communication, online training (MOT) to guide establishment of an Institute for Workforce Development in West Africa.

Methods: A mixed-methods study was conducted among public health workers in 16 West African countries between Aug 10, 2023, to Oct 10, 2023. Participants were invited through a multisectoral health forum and sub-regionally coordinated efforts to complete an online survey that was created in English, pilot-tested and translated to French and Portuguese. Contextual fit was measured with MOT preference and acceptability, while feasibility was measured with MOT willingness to use and workplace ICT availability using a scoring system developed based on implementation science. Statistical weighting was applied to improve representativeness. In-depth interviews were thematically analysed.

Results: A total of 231 survey responses were collected and seven in-depth interviews conducted. MOT was found to be of “somewhat” contextual fit with population estimates of (*preference:* 29.61%, 23.96–35.27; *acceptability:* 95.99%, 93.79–98.18) and “strong” feasibility (*willingness to use:* 95.56%, 93.78–97.35; *workplace ICT availability*: 82.09%, 77.50–86.68). Work area was found as a major predictor of MOT contextual fit and feasibility, where probabilities of MOT preference, acceptability, willingness to use, and workplace ICT availability were 42% lower (0.58–0.59), 99% lower (0.01–0.14), 95% lower (0.01–0.40), and 2.57 (1.22–5.40) times higher respectively for public health workers in rural areas compared to those in urban areas. The three leading constraints identified were poor internet connectivity, high internet costs and unreliable electricity, while protected work time, contextual practice-based training and consensual training schedule were identified as the top three recommendations.

Conclusion: The study findings suggest MOT is contextually fit and feasible, but geographic disparities exist. Constraints on limited access to ICT including internet, and unstable electricity, with recommendations for protected work time and better training delivery highlight the need for equity-focused workplace policies and increased investments in social infrastructure to improve the public health workforce capacity for global health security.

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Table of Contents

Supplemental File

Acronyms

AFENET: African Field Epidemiology Network

AFRO: African Regional Office

CDC: Centers for Disease Control and Prevention

EIS: Epidemic Intelligence Service

EPR: Emergency Preparedness and Response

FAO: Food and Agriculture Organization of the United Nations

F2F: Face-to-Face

FETP: Field Epidemiology Training Programme

GDP: Gross Domestic Product

GFEP: WHO Global Field Epidemiology Partnership

GHS: Global Health Security

GHSA: Global Health Security Agenda

ICT: Information Communication and Technology

IDIs: In-depth Interviews

IDSR: Integrated Disease Surveillance and Response

IHR: International Health Regulations

INB: Intergovernmental Negotiating Body

IQR: Interquartile Range

IRB: Institutional Review Board

IWD: Institute for Workforce Development

KA: Knowledge-to-Action

LMICs: Low- and Middle-Income Countries

MoH: Ministries of Health

MOT: Multi-communication, Online Training

NGOs: Non-Governmental Organizations

NPHI: National Public Health Institutes

OHHLEP: One Health High-Level Expert Panel

WAHO: West African Health Organization

WGIHR: Working Group on Amendments to the International Health Regulations

WHA: World Health Assembly

WHO: World Health Organization

WOAH: World Organization for Animal Health

PH-P: Public Health Worker-Population

POE MTP: Points of Entry Master Training Programme

PROSE: Promoting Resilience of Surveillance Systems for Emergencies

PVS: Performance of Veterinary Services

SD: Standard Deviation

SDG: Sustainable Development Goals

SURGE: Strengthening and Utilizing Response Groups for Emergencies

TASS: Transforming African Surveillance Systems

UNEP: United Nations Environment Programme

US: United States

UTAUT: Unified Theory of Acceptance and Use of Technology

Chapter 1: Introduction

A well-trained public health workforce is critical for global health security (GHS) to prevent, detect, and respond to public health threats and emergencies (e.g., epidemics, man-made and natural disasters, public health events of international concern) anywhere in the world. [1, 2, 3, 4] Yet the training and ongoing development of the public health workforce remains under-implemented in many countries, particularly in Africa – where the burden of public health emergencies, and shortage of skilled public health personnel are great – despite advances in information and communication technology (ICT). [5, 6, 7, 8]

Suboptimal training implementation not only limits the capability of national public health systems to address the most pressing complex health issues (e.g., pandemics, antimicrobial resistance, climate change) that threaten our collective security and wellbeing, but also hinders progress towards the attainment of universal health coverage and sustainable development goals. [9, 10]

There are three modalities of training delivery: face-to-face; online; or a combination. Each has its own benefits and limitations including interactivity, geographic convenience, personalization, and costs. [11, 12, 13]

Nonetheless, the use of online training, delivered asynchronously (i.e., self-paced learning with recorded materials) and/or synchronously (i.e., real-time learning through video conferencing) is becoming increasingly popular among health professionals in Africa compared to traditional, face-to-face training due to increased accessibility, greater flexibility, and reduced costs, despite existence of multiple social determinants (e.g., language barriers, reduced ICT access, poor digital literacy). [11, 12, 13, 14]

While widespread adoption of online training in Africa is commendable, from an equity standpoint, the advantages to improve competency through online training methods and approaches has not been fully leveraged. This is especially important because Africa contributes a large share to the global burden of epidemic and pandemic-prone diseases with West Africa disproportionately impacted. [6, 15] Thus, implementing a robust and innovative online training pedagogy is important to improve accessibility and usability of health information among the public health workforce for the prevention, detection and response to public health threats and emergencies.

This shows the need to implement online training for the public health workforce in global health security commensurate with the contextual needs and vulnerabilities of public health systems for improved public health outcomes consistent with global recommendations (e.g., One Health, International Health Regulations) as well as implementation frameworks, with equity as a foundational principle. [7, 8]

Current evidence suggests the use of multi-communication, online training (i.e., a training intervention that incorporates a combination of synchronous and asynchronous online methods, and a wide range of ICT-enabled approaches/strategies (e.g., facilitated, digital simulation-based, or social media-based learning) as a feasible and high-impact solution to improve competency among the public health workforce given its successful implementation and effectiveness in higher institutions of learning. [11, 12, 13]

However, it is still unclear whether multi-communication, online training can be adopted in Africa because of a scarcity of baseline evidence on the contextual fit and feasibility of online training among the public health workforce in this setting.

Through a mixed-methods concurrent design triangulating both quantitative survey, and qualitative interviews, this study aims to primarily assess the contextual fit (with measures on preference and acceptability), and feasibility (with measures on willingness to use and workplace ICT availability) as well as to understand the perceived constraints, enablers and recommendations for multi-communication, online training among the public health workforce in West Africa to guide establishment of an Institute for Workforce Development (IWD) in the subregion for global health security.

Chapter 2: Literature Review

2.1 Public Health Workforce Development and Global Health Security

Public health workforce is an integral component of any health system to improve health and livelihood locally, regionally, and globally. [16] In simple terms, the public health workforce could be professionals who work in areas of diseases prevention, life prolongation, and health promotion through equitable evidence-informed and collaborative actions. [17]

To provide an understanding of the public health workforce, particularly in the context of health emergency preparedness and response, where engagements and actions across multiple sectors are necessary and associated with impact, the World Health Organization (WHO) categorized public health workforce into three groups: core public health workers (e.g., epidemiologists); healthcare workers with one or more public health functions (e.g., community health workers); and allied workers (e.g., veterinarians). [3, 18]

This occupational classification of the public health workforce is based on whole or in part delivery of public health services and provides a strategy for emergency preparedness and response (EPR) at any political level nationally, or regionally, or globally. In addition, this classification also adopts One Health by leveraging existing collaborations, communication, coordination, and capacity building for public health workforce development through education and training. [18-20]

The global health security (GHS) agenda – focused on strengthening public health systems to prevent, detect, and respond to health threats and emergencies either biologic (e.g., infectious diseases outbreaks) or environmental (e.g., climate change) or technological (e.g., infodemic) – is unattainable without a public health workforce

with the appropriate skills needed to drive the leadership, technical and administrative functions of public health systems. This necessity explains why workforce development has been identified as one of the 14 technical areas of the GHS agenda. [21-22, 5]

For any public health system to be strong and resilient, its workforce should not only be trained but also be *indigenous* to promote local data insights for culturally-acceptable solutions; *integrated* to perform routine public health functions and promote universal health coverage; *inclusive* to improve community wellbeing, and accelerate achievement of sustainable development goals (SDG); and *interoperable* to effectively and efficiently respond to basic public health needs, and health risks for protection of GHS. This could be called the *four Is of Health Systems Strengthening*.

Against the backdrop of unmet health workforce skills-mix needs and outbreaks threat, especially those of low- and middle-income countries (LMICs), [9-10] increasing investments in education and training of the health workforce through online, and other digital training modalities using regional or global infrastructures for equitable and transdisciplinary learning that is in agreement with national or regional contexts and priorities. With a focus on underserved settings (e.g., Africa) even more imperative is evidence-informed decision making. [22-24]

Hence, public health workforce development is pivotal to GHS through improved competencies, productivity, and retention of public health workers.

2.2 Training Modalities for Public Health Workforce Development

The training modality is used to describe how a training or learning instruction is designed and delivered. [11, 13, 25] While these modalities have different objectives, the meaning of training modality is often interpreted as the method of training for

delivery. When intended to describe how a training is designed, authors use the specific term “training design approaches” and provide a detailed description to avoid the common misinterpretation as a training delivery method. [11-14, 25, 31]

Although, evidence shows that training delivery methods (e.g., online) are sometimes used interchangeably with training design approaches (e.g., computer-assisted learning), global best practice to make a distinction between training modalities for effective training interventions. [11-14, 25, 31]

2.2.1 Training Delivery

The training delivery methods for health professionals include face-to-face (F2F), online, and hybrid (i.e., combination of F2F and online) modalities. These methods have been described in the literature with other synonyms such as physical or traditional (for F2F), eLearning or virtual (for online), and blended or mixed (for hybrid) training modalities. [11-14, 26-27, 31]

There are no generally accepted definitions for training modalities, F2F is a type of training delivery that is characterized by the physical presence of both the learners and the instructor in a given geographic location and at a specific time. F2F training encompasses the constant direct engagements between the learner and instructor irrespective of the training design approaches/strategies (e.g., didactic lectures and computer-assisted learning) that are undertaken. Of the three methods, F2F is the most common for in-service training of public health workers given its long history of usage in the pre-service learning settings (e.g., academic institutions), and non-formal learning settings (e.g., religious institutions). [11, 27]

Online or eLearning is a rapidly evolving training delivery method that is driven by the advances in information and communication technology (ICT). Online training

has been described as the use of ICT tools including digital devices and internet to provide educational and learning interventions. Unlike F2F, eLearning is not bound by physical interaction, geographic location, and time requirements, thus offering greater flexibility for the delivery of training instructions as demonstrated, for example, with restriction of in-person activities during the COVID-19 pandemic. Its flexibility in part underscores the paradigm shift from F2F to novel online tools for training of public health workers. [11-14, 30]

Hybrid (combining the elements of F2F and eLearning) is another method increasingly gaining traction in academia, and in the public health ecosystem due to the opportunity it provides to meet a group of trainees – who have varied training preferences, resources access, and competing priorities – *where they are*. [11, 26-27] Further, depending on the training objectives, and trainees' needs, hybrid training may be delivered concurrently (i.e., trainees participate in F2F or via eLearning) or consecutively (i.e., different parts of a training are delivered F2F, or eLearning, in no particular order). [13]

2.2.2 Training Design Approaches

Compared to the training delivery methods, the approaches used in the design of a training intervention for public health workforce development are not very straightforward. This is in part due to the complex and dynamic nature of trainees' needs. Notwithstanding, the approaches for the training of public health workers that have been documented in the literature can be broadly classified into non-interactive and interactive training designs. [11, 13, 25, 31]

Non-interactive training design is an approach that is characterized by a top-down distribution of training content (i.e., from the instructor to the trainees) with no

opportunity for an iterative bi-directional human and/or ICT-enabled interactivity between the instructor and the trainees irrespective of the methods used in the delivery of the training. One example of non-interactive training design is a didactic lecture, which may be offered F2F in classroom or workplace settings. Another example is the training of the public health workforce using what is referred to as “simple learning resources” (e.g., PowerPoint slides, and recorded audio-visual materials) or unfacilitated “Massive Open Online Courses” (e.g., OpenWHO) in an asynchronous online environment provided in modules. [13-14, 25, 29]

In contrast to non-interactive approach, interactive training design promotes a co-creation, and knowledge management culture through an iterative bi-directional human and/or ICT-enabled interactivity between the instructor and the trainees regardless of the methods used in delivery. Interactive training designs include but are not limited to synchronous (e.g., Zoom) or asynchronous (e.g., webinar) online training, computer-assisted learning, digital simulation-based learning, social media-based learning (e.g., LinkedIn), individualized learning, tests-supported learning (e.g., Poll Everywhere), F2F or online mentored learning, F2F or online community of practice, and multi-communication online training. [11, 13, 25, 29, 31]

Regardless of the training modality found appropriate for a particular context, research has shown that training designed and delivered in accordance with principles of global health learning: cultural humility and servant leadership; transparency; responsible ethical conduct; local capacity development; diversity equity and inclusivity; transdisciplinary learning; One Health; respect for intellectual property; trainee-centered design; open source content and responsible knowledge sharing; solution-oriented teaching, expert-supported implementation and evaluation;

as well as provision of performance support tools (e.g., checklists, feedback system) enhance learning and competency outcomes. [11, 13, 30]

2.3 Benefits and Limitations of Training Modalities for Public Health Workforce Development

Understanding the benefits and limitations of training modalities is crucial for training program implementers (e.g., designers and instructors) to make an informed choice on the type of training delivery methods and design approaches that most complement a training objective for the public health workforce. There are two major training objectives that exist in the literature. They include an objective that seeks to increase the reach of a competency-based training among a particular health workforce, and to deliver an individual- or group-specific competency-based training. [11, 12, 13]

However, even with an assumption that there is no difference in the feasibility of the different training modalities based on access to ICT for a health workforce, evidence suggests that training implementers must navigate a complex decision-making process with consideration of other institutional, political, and socioeconomic contextual factors that extend beyond training objectives, and training modality benefits to make informed choices. Examples include trainees' needs (e.g., competing personal or family priorities, and transportation), and training implementers' resources which include funds, technology, and time. [11, 13]

Incorporating the essential elements of any program design and deployment, the benefits and limitations of training delivery methods could be described across 11 key areas (i.e., **r**each, **r**esiliency, **r**eproducibility**, h**elp**, e**nvironment, **e**ffectiveness**,**

evaluation, **t**asks, **i**mplementation, **c**ontent, and **s**kills, in no particular order, and acronymized as *R³HE³TICS.*

F2F

Training delivered F2F has been associated with some key benefits as well as certain limitations. With regards to the benefits, F2F compared to eLearning have been demonstrated to support a more interactive training environment, suitable for developing interpersonal & psychomotor skills of trainees offering opportunity for trainees to receive fast help or feedback from instructors, and requires minimal learning tasks (i.e., listening, writing). [11, 13, 30, 31, 32, 33]

F2F has also been reported to be limited to low reach, inability to support the delivery of a large and multi-language training content, lack of resiliency (i.e., training lectures cannot be edited, and updated for reuse), irreproducibility (i.e., lack of consistency in training lecture delivered to similar groups of trainees), implementation infidelity (i.e., inability of the training lecture to be delivered as intended due to lack of control over external factors [e.g., trainees' interruptions, instructor's biases]), complexity and subjectivity of evaluation that is likely to prevent accountability of instructors. [11, 13, 30, 31, 32, 33] Concerning effectiveness in terms of learning outcomes and costs, F2F has been shown to be less cost-effective than online trainings while evidence on improvement in learning outcomes (e.g., knowledge, skills) is similar. [12, 34, 35, 36] An example was conducted among health students and professionals in an LMICs setting, showed the implementation costs of its training intervention per trainee was 68 times greater for F2F (£150.0) than for the eLearning (£2.2). [35]

eLearning

In contrast to F2F, eLearning is best for enhancing cognitive skills of trainees for strategic thinking about a problem-based question or scenario presented to them. eLearning is high in reach, large and multi-language training content supported, resilient, reproducible, likely to be implemented with fidelity, less cumbersome to evaluate, associated with improved learning outcomes and cost-effective. [11, 13, 30, 31, 32, 33, 34, 35, 36] Further, when eLearning was compared with F2F among healthcare professionals, in a meta-analysis in 2016 by Vaona et al, eLearning was associated with minimal or no improvement in healthcare professional knowledge. [12]

While the limitations of eLearning range from low interactivity (especially when trainees are less motivated, and the facilitation of is poor) to delayed receipt of instructor help or feedback, as well as high learning tasks (i.e., reading, listening, writing, and navigation of ICT tools). [11, 13, 30-33]

Hybrid

Unlike training delivered via F2F or eLearning, the hybrid balances the benefits and limitations to cost-effectively maximize the impact of training on competency of public health workers. [11, 12, 13, 30, 31, 32, 33, 34, 35, 36] Specifically, evidence from two meta-analyses in 2014 and 2019 suggested that hybrid training led to a significant increase in knowledge of health workers compared to either F2F or eLearning, but with high heterogeneity. [26, 27]

Non-Interactive

While the non-interactive training approach is unpreferable due to lack of human and social dimensions, studies showed it is associated with reduction in training time,

lower implementation costs, and minimal tasks for instructors and trainees. [11, 13] Despite these, non-interactive approach has been associated with lower training satisfaction, poor learning outcomes, increased likelihood of training non-completion, short-term learning and collaboration opportunities. [11, 13, 37]

Interactive

Interactive approaches provide better training satisfaction, lesser training attrition, long-term learning and collaboration opportunities, but its limitations include longer training time, higher costs, more demanding tasks, as well as information overload. [11, 13, 37, 38]

2.4 Public Health Workforce Development with Online Training in Africa

Prior to the COVID-19 pandemic, delivery of training for public health workers in the African region using online methods. With the emergence of the COVID-19 pandemic, the African region like most other regions of the world, witnessed an unprecedented rapid uptake of online trainings for its public health workforces. Specifically, these were developed as an important and necessary alternative to the conventional, face-to-face methods used in existing training programmes to improve competencies to manage those infected with COVID-19 and provide safe and uninterrupted essential healthcare and public health services. [63] Evidence suggests that online trainings have been associated with improvement in core public health functions (e.g., IDSR implementation, IHR compliance), workforce and institutional capacities (e.g., country-driven cascaded trainings, higher training enrollments), health emergency indexes (shortened emergency detection and response times), and population health in most countries, [47, 48, 58, 60]. This culminates into a strengthened public health and healthcare systems.

WHO AFRO Integrated Disease Surveillance and Response Online Course

Through the OpenWHO platform, WHO launched the Integrated Disease Surveillance and Response (IDSR) online technical package in three languages (English, French, and Portuguese) in 2021 to increase access in the African region to up-to-date and practice-based training materials on IDSR towards strengthening their capacities to prevent, detect, and respond to public health emergencies anywhere in the region. [60]

The IDSR online course employs several design approaches (i.e., synchronous online, asynchronous online, and online community of practice), and continues to be relevant for improving the competencies of the public health workforce in the African region based on evidence of increasing enrollments, and training completion. [60]

Africa Centers for Disease Control and Prevention Institute for Workforce Development

In partnership with Rollins School of Public Health, Emory University, the Africa Centers for Disease Control and Prevention (CDC) established its Institute for Workforce Development (IWD) in 2019 to deliver context-specific, and trainee-centered online training in four priority areas: public health surveillance, antimicrobial resistance, scientific writing, and leadership and management to public health workers represented across National Public Health Institutes (NPHI), Ministries of Health (MoH), Non-Governmental Organizations (NGOs) in the African region. [61]

With technical, and human resources supports from Emory University, the design of the Africa CDC IWD online trainings involved a variety of ICT-enabled approaches including but not limited to synchronous online training, social media-based learning,

asynchronous online training, and online community of practice in accordance with global health learning best practices. [11, 61]

African Field Epidemiology Network Field Epidemiology Training Programme

Between 2004 and 2005, African Field Epidemiology Network (AFENET) Field Epidemiology Training Programme (FETP) was established in Africa with supports from the United States (US) CDC and other stakeholders. The FETP was modelled after Epidemic Intelligence Service (EIS) of the US CDC to provide competency-based trainings to public health workers including laboratory scientists/technicians on emergency preparedness and response (EPR) given the region's disproportionate vulnerability to outbreaks and epidemics (e.g., Ebola virus disease, Rift Valley fever). [48, 62]

FETP exists in three formats: three month-basic/frontline, nine month-intermediate, and two year-advanced for early career, mid-level, and senior-level public health workers respectively, and is delivered majorly via F2F method in collaboration with local and international implementing partners (e.g., MoH, academia). FETP is designed with training approaches/strategies such as mentored learning, tests-supported learning, and online community of practice to meet national contexts and priorities. [48, 62]

Though, FETP is mostly delivered F2F, there is still evidence from the field that suggests that the current F2F method has been transitioned into a hybrid method (i.e., F2F, and asynchronous online) due to financial constraints in some African countries like Nigeria. Currently, it is estimated that the average training costs per participant using F2F method for the advanced FETP in any African country is as high as $40,000 over the course of two years of training. [48, 62]

2.5 Gaps in Public Health Workforce Development with Online Training in Africa

Despite successes recorded in the use of online training for the public health workforce worldwide including in Africa, there are still gaps in knowledge and practice that limit the impact of the benefits and opportunities provides by an online training method. Further compounding these gaps is the complex nature of the public health workforce in terms of its diversity, functions, and the externalities of the public health ecosystem. [63]

A public health ecosystem comprises of diverse structures (e.g., public health institutions, hospitals, academia, and non-governmental organizations), and so is the public health workforce, which contains different groups of practitioners. Public health practitioners differ by locality (i.e., rural, urban), competency, work responsibilities, work experience, language, training modality preferences, training modality acceptability, and access to training resources (e.g., time, funds). Externalities such as variability in the political, and socioeconomic landscapes are also other factors that shape the complexity of a public health workforce. [63]

While online training is a proven evidence-based practice for public health workforce development, understanding existing gaps, particularly in research, policy, and practice is critical for ethical, effective, and equitable implementation of this intervention in any setting. In consideration of the African region's epidemics burden and workforce challenges, the contextual fit and feasibility of online training among the public health workforce, and the existence of locally driven integrated and coordinated learning systems become important areas for exposition that may inform strategies for the successful implementation of online training in the region with a focus on most vulnerable setting like West Africa to protect global health security.

2.5.1 Research Gap

Though, there is overwhelming evidence on the widespread adoption of several forms of online training among the public health workforce in the African region, especially during the COVID-19 pandemic, yet there is a scarcity of evidence on the contextual fit (i.e., preference, and acceptability), and feasibility (i.e., willingness to use, workplace ICT availability) of online training interventions in the region given the existence of constraints such as digital divide (i.e., “the gap between people who can easily use and access technology, and those who cannot”), economic inequality (i.e., “the unequal distribution of income and opportunity between different groups in a society”), and disparities in other social determinants such as lack of workplace ICT policies, and unstable electric power. [11, 12, 30, 58, 61, 62, 64, 65]

Concerning the preference of online training among public health workers in Africa, findings from a scoping review conducted before the COVID-19 pandemic suggests that there was no difference in the preference of online training delivery method compared to F2F or hybrid. [66] The same study also reported that public health workers preferred interactive training design approaches compared to non-interactive approaches. [66] This inconclusive evidence might be because of information bias from unequal exposure of the study populations to the different training delivery methods, especially because online or hybrid trainings were less prevalent compared to F2F trainings in the pre-COVID-19 era, thereby limiting abilities to accurately report preference.

In contrast, evidence from a meta-analysis performed during the COVID-19 pandemic by Dedeilia et al reported that the preference of African healthcare workers for online training (29.7%) was marginally comparable to F2F (33.5%), and significantly less than hybrid (70.3%). [30]

Regarding acceptability, evidence suggests acceptability of online trainings among healthcare professionals in the African region with a rate as high as 90.5%. This demonstrates that online training may be a contextual fit for the public health workforce in the African region. [37]

Regarding willingness to use online training interventions, findings from the same meta-analysis by Dedeilia et al showed 49.5% of healthcare workers were willing to continue the use of online training for their education after the COVID-19 pandemic, which may suggest fair feasibility of online training among the public health workforce in the African region. [30]

Further, while so much is known about the downstream factors (e.g., sex, age, personal access to internet) that are associated with acceptability of and willingness to use digital technology, with evidence that suggests that men and young adults are more likely to demonstrate better attitude towards digital technology than their counterparts, there exists a gap in knowledge about sex and age differences, upstream factors (e.g., workplace ICT availability, financial incentives), and midstream factors (e.g., self-efficacy, performance expectancy) in mediating the acceptance and use of eLearning among the public health workforce in a resource-constrained setting like Africa. [11, 12, 68]

Although, findings from these few studies provide insights into the contextual fit and feasibility of online training among the public health workforce in the African region, the generalizability of these findings are limited due to lack of representativeness of the study population either by country (i.e., studies are usually conducted in a single country) or work setting (i.e., studies are predominantly hospital-based and exclude other settings such as community-based organizations), work sector (i.e., studies are

mostly human health-focused and exclude other sectors such as animal health), plus little qualitative evidence. This highlights the need for further research with a mixed-methods design that addresses these limitations to provide better insight into the contextual fit and feasibility of online training among the public health workforce in the African region towards protection of global health security.

2.5.2 Policy and Practice Gap

Though, online training is a well-documented, evidenced-based training intervention with potential to enhance learning and improve competency among the public health workers, [13, 34, 35] evidence from the field suggests that implementation of online training in Africa, particularly at the subregional level remains fragmented, uncoordinated, and unacceptably inequitable.

With rapid advances and proliferation of digital technology, plus renewed global commitments to improve population health and protect global health security, [22, 23, 51, 52, 54, 55, 56] access to health information, whenever needed or wherever it is needed has now become more achievable, perhaps a basic human right, as some have argued.

While a current review of the literature might demonstrate some degree of contextual fitness and feasibility of online training among the public health workforce in the African region, there is an unmet need for a sustainable training infrastructure such as IWD that leverages existing subregional institutional platforms (e.g., West African Health Organization [WAHO]) as proposed in our study to manage the delivery of integrated and coordinated online trainings on GHS for the public health workforce.

2.6 Global and African Region's Policies for Public Health Workforce Development

The world has never been more interconnected. This new era of a globalized community is in part due to rapid technological development, increasing transnational migration and human travel, and international trades. More so, equally connecting us, is the potential of the infectious diseases (e.g., MERS-CoV, SARS, H1N1, COVID-19) to rapidly spread across borders, and causing devastating consequences that often require global mechanisms to adequately curtail their impact. [39, 40]

It is a common notion that "a disease threat anywhere is a disease threat everywhere," where it has been demonstrated that a disease has the potential to travel anywhere in as fast as 36 hours, hence necessitating the need for global and regional policy instruments for strengthening public health systems all around the world, particularly its workforce to detect, prevent, and respond to health threats including diseases outbreaks effectively and efficiently. [5, 6, 8, 18, 19, 41, 42, 44]

Global

International Health Regulations 2005

Since the operationalization of the International Health Regulations 2005 (IHR 2005) by the WHO in 2007, the public health workforce is not only one of the core capacities of the IHR 2005, but it has been pivotal to the implementation of each of other IHR capacities. The IHR 2005 mandate, which seeks "to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks, and which avoid unnecessary interference with international traffic and trade" is for the most part not achievable without a well-trained public health workforce. Examples of

the workforce development efforts that are rooted in the IHR 2005 are the FETP, and the Points of Entry Master Training Program (POE MTP), which are aimed to strengthen the competencies and capabilities of the public health workforce in health emergency preparedness and response within and across international borders. [8, 43, 48, 49, 50]

Further, using mostly F2F training delivery method, the FETP, which benefits from the generous supports of the United States Centers for Disease Control and Prevention (US CDC), WHO, European CDC, and other stakeholders has been used to deliver competency-based trainings on health emergency preparedness and response to over 3,900 public health workers in 65 countries since its inception in 1980. [48]

Despite this laudable achievement, evidence from a high-level review of the IHR functionality during the COVID-19 revealed that the implementation of the IHR in most countries remains a challenge in part due to under-resourced public health systems. Thus, underpinning the recommendations of the COVID-19 IHR review committee and ongoing discussions by the working group on amendments to the International Health Regulations 2005 (WGIHR) on the provision of adequate human resources, and the use of digital technology for capacity building (e.g., surveillance, training) as some of the key solutions to bridge the IHR implementation gap. [43]

One Health Framework

The concept of “One Health” has continued to gain traction in the public health ecosystem to protect global health security. According to the American Veterinary Medical Association, One Health is defined as the “collaborative efforts of multiple

disciplines, working locally, nationally and globally, to attain optimal health for people, plants and the environment". [18]

While One Health has been recognized in the past decade as a potential high-yield approach to combat the emerging threats of infectious diseases linking humans, animals, plants and the environments either at the community, national, regional and global level, studies have shown that the concept is yet to permeate the inner fabrics of the public health ecosystem's operations and strategies for the prevention, detection, response and control of the health risks in most national governments and their relevant ministries, departments and agencies in the health, agriculture, environment sectors worldwide largely as a result of weak human resource capacity, and poor collaboration. [19, 20, 51, 52]

However, the COVID-19 pandemic has presented a window of opportunity in the public health space to accelerate efforts for a paradigm shift towards the promotion of One Health. [20] The increasing health risks including (re)emerging infectious diseases such as the COVID-19 pandemic, the recent mpox outbreak reported in 109 countries with 94% of these countries having no historical evidence of the disease, the silent epidemic of antimicrobial resistance, and food insecurity clearly demonstrate the need for national governments across the world to embrace and remain committed to upholding the foundational principles of capacity building (e.g., competency-based trainings), collaboration, communication, and coordination for the One Health as recommended by the quadripartite organizations including WHO, World Organization For Animal Health (WOAH), Food and Agriculture Organization of the United Nations (FAO) and United Nations Environment Programme (UNEP). [19, 20, 51, 52, 53]

To accelerate progress towards the effective integration of One Health into the current public health systems, global recommendations have been proposed by many authors including the One Health High-Level Expert Panel (OHHLEP) to address the root barriers of One Health such as lack of transdisciplinary education, siloed professional trainings, and lack of integrated mechanisms for public health emergency response to ensure ownership, accountability, and sustainability of the One Health framework. [19, 20, 54]

Global Health Security Agenda 2024 Framework

With a vision of keeping the world safe from public health threats posed by rapid transmissibility of infectious diseases across national and regional borders, the Global Health Security Agenda (GHSA) was first developed as a five-year framework in 2014 and has till date been signed by more than 70 countries in collaboration with international organizations, NGOs, and private companies following its renewal for another five years as GHSA 2024. [5] The GHSA framework, which seeks to foster collaborations for global health security across the breadth and depth of human health, animal health, agriculture, and security, has workforce development as one of its 14 technical areas (e.g., real-time surveillance, national laboratory system, emergency operation centers). [5]

To achieve this goal, the GHSA 2024 has as its mandate for workforce development to "*develop prevention, detection, and response activities conducted effectively and sustainably by a fully competent, coordinated, evaluated, and occupationally-diverse multisectoral workforce*," as one of its objectives to "enhance and promote utilizing of public health information for evidence-based decision making and resource mobilization at regional and national levels," and as its target to have "one trained field epidemiologist per 200,000 population and one trained veterinarian per 400,000

animal units (or 500,000 population, who can systematically cooperate to meet relevant IHR and Performance of Veterinary Services (PVS) core competencies in the countries". [5, 21, 22]

Pandemic Accord

The Pandemic Accord is another international instrument that is proposed and developed unanimously by the Intergovernmental Negotiating Body (INB) consisting of 194 Member States, and partners that is working in tandem with the WGIHR to strengthen national preparedness, and response capacities for pandemics in "coherence and complementarity" with the IHR, and with respect for national sovereignty and human rights and solidarity drawing from gaps (e.g., disparities in access to well-trained workforce) identified from the COVID-19 pandemic and other outbreaks with regional and global impact (e.g., Ebola virus disease, Middle East respiratory syndrome). [44, 45, 46]

If implemented as planned with support from the WHO, the Pandemic Accord seeks to ensure equitable, well-coordinated, and sustained access of countries to tools such as health technologies, information and expertise, and medical countermeasures (e.g., vaccines) that are critical to prevent, detect, and respond to future pandemics through stronger whole-of-government and whole-of-society political commitments, human capital and social infrastructural development, and funding at the national, regional and global levels. [44, 45, 46]

World Health Assembly Resolutions (WHA75.17, WHA76.10)

The world has never been more pressed than now to come together to deliberate and prioritize issues that affect the health and well-being of all such as pandemic threats, and universal health coverage as well as global shortage of health

workforce. [23] Before and during the COVID-19 pandemic, there have been reports of global decline in health workforce size and disparities in their skills-mix needs across regions that is in part driven by poor salaries, limited access to continuing professional development opportunities among other things. [4, 9, 55] For example, Africa shares as high as 25% of the burden of diseases and only 3% of health workforce globally, suggesting a critical shortage of expertise to address the health needs of the communities in this region. [55]

To tackle these problems, during the past Seventy-fifth World Health Assembly (WHA) in May 2022, the WHO Member States have been called upon to improve human resources for health for all people using the WHA75.17 recommendations. [23] As contained in the WHA75.17, recommendations were made for "Member States, in accordance with national contexts and priorities, *to engage at the national, regional and global levels to undertake and accelerate work on building a health and care workforce through training programmes and using best available educational and training facilities, online platforms and hybrid learning opportunities; and to increase the absorption of trained staff into health and care systems through sustainable employment practices*". [23]

In the same vein, the WHA75.17 has as one of its recommendations for "international, regional, national and local partners and stakeholders from across the health sector, and other relevant sectors, as appropriate, to engage in and support implementation of the Working for Health Action Plan 2022-2030, *to invite Member States and regional bodies to undertake educational investment and educational training opportunities in person and through hybrid learning or other technological platforms to allow greater access to learning tools, including through the WHO Academy*". [9, 23]

More so, with COVID-19 pandemic, being the catalyst for most of the action changes at all levels of governments around the world due to its devastating impact on health, and economies, the WHO highlighted a "*strengthened workforce capacity for health emergencies*" in its WHA76.10 resolution in 2023, as part of the three key capabilities essential to achieve a strong health emergency coordination at national, regional, and global levels, further emphasizing the importance of public health workforce development in GHS, and the need for urgent evidence-informed actions. [18, 56]

African Region

WHO AFRO's Regional Strategy for Health Security and Emergencies 2022-2030

In line with other global recommendations (e.g., GHSA), the WHO AFRO developed its strategy to ensure health security and emergencies in the African region. This strategy, which focuses on the three priority areas of GHSA: prevent, detect, and respond to global health threats, culminates into what has been regarded as the "Emergency Preparedness and Response (EPR) Flagship Programmes" that involves three interventions: "promoting resilience of systems for emergencies (PROSE), transforming African surveillance systems (TASS), and strengthening and utilizing response groups for emergencies (SURGE)" targeted to operate at the prevention/preparedness, detection, and response levels respectively. [5-6, 47, 57]

Like other regions of the world, the devastating impact of the COVID-19 pandemic laid bare the weaknesses in the emergency preparedness and response systems in the African region including suboptimal public health workforce capacity and technical know-how, limited access to medical countermeasures, lack of sustainable and predictable financing, and weak implementation of the IHR. [6, 18]

In addressing these problems, the workforce development is recognized as one of the four pillars of the EPR flagship programmes to train 3000+ public health workers with the goal of "*ensuring the availability of a dedicated, well-trained, and ready-for-deployment multidisciplinary health emergency expert teams at the national, and sub-national levels to enable quicker initial mobilization of high calibre African responders (within 24 hours) and a shorter response time to emergencies*" by leveraging existing programmes (e.g., FETP), and partnerships (e.g., Africa CDC) within the EPR domain. [6]

Africa CDC's Joint Emergency Preparedness and Response Action Plan 2023-2027

The Africa CDC, which is an independent public health institution empowered by the African Union, has crystallized its partnerships with the WHO AFRO and other stakeholders to align its EPR activities for the African continent towards protecting underserved and vulnerable populations from public health threats and emergencies. [56, 57]

Similar to the WHO AFRO, workforce development constitutes an essential component of the Africa CDC's Joint Emergency Preparedness and Response Action Plan 2023-2027 priority collaboration areas to "*achieve an emergency health workforce that is qualified, interoperable, and inter-connected in Africa*" for a safer, healthier, and prosperous Africa. [56]

2.7 Leveraging Multi-communication, Online Training for Global Health Learning in West Africa

Despite constraints associated with online training in the African region such as poor internet connectivity and, the increasing access of Africans to ICT resources (e.g., internet) [565 million users, 38%], and smartphones [600 million users, 41%], and

prevalent use of online training during the COVID-19 pandemic), [67] there is no better time to leverage multi-communication, online training implemented using existing institutional platforms and partnerships to bridge barriers of access to up-to-date, culturally-sensitive, and practice-based health information needed to improve training outcomes among public health workers in West Africa.

The use of a multi-communication, online training (i.e., training that incorporates a combination of synchronous and asynchronous online methods, and a wide range of ICT-enabled approaches such as facilitated learning, digital simulation-based learning, social media-based learning) provides the unique opportunity to combine the benefits of online delivery and interactive design approaches/strategies such as increased reach, good implementation fidelity, high cost-effectiveness, and long-term learning and collaboration opportunities for maximized learning impact.

Equally important, are the incentives that a multi-communication, online training is likely to provide, which includes but not limited to reduced duplication of efforts, training cost savings, better coordination and cohesive partnerships, promotion of accountability, and reversal of brain drain.

Therefore, the establishment of an IWD in the West African subregion with online training infrastructure for its public health workforce training guided by context-specific evidence, and relevant policy instruments would not only help to further strengthen the GHS architecture, but also yields triple returns on investment (i.e., improved education, population health, and economic growth in the West African Member States, African continent, and globally.

Chapter 3: Description of the Project

3.1 Project Overview

This study is a formative assessment of a multi-pronged implementation aimed at developing an Institute for Workforce Development (IWD) with multi-communication, online training (MOT) infrastructure to manage the delivery of integrated and coordinated online trainings on global health security (GHS) for the public health workforce in West Africa (**Figure 1**).

3.2 Operational Definition of Terms

Contextual Fit: is "how well the program or practice aligns with the implementing site and focus populations' perceptions of strengths and needs, values, culture, and history, other initiatives and priorities, as well as internal capacity resources available for implementation". [68]

Feasibility: is "how well the program or practice can be integrated into the implementing site based on how operationalized the program or practice is, the supports available at the site to support implementation, and the strength and availability of research data". [68]

Acceptability: is "the perception among implementation stakeholders that a given treatment, service, practice, or innovation is agreeable, palatable, or satisfactory". [69]

Preference: is a "statement made by individuals regarding the relative desirability of a range of health experiences, treatment options, or health states". [70]

Willingness to Use: referred to as *adoption* is defined as "the intention, initial decision, or action to try or employ an innovation or evidence-based practice". [69]

Facilitating Condition: is “the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system”. [71]

Self-Efficacy: are “individuals perceived knowledge and skills to use computers effectively for a specific task”. [71]

Effort Expectancy: is “the degree of ease associated with the use of the system”. [71]

Performance Expectancy: is “the degree to which an individual believes that using the system will help him or her to attain gains in job performance”. [71]

Attitude: is a “psychological construct that shows how people think, feel, and tend to behave with regard to an object or a phenomenon”. [72]

Social Influence: is “the degree to which an individual perceives that important others believe he or she should use the new system”. [71]

Constraint: from a population-level perspective can be defined as a factor that prevent or reduces the ability of a population from undertaking a recommended evidence-based practice. Similarly, from a system perspective, constraint is defined as “anything that limits a system from achieving higher performance versus its goal”. [73]

Enabler: from a population-level perspective can be defined as a factor that motivates or fosters the ability of a population to undertake a recommended evidence-based practice. Similarly, from a system perspective, enabler be defined as anything that enhances a system to achieve higher performance of its intended goal. [73]

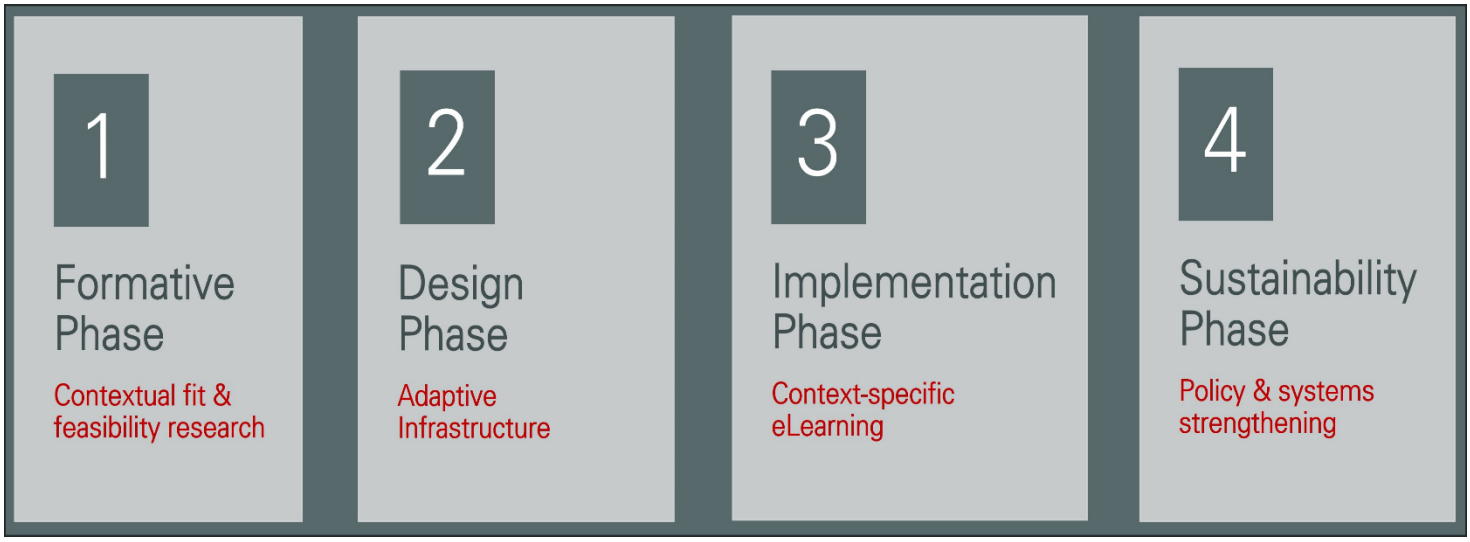

Figure 1. Overview of proposed Institute for Workforce Development for implementation of multi-communication, online training (MOT) among public health workers in West Africa, 2023. An implementation science-based model for strengthening the public health workforce through existing subregional platforms such as the West African Health Organization (WAHO).

3.3 Conceptual Framework: Theories, and Assumptions

We triangulated knowledge-to-action (KA) framework [7] and a modified unified theory of acceptance and use of technology (UTAUT) for our study's conceptual framework. [72] Of several well-established implementation frameworks (e.g., consolidated framework for implementation research, RE-AIM framework) used for translating evidence-based practice into routine practice, [33] we determined KA framework to be most appropriate for our study because it is mainly designed for guiding the development of an intervention prior to its implementation, as in the case of our study goal. KA framework elucidates the sequential mechanisms that leads to successful implementation, namely "knowledge creation" (i.e., synthesis of evidence); "knowledge adaptation" (i.e., alignment of evidence to local context; and assessment of barriers and facilitators of evidence use); and "knowledge activation" (i.e., selection and tailoring of evidence). [7]

Compared to other theories (e.g., theory of planned behaviour, and technology acceptance model), UTAUT is the most validated theory used to evaluate intention to use and actual use of technology in diverse global settings. [72, 75, 74, 77, 74, 79] We used a modified UTAUT because it was validated specifically in a low- and middle-income countries (LMICs) setting, hence making it culturally appropriate for our study. Another advantage of the modified UTAUT is that it provides a more detailed assessment of behavioral choices with additional constructs including "self-efficacy"; and "attitude" in addition to the four predictors, namely "effort expectancy"; "performance expectancy"; "facilitating condition"; and "social influence" that are used in UTAUT. [71, 75]

We grouped "self-efficacy"; "effort expectancy"; "performance expectancy"; "attitude"; and "social influence" as "midstream determinants" of behavioral choices because

they are profoundly influenced by the proximate effects of the characteristics (e.g., convenience of use, competitive advantage) of a recommended technology that are shaped by business forces, and in most cases, are beyond an individual's control. We categorized "facilitating condition" that is herein denoted as "Workplace Internet Funds" into the "upstream determinants" group because it is related to policy. We categorized other factors including sociodemographics; personal ICT accessibility; previous eLearning; and eLearning preference as "downstream determinants" to provide better understanding of the social determinants that influence the behavioral choices (i.e., acceptability, and willingness to use) towards MOT among public health workers.

Our framework depicts how multiple levels of social determinants for an individual exposed to MOT could interact to influence their acceptability, and willingness to use MOT to determine the contextual fit and feasibility of MOT implementation among the target population. Though, modified UTAUT is used to assess its constructs among populations who have been exposed to a new technology, in our study, we assumed that the awareness of public health workers about online training is high to sufficiently inform their perceptions towards the modified UTAUT's constructs, and the acceptability of, or willingness to use MOT. Additionally, we used "eLearning preference" as a proxy measure of "MOT preference" with the assumption that those who prefer to be trained via eLearning are likely to prefer any approach (e.g., multi-communication) used in its delivery (**Figure 2**).

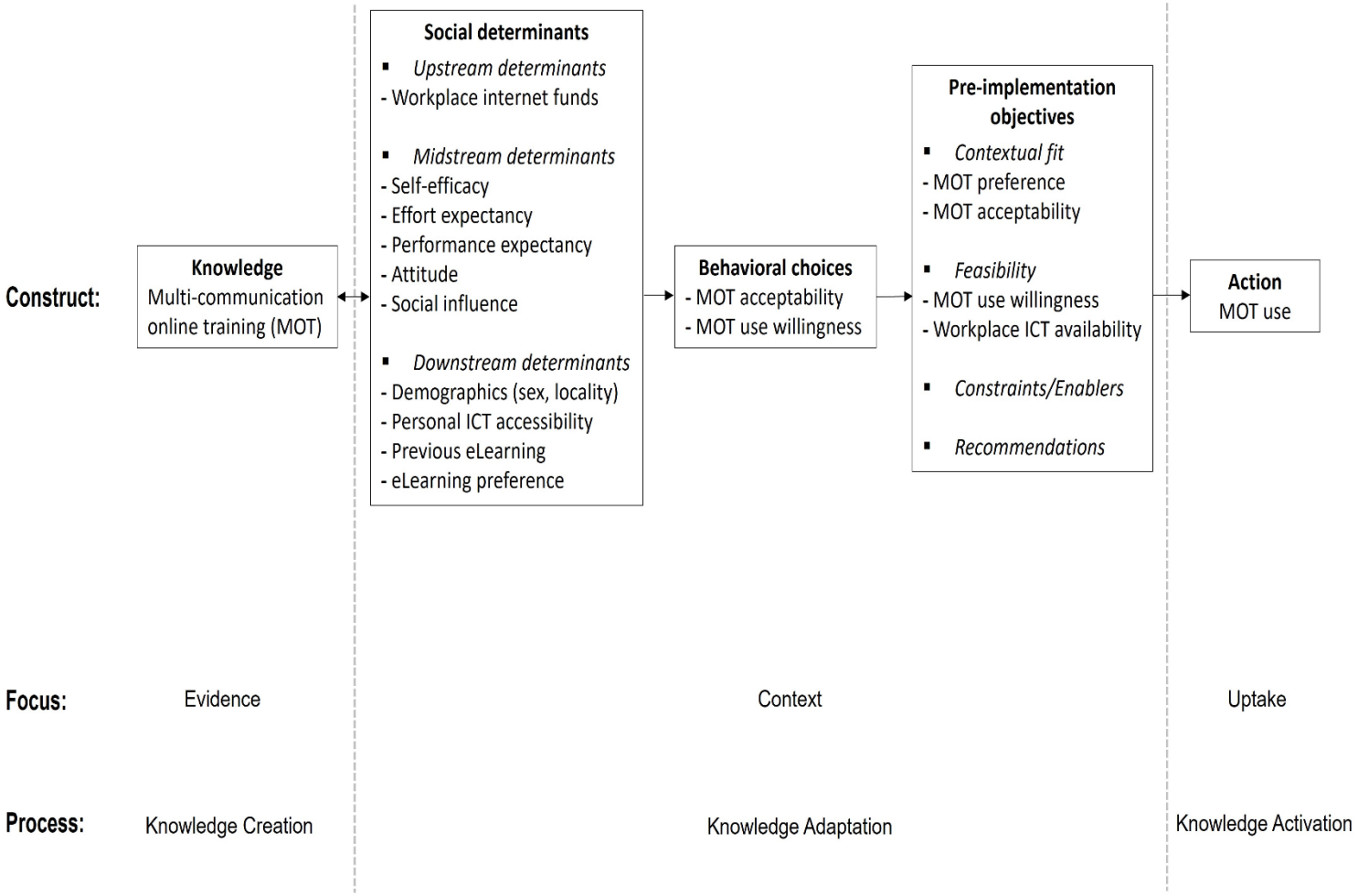

Figure 2. Conceptual framework for implementation of multi-communication, online training (MOT). Developed by triangulation of Knowledge-to-Action (KA) implementation science framework, and a modified Unified Theory of Acceptance and Use of Technology (UTAUT).

Chapter 4: Methods

4.1 Study Design

This is a mixed-methods study with a quantitative survey, and qualitative interviews. A mixed-methods concurrent study design with online survey and in-depth interviews (IDIs) was used to determine the views of public health workers on the study's primary objectives including preference; acceptability; willingness to use; and workplace information and communication technology (ICT) availability, and secondary objectives: perceived constraints, enablers and recommendations towards multi-communication, online training (MOT) to inform understanding of its feasibility and contextual fit in West Africa. The qualitative data provided more information on how and to what extent these objectives were perceived by public health workers. Quantitative data were triangulated with qualitative data to explain the contextual fit and feasibility of a MOT intervention in the subregion. The study was conducted from Aug 10, 2023, to Oct 10, 2023.

4.2 Study Settings

To improve representativeness, all 16 countries of West Africa were included in this study, which were stratified by the three main official languages in the subregion: *English* (The Gambia, Ghana, Guinea, Liberia, Nigeria, Sierra Leone); *French* (Benin, Burkina Faso, Cote d'Ivoire, Mali, Mauritania, Niger, Senegal, Togo); and *Portuguese* (Cabo Verde, Guinea-Bissau). [83] These countries differ by public health worker-population (PH-P) ratio, economy, and emergency preparedness and response (EPR) capacity (**Figure 3**). The subregion is reported to have a total of 1,054,042 public health workers serving a population of 390,953,045 (i.e., PH-P ratio of 1:371), an average gross domestic product per capita of $2,594 prior, and an average global health security index score as low as 32.3 [63, 81, 82, 83]

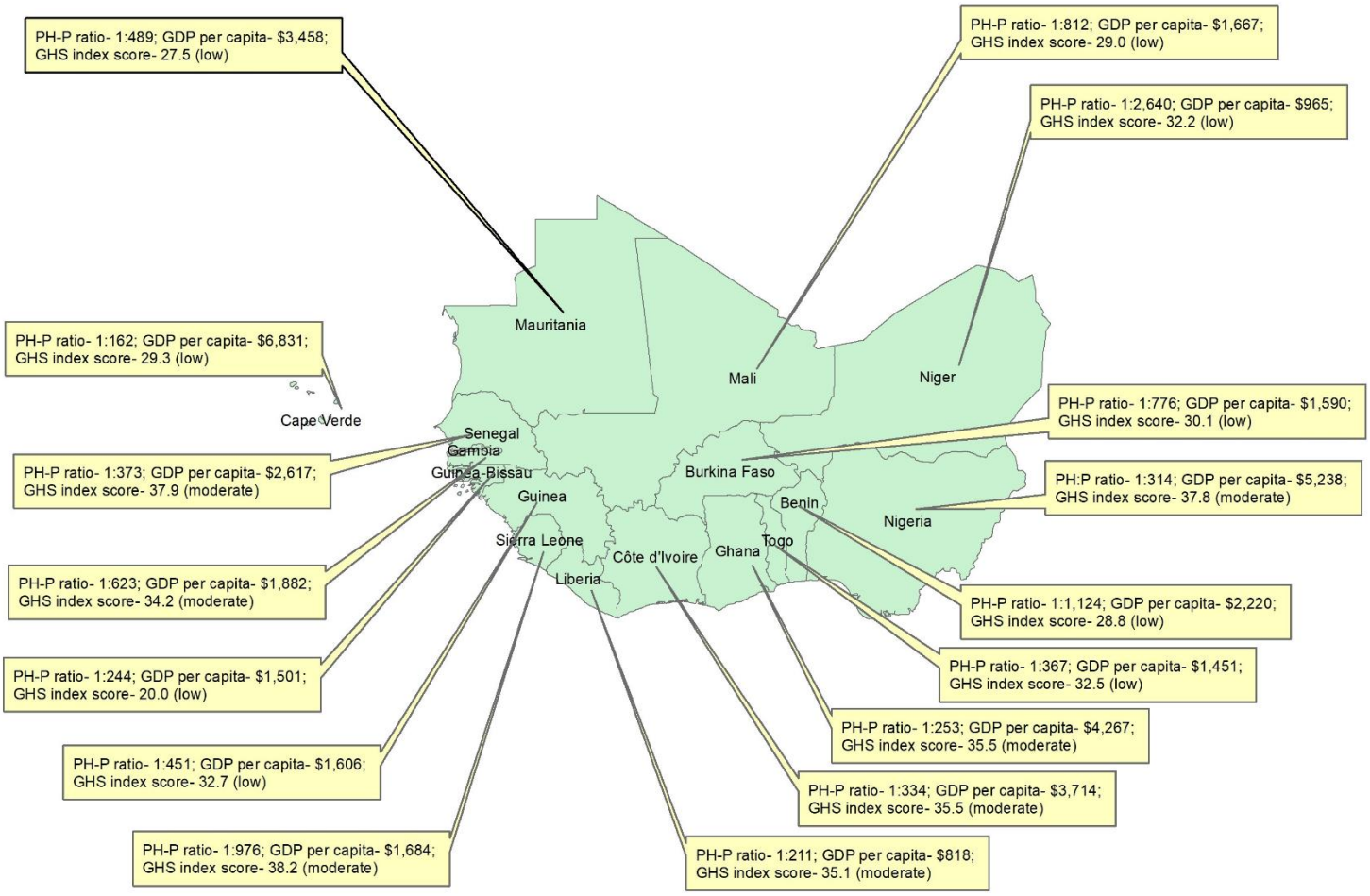

Figure 3. Distribution of public health workforce density, economy, and emergency preparedness capacity of study sites in West Africa, 2023. Map was created based on data from WHO 2018, World Bank 2018, GHS 2019, and Our World in Data's website (more details are given in appendix 7). PH-P: public health worker-population, GDP: gross domestic product, GHS: global health security, WHO: World Health Organization.

4.3 Study Population

A diverse population of public health workers across the human, animal, and environmental health sectors in West Africa were invited to voluntarily participate in quantitative survey and qualitative interviews. Participants in this study included public health specialists, physicians, nurses, environmental health scientists and technicians, laboratory scientists and technicians, veterinarians and assistant veterinarians, and other allied health workers.

4.4 Sample Size Estimation

The estimated sample size for the quantitative survey was 222 based on an expected proportion of 90.5% of public health workers that considered eLearning as an acceptable modality of training in an African setting at 95% confidence, and after adjusting for non-response rate of about 40% for online surveys focused on eLearning topic. [37, 84]

$$n = \frac{Z^2\, P(1-P)}{d^2}$$

$Z\ (standard\ deviate\ at\ 95\%\ confidence)$: 1.96

$P\ (estimate\ of\ true\ proportion)$: 0.905

$d\ (level\ of\ significace)$: 0.05

$$= \frac{1.96^2 \text{ x } 0.905\ (1-0.905)}{0.05^2}$$

$$= \frac{1.96 \text{ x } 1.96 \text{ x } 0.905 \text{ x } 0.095}{0.05 \text{ x } 0.05}$$

$$= \frac{0.33028156}{0.0025} = 133$$

Adjusting for non-response rate of 40%

$$= \frac{133}{1 - non\ response\ rate}$$

$$= \frac{133}{1 - 0.4}$$

$$= \frac{133}{0.6}$$

$$n = \mathbf{222}$$

A total of 231 public health workers completed the online survey. Of the total survey responses, 146 were completed in English, 80 in French, and 5 in Portuguese.

For qualitative interviews, nine IDIs were considered sufficient to generate all relevant themes. [85] However, we were only able to interview seven participants (four English and three French speakers) due to lack of Portuguese speaking proficiency among the research team.

4.5 Sampling Technique

Participants were sampled for the quantitative survey using a virtual snowball technique. We identified 43 EPR focal persons across the human, animal, and environmental sectors in each study site from the West African Health Organization (WAHO)'s workforce database; they were then contacted via email to sensitize them about the study. Second, another follow-up email was sent to: (1) complete the study's pre-test survey via Google Forms; and (2) participate in an online forum via Zoom, where they received more information about the study's objectives and were requested to assist in wider dissemination of the main survey's Google Forms to their colleagues and networks using any communication media (e.g., email, social media).

In the case of qualitative interviews, we recruited interviewees from the focal persons that participated in the online forum using voluntary response sampling technique given that the study population were appropriately represented in the forum sample.

Of the 27 participants that attended the online forum, we had 12 diverse participants that expressed interest in the IDIs, out of which seven confirmed their availability and were included in the IDIs.

4.6 Data Collection

Quantitative data were collected using a self-designed, semi-structured questionnaire. The development of the survey questionnaire was guided by the modified unified theory of acceptance and use of technology (UTAUT), and literature review. [37, 66, 71, 72] The survey contained 23 questions that correspond to ten categories: sociodemographic information (job discipline, age, sex, years of experience, work setting, work sector, work area, work country); personal ICT accessibility; previous eLearning; workplace internet funding; ICT acceptability and use mediating factors (self-efficacy, effort expectancy, performance expectancy, attitude, social influence); contextual fit (MOT acceptability, MOT preference); feasibility (MOT use willingness, workplace ICT availability), and perceived ICT constraints and enablers, including a question on recommendations for eLearning delivery. The survey questions were mostly closed-ended with a few that were open-ended. The open-ended questions included parts of the survey where participants could enter their responses for “other” answer option, and the question on recommendations for eLearning delivery. Questions on perceived ICT constraints and enablers were in multiple responses. To reduce response bias from guessing, “Not sure” was included as part of the answer options where appropriate (**Appendix 1**). The survey questionnaire was created in English and translated into two languages: French, and Portuguese, and back translated to English by the translation unit of WAHO to ensure that meaning was retained (**Appendices 2, 3**). Quantitative data were collected online using Google Form (Google LLC, Mountain

View, CA, USA) with a user-friendly interface. The survey Google Form link was created for each language. The survey questionnaire was pilot tested among 39 public health workers, who represented a majority of study sites. The average completion time for the survey was about 10 minutes. Recipients of the pilot-test survey had no suggestions for improvement of the questionnaire. To reduce missing data and to balance for an anticipated low response rate, responses to all survey questions were made “required” for the survey to be successfully completed. The survey link was shared via email to focal public health personnel in each study site identified from the workforce database of WAHO. These focal persons were encouraged to further share the survey link among their subregional public health networks to achieve a virtual snowball sampling. Only focal persons who did not complete the pilot-test survey were required to complete the main survey before sharing the link with their networks. Responses from the pilot-test survey were not included in the final analysis. To increase participation of the target population, the survey was also promoted through the WAHO website, newsletter, and social media. The Africa Centers for Disease Control and Prevention (CDC), and African Field Epidemiology Training Network (AFENET) were contacted via email and phone call to promote subregional participation. Responses to the survey questionnaire were voluntary, and anonymous. All were asked to give informed consent in the online survey before being prompted to respond to the questions and were informed that they could withdraw at any time of the survey. To protect privacy of the participants, no personally identifiable information (e.g., email) of the participants were recorded in the Google Forms during completion of the survey. Confidentiality was ensured by not sharing the data to anyone outside of the research team.

The qualitative interviews were conducted among public health experts (e.g., managers, trainers, policy makers) with varying experience across the human, animal, and environmental health sectors. A semi-structured IDIs guide was developed with 9 open-ended main questions with associated seven probing questions. A broad data-generating question was first used: “tell me about your work experience”. Open-ended main questions were used to obtain detailed descriptions (e.g., “can you describe a particular training modality that is mostly used in your workplace”; and “what are your thoughts on the acceptability of a multi-communication, online training among practitioners in your field”). Probing questions ranged from non-specific questions (e.g., “Please tell me more about that”) to specific questions (e.g., “could you describe what you think are some of the factors that may influence the acceptance of a multi-communication, online training among practitioners in your field”). The IDIs guide was created in English and translated to French. Consistent with the quantitative survey, our IDIs guide focused on interviewees’ opinions on how they perceive preference; acceptability; willingness to use; and workplace ICT availability towards implementation of MOT, and the underlying reasons for their perceptions. The IDIs also explored their thoughts on existing ICT constraints and enablers, including their recommendations for eLearning delivery (**Appendices 4, 5**). The IDIs guides were not pilot-tested due to a small sample of available participants that volunteered to be interviewed. The IDIs were facilitated by two members of the research team, who have English and French speaking proficiency respectively), and are experienced qualitative interviewer using the semi-structured IDI guides. The IDIs were conducted via an institutional-sponsored Zoom platform (Zoom Video Communications Inc, CA, USA) in a private and quiet location. The main and probing questions were added or removed through

the course of the IDI depending on the type of responses provided. Examples of instances that necessitated these modifications include the interviewee bringing up an issue that required clearer explanation, an interviewee answering a question in a closed manner, or an interviewee having already thoroughly described an issue in a previous part of the IDIs. We conducted the IDIs until thematic saturation was reached for each interviewee and no new themes were emerging. The IDIs took approximately one hour. With interviewees' permission, the IDIs were concurrently audio-recorded and transcribed verbatim during each session using the Zoom's in-built recording and multi-language transcript services. The IDIs were transcribed verbatim in English and French languages respectively. By listening to the audio recordings, all verbatim transcripts were reviewed by the interviewers for accuracy. The verbatim transcripts in French were translated to English by the translation unit. The IDIs were voluntary, and all interviewees were asked to give verbal informed consent before each interview and were informed that they could withdraw at any time of the interview without any penalty or loss of benefits to which they may be otherwise entitled. All transcripts were de-identified to ensure confidentiality. All personally identifiable information was removed from the transcripts, for example, by replacing names with generic phrases and numbers (e.g., public health specialist PH1, veterinarian V1). The survey responses were automatically generated into an Excel spreadsheet by the Google Form's software and combined (**Supplemental file 1**). The Excel spreadsheet, audio recordings, and transcripts were stored on a password-protected computer prior to data analysis.

4.7 Data Analysis

Quantitative data were cleaned and analyzed using SAS version 9.4 (SAS Institute, Cary, North Carolina, USA). The study's primary outcome variables are MOT preference rate (defined as the proportion of participants who indicated eLearning as their preferrable training method); MOT acceptability rate (proportion of participants who found MOT as an acceptable method for their training); MOT willingness to use rate (proportion of participants who have the intention to use MOT for their capacity building); and workplace information and communication technology (ICT) availability rate [proportion of participants who reported accessibility to both computer, and internet in their workplaces). Preference variable was created by coding "eLearning" answer to question 12 as "Yes", and "Physical" and "Hybrid" answers as "No". Workplace ICT availability variable was created by coding "computer, and internet" answer to question 11 as "Yes", and "Computer" and "None" answers as "No". Since binary variables (i.e., variables which can have only a Yes or No value) are used in SAS statistical analysis of categorical outcome variables, "Not sure" and "No" responses were combined as "No" value. To improve representativeness in the results, statistical weighting procedure was employed with inverse probability weights and post-stratification weights at the country level using data from the WHO report on health workforce in the African region in 2018 to account for unequal probability of selection of participants, and due to differences in the distribution of baseline characteristic at the country level between our study sample and target population (**Appendices 6, 7,8; Supplemental file 2**). The SAS survey procedure was used to account for clustering at the country level, and statistical weights. Unweighted frequencies, weighted frequencies, and weighted proportions of the categorical outcome variables were reported overall, and by country. Normality of

continuous variables (age, experience) was assessed using Sharpiro-Wilk test given that our sample size is less than 2000, with variables determined as normal if $p>0.05$, and they were both found to have non-normal distributions. Normality was also assessed graphically using histogram (**Appendix 8**). Weighted medians and interquartile ranges (IQRs) were reported for age, and experience given their non-normality. Differences between distribution of independent variables or factors (job discipline, age categories, sex, years of experience categories, work setting, work sector, work area, work country, personal ICT accessibility, previous eLearning, self-efficacy, effort expectancy, performance expectancy, attitude, social influence, and workplace internet funds) associated with outcome variables were assessed using Rao Scott Chi-square test and Fisher's exact test. The factors that were significant at $p<0.05$ in the Rao-Scott Chi-square and Fisher's exact tests were included in the bivariate logistic regression models to evaluate factors that predicted the outcome variables. Associations between factors and primary outcome variables were assessed using multivariable logistic regression models with traditional Maximum Likelihood estimates. Multicollinearity diagnostics were conducted to ensure that the independent variables included in the multivariable logistic regression models were not highly correlated with each other. Multicollinearity was established if two or more independent variables had eigenvalues close to 0, and variance decomposition proportions greater than 0.3 with corresponding condition index of 10-30 or higher, for which they were dropped in the multivariate logistic regression model (**Appendix 8**). In analytical situations where quasi-complete separations (i.e., situations linear combinations of all or some of the independent variables yields a perfect prediction of the primary outcome variables that leads to non-convergence of and biased traditional Maximum Likelihood estimates) were detected in part due to our study

small sample size, in addition to the inclusion of multiple independent variables, the Firth's Penalized Likelihood regression technique was used to produce odds ratio estimates to reduce such analytical bias. And, in instances where complete separation persisted with a particular independent variable after the Firth's Penalized Likelihood regression technique, the variable was excluded in the multivariate regression model. 3-level categorical variables (low, moderate, and high) were created to rank MOT preference; MOT acceptability; MOT willingness to use; and workplace ICT availability rates for easier interpretation. This was determined by geospatially calculated tertile cut-point values for each outcome variable rate at the country level using quantile data classification method in ArcGIS version 10.3.1 (Esri, Redland, CA, USA) because it is considered most appropriate for ordinal data, and their proportion distributions are presented with choropleth maps created by symbology procedure. For MOT preference, ranking was determined as "low" when the rate is ≤ 22.2%, "moderate" (22.3%-37.5%), and "high" (37.6%-100%), while MOT acceptability is ranked as "low" when rate is ≤ 87.5%, "moderate" (87.6%-95.0%), and "high" (95.1%-100%). For MOT willingness to use, ranking was defined as "low" when the rate is ≤ 92.3%, "moderate" (92.4%-95.0%), and "high" (95.1%-100%), while workplace ICT availability was ranked as "low" when rate is ≤ 37.5%, "moderate" (37.6%-72.7%), and "high" (72.8%-100%). A two-sided $p<0.05$ was considered statistically significant for all analyses. The frequencies and percentages of responses to secondary outcome variables: perceived MOT constraints and enablers were determined and presented with bar charts respectively, while responses to the open-ended question on recommendations for eLearning delivery were inductively organized into codes in Microsoft Excel and their percentage distribution were presented with a donut chart (**Supplemental file 3 and 4**).

Qualitative data were analyzed using thematic analysis. The IDIs transcripts were independently coded by 2 coders (the interviewers). The analysis included reading of the transcripts several times to gain understanding of the meanings conveyed and identify key issues. The key issues identified were used to create codes. A codebook was developed with code definitions, inclusion criteria, exclusion criteria, and examples (**Supplemental file 5**). Coding was performed until thematic saturation was reached. Codes were then compared and discussed by the team until consensus on the themes was achieved. Thick descriptions were produced, and sufficient quotations collected from the transcripts for the themes to explain the research questions. Qualitative data were managed using MAXQDA 10. Our qualitative data analysis was consistent with Braun & Clarke 15-point Thematic Analysis checklist (**Appendix 9**). [86]

Findings from the quantitative data and qualitative interviews were triangulated to understand preference, acceptability, willingness to use, and workplace ICT availability towards MOT among public health workers in West Africa using a joint display (**Figure 4**). The joint display was developed with meta-inferences that evaluated the coherence of the quantitative and qualitative findings by (1) “confirmation” (i.e., agreement between quantitative and qualitative findings); (2) “expansion” (i.e., existence of different aspects of the same phenomenon identified by quantitative and qualitative findings); and (3) “discordance” (i.e., disagreement between quantitative and qualitative findings). [87]

To explain contextual fit and feasibility, we adapted the Hexagon Discussion and Analysis Tool’s 5-category qualitative ranking (strong, adequate, somewhat, minimal, and none) of its “fit” and “capacity” implementing site indicators to 3-category rating (strong, somewhat, weak). The capacity indicator of this tool is taken as “feasibility”

since its definition addresses structural resources and buy-in of end users for implementation, which aligns with the operational definition of feasibility in this study. In adapting the tool ranking method, we combined “strong” and “adequate” to “strong”, maintained “somewhat”, re-categorized “minimal” to “weak”, and excluded “none” given the assumption that it is unlikely to have zero rates of the outcome variables (MOT preference, MOT acceptability, MOT willingness to use, and workplace ICT availability). Consistent with our operational definitions for contextual fit and feasibility, study conceptual framework, and the Hexagon Discussion and Analysis Tool’s fit and capacity ranking definitions, we interpreted the contextual fit and feasibility rankings overall, and by country for this study by triangulating rankings of outcome variables (**Table A**). We presented the geospatial distribution of contextual fit and feasibility rankings at the country level using manual interval data classification method in ArcGIS by converting their 3-level categorical variables (strong, somewhat, and weak) to percentages where “strong” was assigned a maximum score value of 3 (100%), “somewhat” a value of 2 (66.67%), and “weak” a minimum value of 1 (33%) to show the quantity of the variables relative to other score values. Throughout this study, we followed the Good Reporting of a Mixed-Methods Study (GRAMMS) checklist (**Appendix 10**). [88, 89]

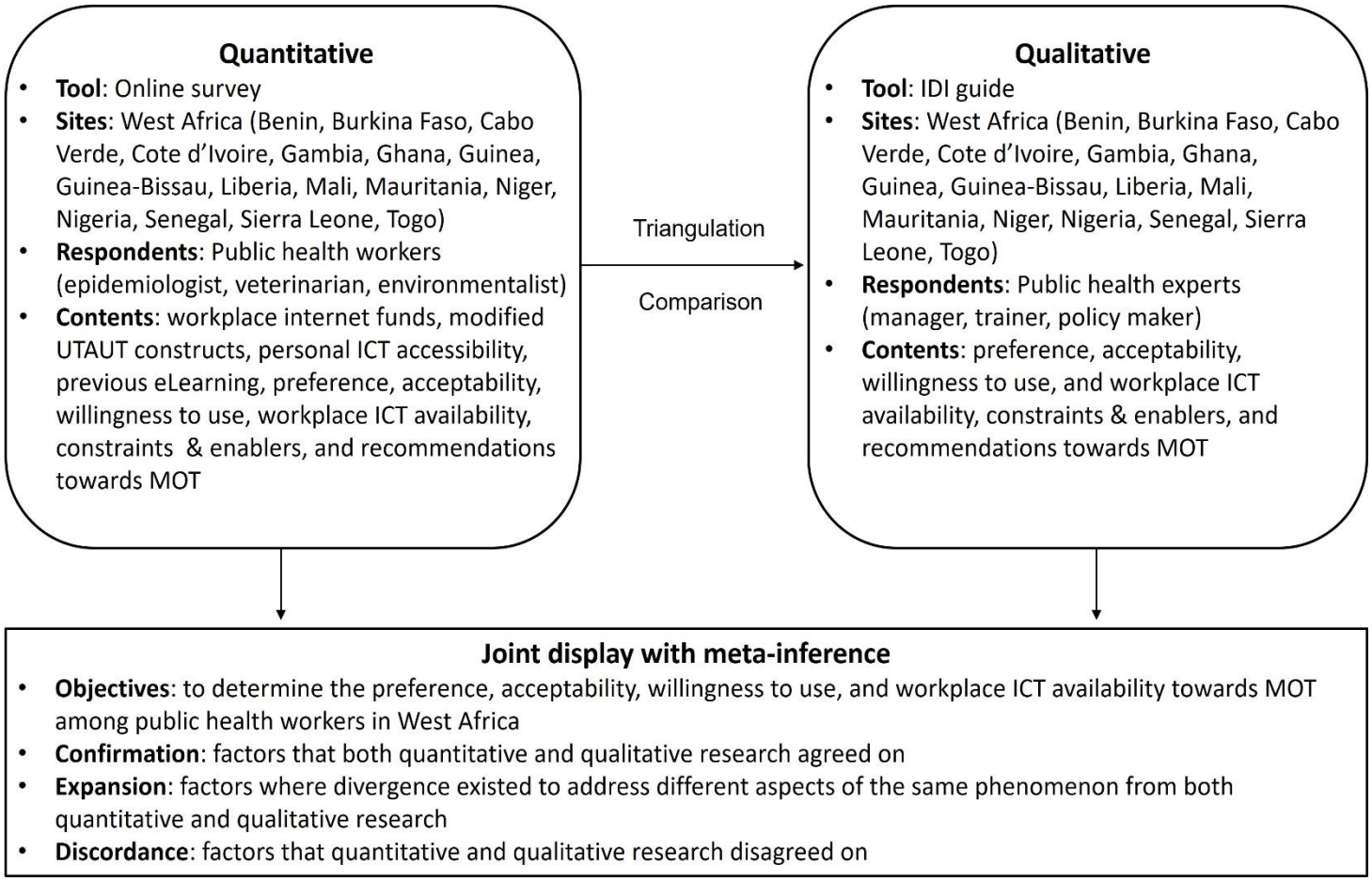

Figure 4. Triangulation of study's quantitative and qualitative research components for joint display of findings. This triangulation approach serves as the basis for the concurrent collection, analysis, interpretation, and reporting of quantitative and qualitative data in this study. UTAUT= unified theory of acceptance and use of technology, ICT= information and communication technology, MOT= multi-communication, online training, IDI= in-depth interview.

Table A. **Ranking of contextual fit and feasibility of multi-communication, online training (MOT).** This proposed scoring system provides a reproducible methodology for consistent assessment and comparability of study outcomes.

	MOT Preference Rate	**MOT Acceptability Rate**	**MOT Willingness to Use Rate**	**Workplace ICT Availability Rate**	**RANKING** score (rank)
MOT CONTEXTUAL FIT	High	High	–	–	3 (strong fit)
	High	Low	–	–	2 (somewhat fit)
	Low	High	–	–	
	Moderate	Moderate	–	–	
	Moderate	High	–	–	
	High	Moderate	–	–	
	Moderate	Low	–	–	
	Low	Moderate	–	–	
	Low	Low	–	–	1 (weak fit)
MOT FEASIBILITY	–	–	High	High	3 (strong feasibility)
	–	–	High	Low	2 (somewhat feasibility)
	–	–	Low	High	
	–	–	Moderate	Moderate	
	–	–	Moderate	High	
	–	–	High	Moderate	
	–	–	Moderate	Low	
	–	–	Low	Moderate	
	–	–	Low	Low	1 (weak feasibility)

– denotes not applicable.

4.8 Ethical Considerations

This study was approved by the Emory University Institutional Review Board (IRB), and the West African Health Organization (WAHO). All participants provided informed consent prior to the quantitative survey and qualitative interviews, including the permission to have the interviews audio-recorded.

Chapter 5: Results

5.1 Sociodemographics of Public Health Workers in the Study (Survey Participants and Interviewees)

A total of 231 public health workers from 16 West African countries completed the quantitative survey for this study, with results computed for a population estimate of 2,873,004 after statistical weighting by country to improve subregional representativeness (**Table 1**). For the quantitative findings, we found that the median age of public health workers that participated in the survey was 39 (IQR: 34-46), while the median years of experience was 10 (IQR: 6-16). Public health workers from urban areas accounted for a majority (78.7%) of the survey participants compared to those from rural areas (21.3%). The proportion of public health workers that participated who are males (63.5%) was higher than those who are females (36.5%). A greater proportion of public health workers in human sector (66.59%) participated than those in animal (18.85%) and environment (14.56%) sectors.

For qualitative interviews, a total of seven individuals were included for in-depth interviews (IDIs). The individuals interviewed were managers, trainers, and policy makers in their respective fields of public health. All were from urban areas with 4 females and 3 males. The IDIs included public health experts from human (n = 3), animal (n = 3), and environment (n = 1) sectors (**Table 1**).

Table 1. Sociodemographic characteristics of public health workers that participated in the assessment of contextual fit and feasibility of multi-communication, online training (MOT) in West Africa, 2023.

Characteristic	Quantitative Survey		Qualitative Interview
	N = 231	Nw = 2,873,004	N = 7
	n	nw (%w)	n
Country			
Benin	6	4129 (0.14)	1
Burkina Faso	11	13816 (0.48)	–
Cabo Verde	9	308.35566 (0.01)	–
Cote d'Ivoire	13	98352 (3.42)	1
Ghana	9	363102 (12.64)	–
Guinea	10	16984 (0.60)	–
Guinea-Bissau	9	1517 (0.05)	–
Liberia	6	22158 (0.77)	1
Mali	6	26561 (0.92)	–
Mauritania	8	2459 (0.09)	–
Niger	9	1777 (0.06)	1
Nigeria	40	2190501 (76.24)	2
Senegal	3	127271 (4.43)	–
Sierra Leone	8	1769 (0.06)	–
The Gambia	28	119.79728 (0.01)	1
Togo	56	2179 (0.08)	–
Area			
Rural	66	611085 (21.3)	–
Urban	165	2261919 (78.7)	7
Age (yrs) Median: 39, IQR:34-46			
≤ 29	24	286994 (10.0)	–
30-39	86	1101107 (38.3)	–
40-49	84	942724 (32.8)	–
50-59	37	542179 (18.9)	–
Sex			
Female	68	1048561 (36.5)	4
Male	163	1824443 (63.5)	3

n= number of participants with a characteristic. nw= weighted number of those participants. %w= weighted percentage of those participants among all study participants. yrs= years. IQR= interquartile range. – means not applicable.

Characteristic	Quantitative Survey		Qualitative Interview
	n	nw (%w)	n
Discipline			
Environmental health scientist/technician	31	360191 (12.54)	1
Laboratory scientist/technician	17	102516 (3.57)	–
Nurse	22	72998 (2.54)	–
Physician	22	542421 (18.88)	–
Public health specialist	99	1046071 (36.41)	3
Veterinarian/assistant veterinarian	29	410929 (14.30)	3
Others	11	337878 (11.76)	–
Sector			
Animal	37	541720 (18.85)	3
Environment	33	418216 (14.56)	1
Human	161	1913069 (66.59)	3
Work experience (yrs) Median: 10, IQR:6-16			
≤ 5	38	617686 (21.51)	–
6-10	69	940234 (32.73)	–
11-15	51	589959 (20.53)	2
16-20	45	373588 (13.0)	3
21-25	18	201534 (7.01)	1
26-30	6	54819 (1.91)	1
> 30	4	95185 (3.31)	–
Setting			
Government public health institution	113	792607 (27.59)	2
Government environment health institution	10	89,449 (3.12)	–
Government animal health institution	14	90700 (3.16)	3
Private public health institution	16	319300 (11.11)	–
Private environment health institution	3	54840 (1.91)	–
Private animal health institution	0	0	–
Human hospital/clinic (public or private)	23	444524 (15.47)	–
Animal hospital/clinic (public or private)	5	96406 (3.36)	–
Academia (public or private)	13	222784 (7.75)	2
Community-based organization	4	9853 (0.34)	–
Non-governmental organization	23	633627 (22.05)	–
Faith-based organization	3	55109 (1.92)	–
Others	4	63805 (2.22)	–

Table 1 (cont'd). n= number of participants with a characteristic. nw= weighted number of those participants. %w= weighted percentage of those participants among all study participants. yrs= years. IQR= Interquartile range. Others for "discipline" include journalist, medical anthropologist, secretary in health institution. Others for "setting" include commercial radio station, department of army health, food and agriculture organization of the United Nations.

5.2 Multi-communication, Online Training (MOT) Preference Rate among Public Health Workers Overall, and by factors

Of the 231 public health workers, a population estimate of 29.61% (95% CI: 23.96–35.27) reported having preference for multi-communication, online training (MOT). The MOT preference rate varied significantly by country (p = 0.0006), from the highest in Mauritania (87.50%) to the lowest in Cote d'Ivoire (7.69%) [**Table 2 and Figure 5**]. MOT preference also differed significantly by area (p = 0.0386), sex (p = 0.0051), and sector (p = 0.0046). Public health workers from rural areas (35.29%) had a higher preference for MOT compared to those in urban areas (28.08%). Public health workers who are females (38.06%) were found to have a greater preference for MOT than those who are males (24.76%). Findings showed that preference for MOT was highest among those in the environment sector (35.60%) than those in human (30.88%) and animal (20.49%) sectors. Public health workers who reported having a performance expectancy for MOT (31.90%) had a higher preference for MOT than those who lacked this attribute (0.64%). The preference for MOT was higher among public health workers who reported the existence of workplace internet funding (41.08%) compared to those public who reported a lack of it (20.52%) in their workplaces. (**Table 2**).

Table 2. Distribution of MOT preference among public health workers in West Africa, 2023.

Characteristic	MOT Preference		
	N = 231	**Nw = 2,873,004**	
	n	nw (%w)	p-value
West Africa			
Overall (95% CI: 23.96-35.27)	63	850759 (29.61)	
Downstream factor			
Country§			**0.0006**
Benin	3	2065 (50.00)	
Burkina Faso	2	2512 (18.18)	
Cabo Verde	5	171 (55.56)	
Cote d'Ivoire	1	7566 (7.69)	
Ghana	3	121034 (33.33)	
Guinea	6	10191 (60.00)	
Guinea-Bissau	1	168 (11.11)	
Liberia	2	7386 (33.33)	
Mali	2	8854 (33.33)	
Mauritania	7	2152 (87.50)	
Niger	2	395 (22.22)	
Nigeria	11	602388 (27.50)	
Senegal	2	84847 (66.67)	
Sierra Leone	3	663 (37.50)	
The Gambia	4	17 (14.29)	
Togo	9	350 (16.07)	
Areaǂ			**0.0386**
Rural	20	215633 (35.29)	
Urban	43	635126 (28.08)	
Ageǂ **(yrs)** Median: 39, IQR:34-46			**0.0028**
≤ 29	13	221318 (77.12)	
30-39	21	258730 (23.50)	
40-49	21	154388 (16.38)	
50-59	8	216322 (39.90)	
Sexǂ			**0.0051**
Female	27	399086 (38.06)	
Male	36	451673 (24.76)	

n= number of participants with a characteristic that indicated yes to MOT preference. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. CI= confidence interval. Bold p-value indicate statistically significant (p<0.05). ǂFrom Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

Characteristic	MOT Preference		
	n	nw (%w)	p-value
Discipline§			0.2287
Environmental health scientist/technician	13	145757 (40.47)	
Laboratory scientist/technician	6	44724 (43.63)	
Nurse	6	51275 (70.24)	
Physician	4	548 (0.10)	
Public health specialist	26	387691 (37.06)	
Veterinarian/assistant veterinarian	4	56255 (13.69)	
Others	6	164509 (48.69)	
Sector§			**0.0046**
Animal	5	111017 (20.49)	
Environment	16	148898 (35.60)	
Human	42	590843 (30.88)	
Work experience§ **(yrs)** Median: 10, IQR:6-16			0.1573
≤ 5	14	11.5144 (53.56)	
6-10	14	5.0916 (15.56)	
11-15	14	6.9302 (33.75)	
16-20	17	4.1577 (31.97)	
21-25	4	1.9183 (27.35)	
26-30	0	0	
> 30	0	0	
Setting§			**0.0005**
Government public health institution	20	154254 (19.46)	
Government environment health institution	4	41288 (46.13)	
Government animal health institution	1	39 (0.04)	
Private public health institution	11	153068 (47.94)	
Private environment health institution	1	39 (0.07)	
Private animal health institution	0	0	
Human hospital/clinic (public or private)	9	161017 (36.22)	
Animal hospital/clinic (public or private)	1	54763 (56.80)	
Academia (public or private)	2	1703 (0.76)	
Community-based organization	2	3727 (37.83)	
Non-governmental organization	9	279077 (44.04)	
Faith-based organization	1	307 (0.56)	
Others	2	1477 (2.32)	

Table 2 (cont'd 1). n= number of participants with a characteristic that indicated yes to MOT preference. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. Bold p-value indicate statistically significant (p<0.05). ǂFrom Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

Characteristic	MOT Preference		
	n	nw (%w)	p-value
Midstream factors			
Self-efficacy§			
Yes	62	795996 (28.28)	0.2968
No	1	54763 (94.19)	
Effort expectancy§			
Yes	61	847805 (30.03)	0.1090
No	2	2954 (5.93)	
Performance expectancy§			
Yes	59	849422 (31.90)	**0.0037**
No	4	1337 (0.64)	
Attitude§			
Yes	63	850759 (32.08)	**<.0001**
No	0	0	
Social influence‡			
Yes	52	744924 (31.62)	0.4934
No	11	105835 (20.46)	
Previous eLearning‡			
Yes	56	733400 (27.23)	**<.0001**
No	7	117359 (65.27)	
Upstream factor			
Workplace internet funding‡			
Yes	26	521882 (41.08)	**0.0004**
No	37	328877 (20.52)	

Table 2 (cont'd 2). n= number of participants with a characteristic that indicated yes to MOT preference. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. Bold p-value indicate statistically significant (p<0.05). ‡From Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

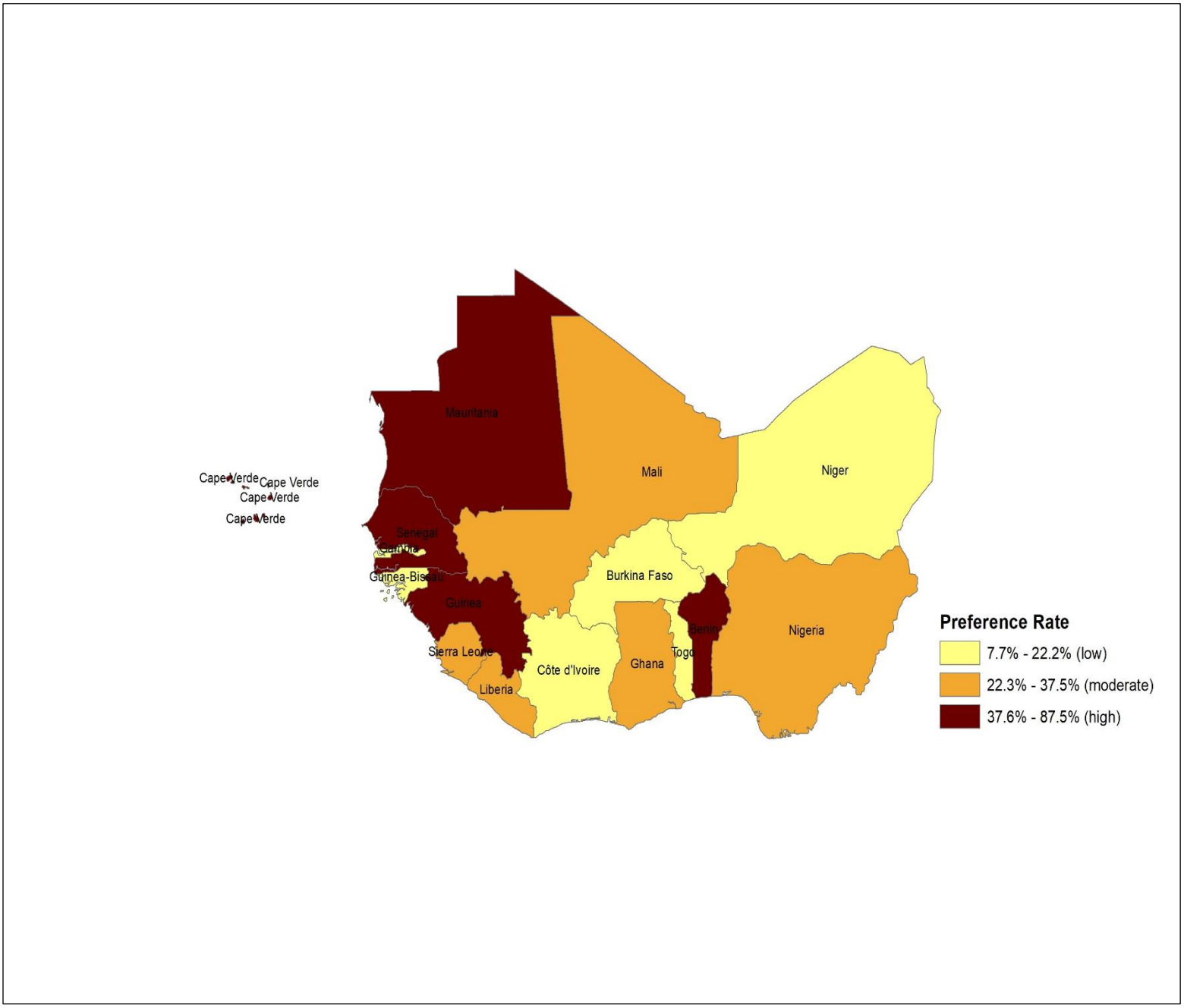

Figure 5. Geospatial distribution of multi-communication, online training (MOT) preference rate among public health workers in West Africa, 2023.

5.3 Bivariate and Multivariate Analysis, Themes, and Meta-Inferences of MOT Preference

Quantitative findings showed that work area, age, sex, performance expectancy, attitude, previous eLearning and workplace internet funding had statistically significant associations with multi-communication, online training (MOT) preference in both bivariate and multivariate analysis. MOT preference was less likely among public health workers in rural areas than those in urban areas (aOR = 0.58; 95% CI: 0.58–0.59). MOT preference was more likely among public health workers aged ≤ 29 years (versus 30-39 years, aOR = 58.22; 95% CI: 56.97–59.49) and 50-59 years (versus 30-39 years, aOR = 1.75; 95% CI: 1.74–1.76), and less likely among 40-49 years (versus 30-39 years, aOR = 0.40; 95% CI: 0.39–0.40). Female public health workers were more likely to have preference for MOT than those who are males (aOR = 2.54; 95% CI: 2.53–2.56). MOT preference was less likely among public health workers who reported lack of performance expectancy for MOT than those who had this attribute (aOR = 0.04; 95% CI: 0.03–0.04). MOT preference was less likely among public health workers who reported lack of internet funding in their workplaces than those who reported existence of workplace internet funding (aOR = 0.37; 95% CI: 0.36–0.37) [**Table 3**].

Overall, opinions from the public health experts, including managers, trainers and policy makers that participated in the qualitative in-depth interviews (IDIs) suggested a moderate preference for MOT among public health workers, where three interviewees (42.86%) of a total of seven reported that public health workers are likely to prefer eLearning compared to three endorsements (42.86%) for face-to-face and one (14.28%) for hybrid, which was in discordance with the result from the quantitative survey. Further discussions from the IDIs were thematically analysed

into three themes: training resources accessibility, training characteristics, and training environment with respective meta-inferences (**Table 3**).

Training resources accessibility

Consistent with the quantitative survey findings, in-depth interviews (IDIs) with the public health experts suggested that access to information and communication technology (ICT) such as computer and internet, which is mostly dependent on the work area (rural or urban) of a public health worker was one of the training resources accessibility factors that could influence the preference for MOT.

"So, the first thing is the cost attached. That is, the data or the internet, that is personally paid for that's one that might discourage one from using that. Two is the equipment also, you need to have a computer and have a laptop. You also need to have a power source. So, it's something that also might discourage someone from using it even when they have an opportunity to do it. Third, and also has to do with the person knowledge on IT. And not too many people know how to use IT equipment or laptop".

-Male veterinarian ID6

In addition, IDIs further elaborated on training resources accessibility with insights on how higher training cost could lower preference for MOT or vice versa.

"Because most times when you are organizing physical training for participants, you are limited by funds. Sometimes you can only pick what you can afford but with the virtual, you can, you can take as many as you need to".

-Male veterinarian ID2

Training characteristics

IDIs added self-efficacy for MOT as some of the factors that could be associated with preference for MOT among public health workers. They expressed their concerns on the differences in self-efficacy of public health workers across area, age, and sex.

"…because they are learned, they can operate the gadget. And, at least they have the basic tools like some have the computer or the handsets that are that can be used to access some of this virtual training".

-Male public health specialist ID4

Training environment

IDIs expanded knowledge on how external environment might affect preference for MOT. IDIs suggested that public health workers who have more work obligations are likely to have preference for MOT.

"If you have an individual that is so, so tied up with personal work, that particular individual may prefer to do an online program. Then if you have someone that has a little bit time on his hand, they would prefer to do a kind of physical stuff".

-Female veterinarian ID3

Table 3. Factors, themes, and meta-inferences associated with MOT preference among public health workers in West Africa, 2023.

Characteristic	MOT Preference			
	Bivariate†	Multivariate¶		
	p-value	aOR	95% CI	p-value
Area	**0.0361**			
Rural		0.58	0.58-0.59	**<.0001**
Urban		Ref	Ref	Ref
Age (yrs)	**<.0001**			
≤ 29		58.22	56.97-59.49	**<.0001**
30-39		Ref	Ref	Ref
40-49		0.40	0.39-0.40	**<.0001**
50-59		1.75	1.74-1.76	**<.0001**
Sex	**0.0439**			
Female		2.54	2.53-2.56	**<.0001**
Male		Ref	Ref	Ref
Setting	**0.0004**	–	–	–
Performance expectancy	**0.0006**			
No		0.04	0.03-0.04	**<.0001**
Yes		Ref	Ref	Ref
Attitude	**<.0001**			
No		<0.001	<0.001-<0.001	**<.0001**
Yes		Ref	Ref	Ref
Previous eLearning	**<.0001**			
No		5.39	5.33-5.46	**<.0001**
Yes		Ref	Ref	Ref
Workplace internet funding	**0.0091**			
No		0.37	0.36-0.37	**<.0001**
Yes		Ref	Ref	Ref
Theme	**Meta-inference**			
Training resources accessibility	**Discordance**: survey showed low rate of MOT preference (29.61%), while interviews suggested moderate preference. **Expansion**: survey found association with training resources accessibility by work area and internet funding, and interviews added training cost.			
Training characteristics	**Expansion**: while survey reported association with training characteristics by performance expectancy, and interviews added self-efficacy.			
Training environment	**Expansion**: while survey showed association with training environment by work area, and interviews added work obligations. **Discordance**: unlike interviews findings, survey found associations with training environment by public health worker's age, sex, attitude and previous eLearning.			

Bold p-value indicate statistically significant (p<0.05). aOR= adjusted odds ratio. CI= confidence interval. †From simple logistic regression. ¶From multiple logistic regression. yrs= years. Setting was not included in the multiple regression model due to persistent complete separation despite the use of Firth's Penalized Likelihood regression technique. – means not applicable.

5.4 MOT Acceptability Rate among Public Health Workers Overall, and by Factors

Of the 231 public health workers, a population estimate of 95.99% (95% CI: 93.79–98.18) found multi-communication, online training (MOT) as an acceptable training modality. The MOT acceptability rate varied by country, from as high as 100% in Benin, Cote d'Ivoire, Ghana, Liberia, Mali, Niger, and Senegal to 77.78% in Cabo Verde and Guinea-Bissau, but this difference was not statistically significant [**Table 4 and Figure 6**]. MOT acceptability also differed significantly by area (p = <.0001), age (p = 0.0432), and social influence (p = <.0001). Public health workers from urban areas had a higher acceptability for MOT (99.90%) compared to those in rural areas (81.50%). Public health workers aged 50-59 years (99.99%) had comparable acceptability for MOT with those aged 40-49 years (99.96%) and 30-39 years (99.70%) and were all higher than the rate reported for those ≤ 29 years (61.11%). Public health workers who reported an agreement with social influence for MOT (97.67%) had a higher acceptability for MOT than those who disagreed (88.34%). (**Table 4**).

Table 4. Distribution of MOT acceptability among public health workers in West Africa, 2023.

Characteristic	MOT Acceptability		
	N = 231	**Nw = 2,873,004**	
	n	nw (%w)	p-value
West Africa			
Overall (95% CI: 93.79-98.18)	212	2757719 (95.99)	
Downstream factor			
Country§			0.5257
Benin	6	4129 (100.00)	
Burkina Faso	10	12560 (90.91)	
Cabo Verde	7	240 (77.78)	
Cote d'Ivoire	13	98352 (100.00)	
Ghana	9	363102 (100.00)	
Guinea	8	13588 (80.00)	
Guinea-Bissau	7	1180 (77.78)	
Liberia	6	22158 (100.00)	
Mali	6	26561 (100.00)	
Mauritania	7	2152 (87.50)	
Niger	9	1777 (100.00)	
Nigeria	38	2080976 (95.00)	
Senegal	3	127271 (100.00)	
Sierra Leone	7	1548 (87.50)	
The Gambia	24	102 (85.71)	
Togo	52	2023 (92.86)	
Area‡			**<.0001**
Rural	58	498047 (81.50)	
Urban	154	2259673 (99.90)	
Age§ **(yrs)** Median: 39, IQR:34-46			**0.0432**
≤ 29	18	175395 (61.11)	
30-39	81	1097807 (99.70)	
40-49	78	942378 (99.96)	
50-59	35	542140 (99.99)	
Sex‡			0.1729
Female	62	990473 (94.46)	
Male	150	1767246 (96.87)	

n= number of participants with a characteristic that indicated yes to MOT acceptability. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. CI= confidence interval. Bold p-value indicate statistically significant (p<0.05). ‡From Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

Characteristic	MOT Acceptability		
	n	nw (%w)	p-value
Discipline§			0.4792
Environmental health scientist/technician	28	305221 (84.74)	
Laboratory scientist/technician	15	102309 (99.80)	
Nurse	19	71222(97.57)	
Physician	21	542387 (99.99)	
Public health specialist	94	1046020 (99.99)	
Veterinarian/assistant veterinarian	25	407446 (99.15)	
Others	10	283115 (83.79)	
Sector§			0.1718
Animal	33	538505 (99.41)	
Environment	28	362934 (86.78)	
Human	151	1856280 (97.03)	
Work experience§ **(yrs)** Median: 10, IQR:6-16			0.0685
≤ 5	33	506255 (81.96)	
6-10	61	936505 (99.60)	
11-15	50	589954 (99.99)	
16-20	42	373476 (99.97)	
21-25	18	201534 (100.00)	
26-30	4	54810 (99.98)	
> 30	4	95185 (100.00)	
Setting§			0.4400
Government public health institution	103	790880 (99.78)	
Government environment health institution	8	988 (99.77)	
Government animal health institution	12	90440 (99.71)	
Private public health institution	16	319300 (100.00)	
Private environment health institution	3	54840 (100.00)	
Private animal health institution	0	0	
Human hospital/clinic (public or private)	21	388063 (87.30)	
Animal hospital/clinic (public or private)	5	96406 (100.00)	
Academia (public or private)	13	222784 (100.00)	
Community-based organization	3	8154 (82.76)	
Non-governmental organization	21	578695 (91.33)	
Faith-based organization	3	55109 (100.00)	
Others	4	63805 (100.00)	

Table 4 (cont'd 1). n= number of participants with a characteristic that indicated yes to MOT acceptability. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. Bold p-value indicate statistically significant (p<0.05). ǂFrom Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

Characteristic	MOT Acceptability		
	n	nw (%w)	p-value
Midstream factors			
Self-efficacy§			
Yes	204	2702572 (96.01)	0.0512
No	8	55148 (94.85)	
Effort expectancy§			0.0572
Yes	197	2712623 (96.08)	
No	15	45096 (90.58)	
Performance expectancy§			
Yes	183	2549462 (95.76)	0.1930
No	29	208257 (98.88)	
Attitude‡			
Yes	184	2539051 (97.73)	0.1193
No	28	218668 (99.09)	
Social influence§			
Yes	156	2300659 (97.67)	**<.0001**
No	56	457061 (88.34)	
Previous eLearning§			
Yes	186	2636430 (97.89)	0.1489
No	26	121289 (67.46)	
Upstream factor			
Workplace internet funding‡			
Yes	66	1215502 (95.68)	0.5160
No	146	1542218 (96.23)	

Table 4 (cont'd 2). n= number of participants with a characteristic that indicated yes to MOT acceptability. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. Bold p-value indicate statistically significant (p<0.05). ‡From Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

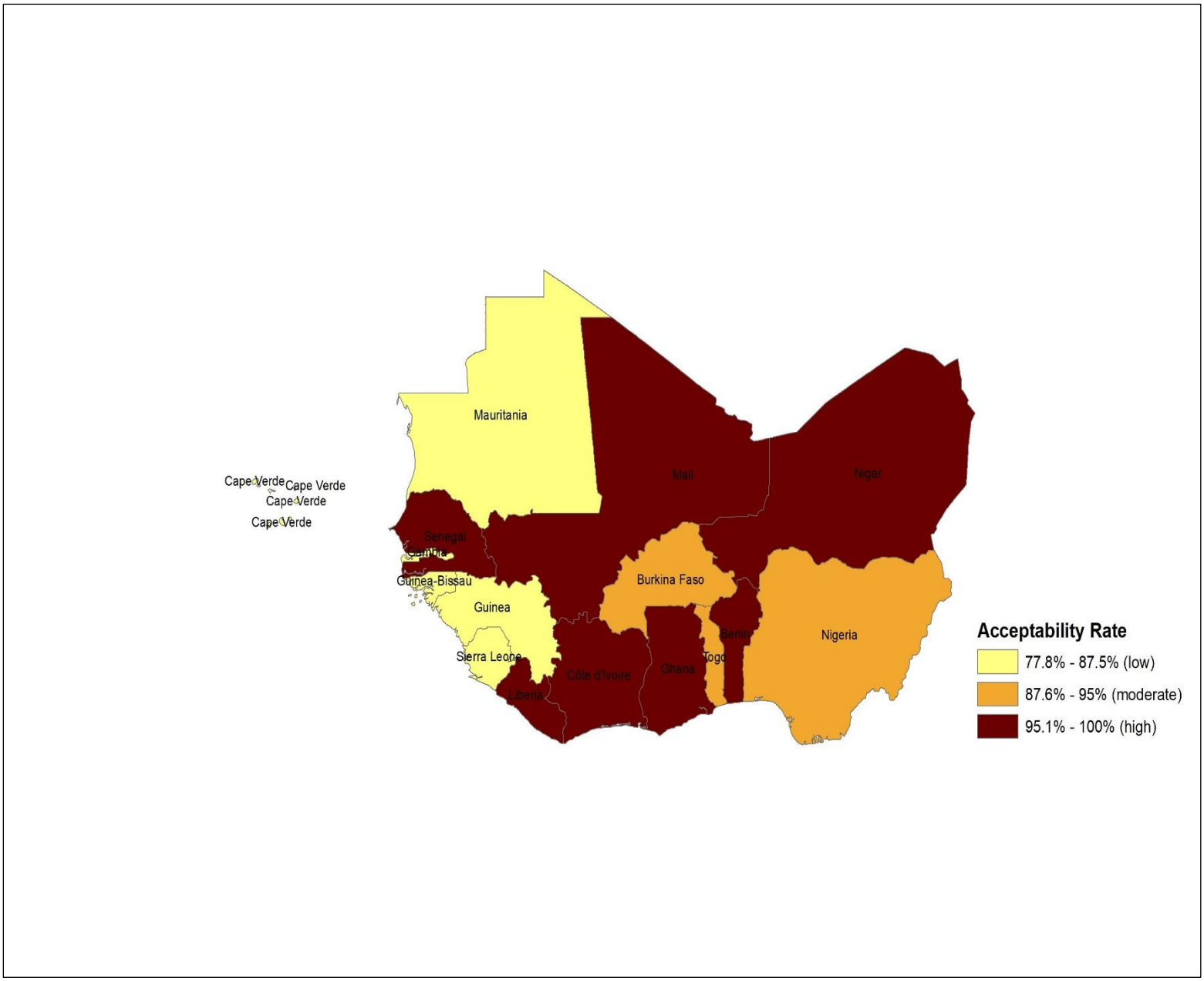

Figure 6. Geospatial distribution of multi-communication, online training (MOT) acceptability rate among public health workers in West Africa, 2023.

5.5 Bivariate and Multivariate Analysis, Themes, and Meta-Inferences of MOT Acceptability

Quantitative findings showed that work area and age had statistically significant associations with multi-communication, online training (MOT) acceptability in both bivariate and multivariate analysis. MOT acceptability was less likely among public health workers in rural areas than those in urban areas (aOR = 0.01; 95% CI: 0.01–0.14). MOT acceptability was less likely among public health workers aged ≤ 29 years (versus 30-39 years, aOR = 0.01; 95% CI: 0.001–0.13) and more likely among 50-59 years (versus 30-39 years, aOR = 32.53; 95% CI: 2.53–418.16), and 40-49 years (versus 30-39 years, aOR = 13.64; 95% CI: 1.35–137.94). [**Table 5**].

Overall, views from the public health experts, including managers, trainers and policy makers that participated in the qualitative in-depth interviews (IDIs) suggested a high acceptability for MOT among public health workers, where six interviewees (85.71%) of a total of seven were in agreements, which was consistent with the result from the quantitative survey. Further discussions from the IDIs were thematically analysed into three themes: training resources accessibility, training characteristics, and training environment with respective meta-inferences (**Table 5**).

Training resources accessibility

Consistent with the quantitative survey findings, in-depth interviews (IDIs) with the public health experts suggested that access to information and communication technology (ICT) such as computer and internet, which is mostly dependent on the work area (rural or urban) of a public health worker was one of the training resources accessibility factors that could influence the acceptability for MOT.

In addition, IDIs further elaborated on training resources accessibility with insights on how higher training cost could lower acceptability for MOT or vice versa. Another issue that many complained about was the instability of electricity in their respective workplaces, which they reported could greatly affect the acceptability of MOT among public health workers in their respective countries.

"Yes, it may be accepted provided the facilities are in place adequately, I know they're good suggestions for training modalities, but also, like in this country, for example, we have issues of internet. Most of the time we have low bandwidth, and also, we have erratic electricity supply. So those are even some of the factors that would not even allow sometimes those internet-based learning".

-Male public health specialist ID1

Training characteristics

Unlike survey findings, IDIs suggested self-efficacy, effort expectancy and performance expectancy for MOT as some of the factors that could be associated with acceptability for MOT among public health workers. They expressed their concerns on the differences in self-efficacy, effort expectancy and performance expectancy of public health workers across area, age, and sex. Of note, one of the public health experts believed that despite these differences, that the extensive use of eLearning during the COVID-19 pandemic could have improved the self-efficacy, effort expectancy and performance expectancy for any eLearning intervention including MOT among many public health workers in Africa.

“Well, you know, after 2020 we discovered that we could meet without being physical, and people are already getting used to the fact that you don't have to attend physical meetings. So, in the workplace so many meetings are being held virtually and we still make headway, we plan, we do meetings, we pass information and things are working. So, I believe that we have come to a place where we know there's no going back again. Yeah, we cannot go back to the way we used to do things before 2020. So, I believe that's it would be a good thing”.

-Female veterinarian ID3

In addition, IDIs further expanded on how the characteristics of MOT could influence its acceptability based on the clarity of its instruction.

“Yes, maybe if instructions also are not clear to those that are to undergo the training, it might influence the issue of acceptability. So, once the instructions on the modalities on how to go about the particular training is made very clear prior to the beginning of the course, I think that there is no problem with that”.

-Male public health specialist ID1

Training environment

IDIs expanded knowledge on how external environment might affect acceptability for MOT. IDIs suggested that public health workers who have more work and/or family obligations are likely to find MOT acceptable, while they also acknowledged the challenge of possible distractions during training.

“So, the first thing is, the kind of work the person does, looking at animal health work, it is mostly field based. So, I think it going to also affect acceptability regardless of the training model. Because it's possible someone who is taking a self-paced course leaves and goes to the field for weeks to attend to animal health diseases issues, and then when the person returns, they can go over the course again”.

-Male veterinarian ID6

“So, if we look at, the person relationship because at times if one is doing self-paced, the person might want to take that course when they are already at home after work, and everything, and then, maybe at a time to have time for your kids or your wife or husband. That might also affect that learning because they have gone to work from 8 to 5 in the routine hours, and once you take a computer to start going through your course, it might seem to be another thing”.

-Male veterinarian ID6

Table 5. Factors, themes, and meta-inferences associated with MOT acceptability among public health workers in West Africa, 2023.

Characteristic	MOT Acceptability			
	Bivariate†	Multivariate¶		
	p-value	aOR	95% CI	p-value
Area	**0.0004**			
Rural		0.01	<.001-0.14	**0.0023**
Urban		Ref	Ref	Ref
Age (yrs)	**<.0001**			
≤ 29		0.01	0.001-0.13	**<.0001**
30-39		Ref	Ref	Ref
40-49		13.64	1.35-137.94	**0.0077**
50-59		32.53	2.53-418.16	**0.0021**

Theme	Meta-inference
Training resources accessibility	**Confirmation**: both survey and interviews reported high MOT acceptability. **Expansion**: survey showed association with training resources accessibility by work area, and interviews added electricity and training cost.
Training characteristics	**Discordance**: unlike survey findings, interviews reported training characteristics, including self-efficacy, effort expectancy and performance expectancy, and further added training instruction clarity.
Training environment	**Expansion**: survey showed association with training environment by public health worker's age, and interviews added work and family obligations.

Bold p-value indicate statistically significant (p<0.05). aOR= adjusted odds ratio. CI= confidence interval. †From simple logistic regression. ¶From multiple logistic regression. yrs= years. (Note: age has a combined p-value of 0.0009 for multivariate analysis).

5.6 MOT Willingness to Use Rate among Public Health Workers Overall, and by Factors

Of the 231 public health workers, a population estimate of 95.56% (95% CI: 93.78–97.35) were willing to use multi-communication, online training (MOT). The MOT willingness to use rate varied significantly by country (p = <.0001), from as high as 100% in Benin, Cabo Verde, Ghana, Mali, Niger, Senegal, and Sierra Leone to 77.78% in Guinea-Bissau [**Table 6 and Figure 7**]. MOT willingness to use also differed significantly by area (p = <.0001), work experience (p = 0.0161), self-efficacy (p = 0.0379), and effort expectancy (p = 0.0392). Public health workers from urban areas had a higher willingness to use MOT (97.27%) compared to those in rural areas (89.23%). Public health workers whose work experience were > 30 years and 21-25 years (100% each) had comparable willingness to use MOT with those who have 16-20 years (99.66%), 6-10 years (99.62%), 11-15 years (98.09%) and ≤ 5 years (90.83%) and were all higher than those with 26-30 years (0.09%). Public health workers who reported having a self-efficacy for MOT (95.58%) had a slightly higher willingness to use for MOT than those who lacked this attribute (94.85%). Public health workers who reported having an effort expectancy for MOT (93.99%) had a slightly higher willingness to use for MOT than those who lacked this attribute (90.58%) [**Table 6**].

Table 6. Distribution of MOT willingness to use among public health workers in West Africa, 2023.

Characteristic	MOT Willingness to Use		
	N = 231	**Nw = 2,873,004**	
	n	nw (%w)	p-value
West Africa			
Overall (95% CI: 93.78-97.35)	214	2745503 (95.56)	
Downstream factor			
Country§			**<.0001**
Benin	6	4129 (100.00)	
Burkina Faso	9	11304 (81.82)	
Cabo Verde	9	308 (100.00)	
Cote d'Ivoire	12	90787 (92.31)	
Ghana	9	363102 (100.00)	
Guinea	8	13588 (80.00)	
Guinea-Bissau	7	1180 (77.78)	
Liberia	5	18465 (83.33)	
Mali	6	26561 (100.00)	
Mauritania	7	2152 (87.50)	
Niger	9	1777 (100.00)	
Nigeria	38	2080976 (95.00)	
Senegal	3	127271 (100.00)	
Sierra Leone	8	1769 (100.00)	
The Gambia	26	111 (92.86)	
Togo	52	2023 (92.86)	
Area‡			**<.0001**
Rural	59	545243 (89.23)	
Urban	155	2200260 (97.27)	
Age§ **(yrs)** Median: 39, IQR:34-46			0.0782
≤ 29	19	230157 (80.20)	
30-39	82	1097807 (99.70)	
40-49	79	931384 (98.80)	
50-59	34	486156 (89.67)	
Sex§			1.0000
Female	63	1041577 (99.33)	
Male	151	1703926 (93.40)	

n= number of participants with a characteristic that indicated yes to MOT willingness to use. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. CI= confidence interval. Bold p-value indicate statistically significant (p<0.05). ‡From Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

Characteristic	MOT Willingness to Use		
	n	nw (%w)	p-value
Discipline§			0.0980
Environmental health scientist/technician	28	297694 (82.65)	
Laboratory scientist/technician	16	102348 (99.84)	
Nurse	18	71183 (97.51)	
Physician	22	542421 (100.00)	
Public health specialist	95	1041114 (99.53)	
Veterinarian/assistant veterinarian	25	352904 (85.88)	
Others	10	337839 (99.99)	
Sector§			0.3820
Animal	34	484003 (89.35)	
Environment	29	355412 (84.98)	
Human	151	1906088 (99.64)	
Work experience§ **(yrs)** Median: 10, IQR:6-16			**0.0161**
≤ 5	34	561017 (90.83)	
6-10	62	936687 (99.62)	
11-15	49	578700 (98.09)	
16-20	44	372332 (99.66)	
21-25	18	201534 (100.00)	
26-30	3	48 (0.09)	
> 30	4	95185 (100.00)	
Setting§			0.3609
Government public health institution	102	731168 (92.25)	
Government environment health institution	8	81716 (91.35)	
Government animal health institution	14	90700 (100.00)	
Private public health institution	16	319300 (100.00)	
Private environment health institution	3	54840 (100.00)	
Private animal health institution	0	0	
Human hospital/clinic (public or private)	22	442826 (99.62)	
Animal hospital/clinic (public or private)	5	96406 (100.00)	
Academia (public or private)	13	222784 (100.00)	
Community-based organization	3	8154 (82.76)	
Non-governmental organization	21	578695 (91.33)	
Faith-based organization	3	55109 (100.00)	
Others	4	63805 (100.00)	

Table 6 (cont'd 1). n= number of participants with a characteristic that indicated yes to MOT willingness to use. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. Bold p-value indicate statistically significant (p<0.05). ǂFrom Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

Characteristic	MOT Willingness to Use		
	n	nw (%w)	p-value
Midstream factors			
Self-efficacy§			
Yes	206	2690355 (95.58)	**0.0379**
No	8	55148 (94.85)	
Effort expectancy§			
Yes	199	2700407 (93.99)	**0.0392**
No	15	45096 (90.58)	
Performance expectancy‡			
Yes	181	2538169 (88.35)	0.3065
No	33	207334 (98.44)	
Attitude‡			
Yes	184	2530156 (88.07)	0.5899
No	33	215347 (97.58)	
Social influence‡			
Yes	153	2288139 (79.64)	0.1040
No	61	457364 (88.40)	
Previous eLearning§			
Yes	188	2569490 (89.44)	0.0596
No	26	176013 (97.90)	
Upstream factor			
Workplace internet funding‡			
Yes	69	1215579 (42.31)	0.1020
No	145	1529924 (95.46)	

Table 6 (cont'd 2). n= number of participants with a characteristic that indicated yes to MOT willingness to use. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. Bold p-value indicate statistically significant (p<0.05). ‡From Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

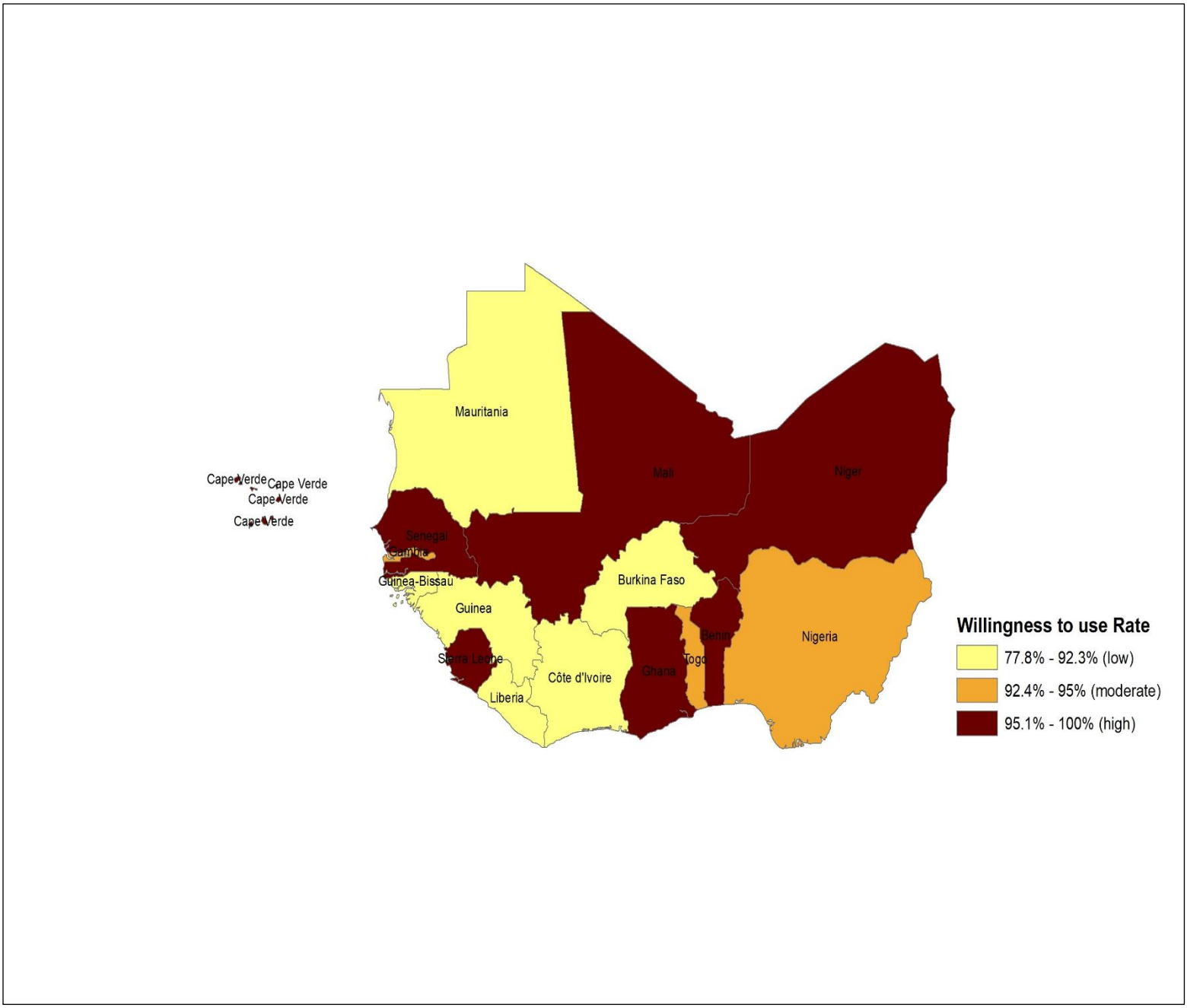

Figure 7. Geospatial distribution of multi-communication, online training (MOT) willingness to use rate among public health workers in West Africa, 2023.

5.7 Bivariate and Multivariate Analysis, Themes, and Meta-Inferences of MOT Willingness to Use

Quantitative findings showed that work area and work experience had statistically significant associations with multi-communication, online training (MOT) willingness to use in both bivariate and multivariate analysis. MOT willingness to use was less likely among public health workers in rural areas than those in urban areas (aOR = 0.05; 95% CI: 0.01–0.40). MOT willingness to use was less likely among public health workers with work experience 21-30 years (versus ≤ 10 years, aOR = 0.02; 95% CI: 0.001–0.367) [**Table 7**].

Overall, opinions from the public health experts, including managers, trainers and policy makers that participated in the qualitative in-depth interviews (IDIs) suggested a high willingness to use MOT among public health workers, where six interviewees (85.71%) of a total of seven were in agreements, which was consistent with the result from the quantitative survey. Further discussions from the IDIs were thematically analysed into three themes: training resources accessibility, training characteristics, and training environment with respective meta-inferences (**Table 7**).

Training resources accessibility

Consistent with the quantitative survey findings, in-depth interviews (IDIs) with the public health experts suggested that access to information and communication technology (ICT) such as computer and internet, which is mostly dependent on the work area (rural or urban) of a public health worker was one of the training resources accessibility factors that could influence the willingness to use MOT.

In addition, IDIs further elaborated on training resources accessibility with insights on how higher training cost could lower willingness to use MOT or vice versa. Another issue that many were worried about was the instability of electricity in their respective workplaces, which they reported could considerably affect the willingness to use MOT among public health workers in their respective countries.

“I will say, take the example of Ministry of Health, the Ministry of Health in all services they have the internet connection, so already, it is not necessarily given money when I say motivation, it is not giving money, it's making sure that the person has an internet connection because when you ask someone the connection remains expensive in Africa because you can buy internet worth 60 gigabytes when you talk about a distance course, it's going to be a platform to download videos etc”.

-Female Academician ID7

Training characteristics

Unlike survey findings, IDIs suggested training relevance and training content as some of the factors that could be associated with willingness to use MOT among public health workers. They emphasized that MOT would have to be relevant to public health workers in terms of relevance to their job, or countries, or subregional priority diseases, or topical public health issues, for them to be willing to use it.

“Yeah, I believe they will be willing to participate. Well, if they perceive that this kind of training is going to be beneficial to what do they do in their workplace then they will surely do it”.

-Female veterinarian ID3

In addition, IDIs further elaborated on how the characteristics of MOT could influence the willingness of public health workers to use it with based on the quality of its contents. It was many suggestions that public health workers would be willing to use MOT if it contains practice-based teachings with indigenous and contextually feasible practices other than merely textbook standards.

"because I said a lot of countries perhaps do not have their own platforms, but even with those that we often have, it is the design of content that is the issue, and therefore if we have a sub-regional platform who manages to make adapted content and for different practitioners in all sectors, I think it would be quite innovative and then people will be interested".

-Female academician ID5

Training environment

IDIs expanded knowledge on how external environment might affect the willingness of public health workers to use MOT. IDIs suggested that public health workers who have more work and/or family obligations are likely to be willing to use MOT, while they also acknowledged the challenge of possible distractions during training.

"…in this country, it is only less than 10% of veterinarians that work in the public or government. Over says 70 to 80% of them work as private individuals, so some of them need time, they need their time. So, moving them around might not be convenient for them. We will be able to have them join you virtually from wherever they are to attend your training, contribute what they need to contribute…",

-Male veterinarian ID2

Table 7. Factors, themes, and meta-inferences associated with MOT willingness to use among public health workers in West Africa, 2023.

Characteristic	MOT Willingness to Use			
	Bivariate†	Multivariate¶		
	p-value	aOR	95% CI	p-value
Area	**<.0001**			
Rural		0.05	0.01-0.40	**0.0092**
Urban		Ref	Ref	Ref
Work experience (yrs)	**<.0001**			
≤ 10		Ref	Ref	Ref
11-20		1.22	0.14-10.39	0.05
21-30		0.02	0.001-0.367	**0.0012**
> 30		∞	∞	**<.0001**
Effort expectancy	**<.0001**			
No		51.15	0.40-∞	0.1040
Yes		Ref	Ref	

Theme	Meta-inference
Training resources accessibility	**Confirmation**: both survey and interviews reported high MOT willingness to use. **Expansion**: survey showed association with training resources accessibility by work area, and interviews added electricity, and training cost.
Training characteristics	**Discordance**: unlike survey findings, interviews reported training characteristics, including training relevance and training content.
Training environment	**Expansion**: survey showed association with training environment by public health worker's age and work experience, and interviews added work and family obligations.

Bold p-value indicate statistically significant (p<0.05). aOR= adjusted odds ratio. CI= confidence interval. †From simple logistic regression. ¶From multiple logistic regression. yrs= years. ∞= infinity.

5.8 Workplace ICT Availability Rate for MOT among Public Health Workers Overall, and by Factors

Of the 231 public health workers, a population estimate of 82.09% (95% CI: 77.50–86.68) reported availability of information and communication technology (ICT) for multi-communication, online training (MOT). The MOT workplace ICT availability rate varied significantly by country (p = 0.0020), from as high as 100% in Senegal to 25% in Mauritania [**Table 8 and Figure 8**]. MOT workplace ICT availability also differed significantly by area (p = <.0001), age ((p = 0.0024), sex (p = <.0001), discipline (p = 0.0003), sector (p = <.0001), performance expectancy (p = 0.0250), attitude (p = <.0001), and previous eLearning (p = <.0001). Public health workers from urban areas had a higher workplace ICT availability for MOT (89.96%) compared to those in rural areas (52.95%). Public health workers aged 40-49 years reported higher MOT workplace ICT availability than those aged 50-59 years (89.80%), 30-39 years (74.82), and ≤ 29 years (61.18%). Public health workers who are males (90.31%) reported a higher workplace ICT availability for MOT than those who are females (67.79%). Findings showed that workplace ICT availability for MOT was highest among those in the environment sector (99.54%) than those in human (81.40%) and animal (71.07%) sectors. Public health workers who reported having a performance expectancy for MOT (82.88%) had a slightly higher workplace ICT availability for MOT than those who lacked this attribute (72.17%). Public health workers who reported a previous eLearning experience (85.12%) reported a higher workplace ICT availability for MOT than those who lacked this experience (36.71%) [**Table 8**].

Table 8. Distribution of workplace ICT availability for MOT among public health workers in West Africa, 2023.

Characteristic	Workplace ICT Availability		
	N = 231	**Nw = 2,873,004**	
	n	nw (%w)	p-value
West Africa			
Overall (95% CI: 77.50-86.68)	156	2358486 (82.09)	
Downstream factor			
Country§			**0.0020**
Benin	2	1376 (33.33)	
Burkina Faso	8	10048 (72.73)	
Cabo Verde	3	103 (33.33)	
Cote d'Ivoire	12	90787 (92.31)	
Ghana	8	322758 (88.89)	
Guinea	7	11889 (70.00)	
Guinea-Bissau	7	1180 (77.78)	
Liberia	4	14772 (66.67)	
Mali	5	22134 (83.33)	
Mauritania	2	615 (25.00)	
Niger	6	1184 (66.67)	
Nigeria	32	1752401 (80.00)	
Senegal	3	127271 (100.00)	
Sierra Leone	3	663 (37.50)	
The Gambia	23	99 (82.14)	
Togo	31	1206 (55.36)	
Area‡			**<.0001**
Rural	31	323595 (52.95)	
Urban	125	2034891 (89.96)	
Age‡ **(yrs)** Median: 39, IQR:34-46			**0.0024**
≤ 29	15	175586 (61.18)	
30-39	47	823817 (74.82)	
40-49	62	872221 (92.52)	
50-59	32	486862 (89.80)	
Sex‡			**<.0001**
Female	42	710848 (67.79)	
Male	114	1647638 (90.31)	

n= number of participants with a characteristic that indicated yes to workplace ICT availability. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. CI= confidence interval. Bold p-value indicate statistically significant (p<0.05). ‡From Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

Characteristic	Workplace ICT Availability		
	n	nw (%w)	p-value
Discipline§			**0.0003**
Environmental health scientist/technician	20	358414 (99.51)	
Laboratory scientist/technician	9	100647 (98.18)	
Nurse	9	62176 (85.18)	
Physician	14	377670 (69.63)	
Public health specialist	81	921283 (88.07)	
Veterinarian/assistant veterinarian	14	309942 (75.43)	
Others	9	228353 (67.58)	
Sector‡			**<.0001**
Animal	21	384992 (71.07)	
Environment	23	416279 (99.54)	
Human	112	1557215 (81.40)	
Work experience§ **(yrs)** Median: 10, IQR:6-16			0.1882
≤ 5	23	341509 (55.29)	
6-10	43	829778 (88.25)	
11-15	32	518570 (87.90)	
16-20	36	372413 (99.69)	
21-25	13	200976 (99.7)	
26-30	6	54819 (100.00)	
> 30	3	40423 (42.47)	
Setting§			**0.0071**
Government public health institution	80	670178 (84.55)	
Government environment health institution	6	88502 (98.94)	
Government animal health institution	7	49452 (54.52)	
Private public health institution	11	315991 (98.96)	
Private environment health institution	3	54840 (100.00)	
Private animal health institution	0	0	
Human hospital/clinic (public or private)	10	273924 (61.62)	
Animal hospital/clinic (public or private)	4	96367 (99.96)	
Academia (public or private)	11	222581 (99.91)	
Community-based organization	1	3693 (37.48)	
Non-governmental organization	19	465646 (73.49)	
Faith-based organization	1	54763 (99.37)	
Others	3	62549 (98.03)	

Table 8 (cont'd 1). n= number of participants with a characteristic that indicated yes to workplace ICT availability. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. Bold p-value indicate statistically significant (p<0.05). ‡From Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

Characteristic	Workplace ICT Availability		
	n	nw (%w)	p-value
Midstream factors			
Self-efficacy§			
Yes	151	2358178 (83.78)	0.1827
No	5	307 (0.53)	
Effort expectancy‡			
Yes	146	2314801 (81.99)	0.6779
No	10	43684 (87.74)	
Performance expectancy‡			
Yes	133	2206484 (82.88)	**0.0250**
No	23	152002 (72.17)	
Attitude‡			
Yes	130	2140174 (80.69)	**<.0001**
No	26	218312 (98.93)	
Social influence‡			
Yes	110	2022421 (85.85)	0.3115
No	46	336064 (64.96)	
Previous eLearning‡			
Yes	138	2292492 (85.12)	**<.0001**
No	18	65994 (36.71)	
Upstream factor			
Workplace internet funding‡			
Yes	62	1210382 (95.28)	0.0536
No	94	1148104 (71.64)	

Table 8 (cont'd 2). n= number of participants with a characteristic that indicated yes to workplace ICT availability. nw= weighted number of those participants. %w= weighted proportion of those participants among all participants with the same characteristic. Bold p-value indicate statistically significant (p<0.05). ǂFrom Rao-Scott Chi-square test. §From Fisher's exact test. yrs= years. IQR= Interquartile range.

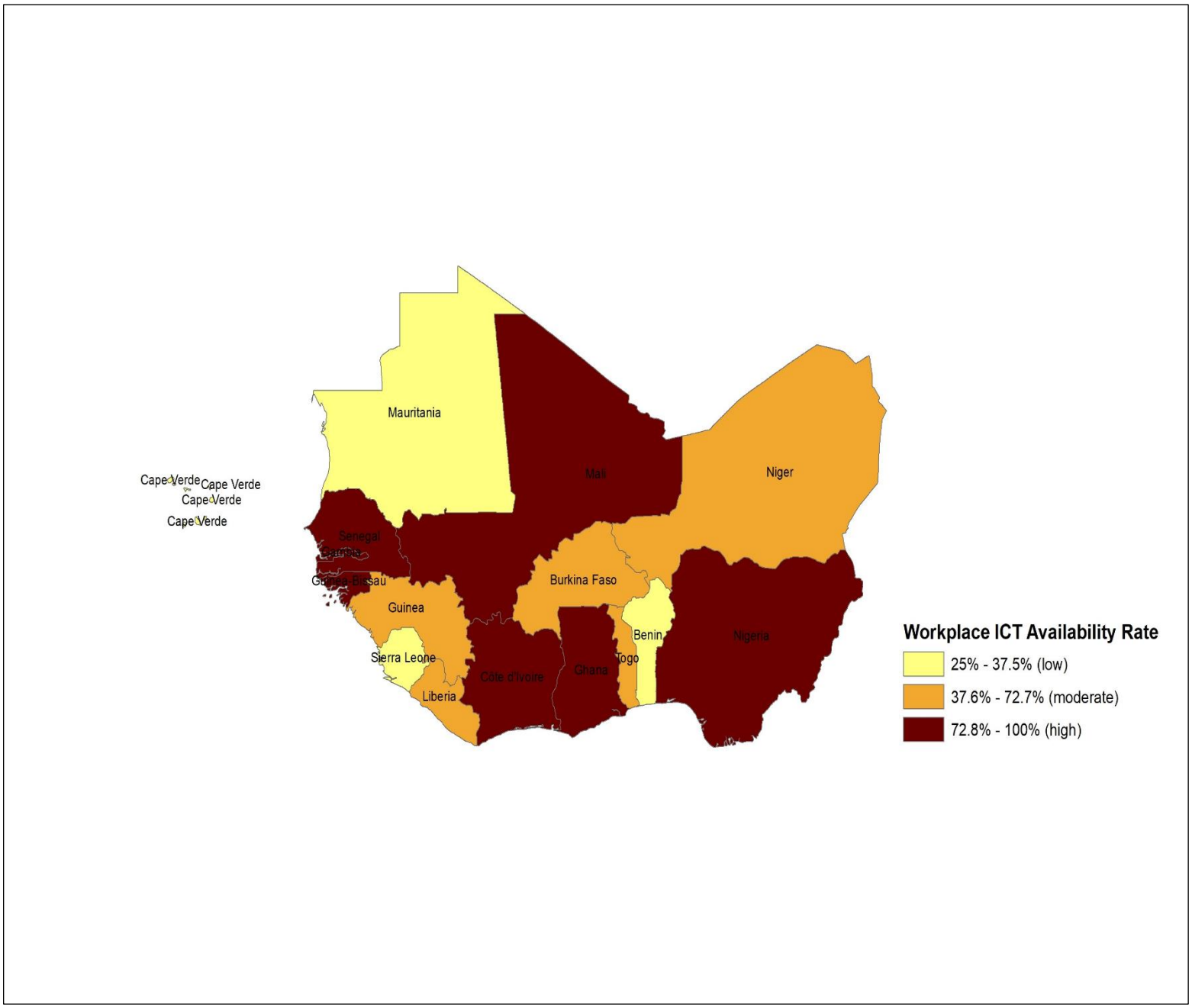

Figure 8. Geospatial distribution of workplace ICT availability for multi-communication, online training (MOT) among public health workers in West Africa, 2023.

5.9 Bivariate and Multivariate Analysis, Themes, and Meta-Inferences of Workplace ICT Availability for MOT

Quantitative findings showed that country, work area, age, sex, discipline, sector, setting, performance expectancy, attitude, and previous eLearning had statistically significant associations with workplace ICT availability for multi-communication, online training (MOT) in bivariate analysis, however, only work area remained statistically significant in multivariate analysis. Workplace ICT availability for MOT was more likely among public health workers in rural areas than those in urban areas (aOR = 2.57; 95% CI: 1.22–5.40) [**Table 9**].

Overall, opinions from the public health experts, including managers, trainers and policy makers that participated in the qualitative in-depth interviews (IDIs) suggested a high workplace ICT availability for MOT among public health workers, where all the seven interviewees (100%) were in agreements, which was consistent with the result from the quantitative survey, but highlighted many challenges as well. Further discussions from the IDIs were thematically analysed into one theme: training environment with respective meta-inferences (**Table 9**).

Training resources accessibility

IDIs expanded knowledge on training resources accessibility, where it was might pointed out that workplace ICT availability for MOT among public health workers might be based on country and work area, particularly stressing out the issue of internet connectivity. While many believed that a considerable number of public health workers have some access to ICT resources such as computer, and internet at their workplaces, they expressed the problem of insufficient internet data bundles and low internet bandwidth. They further shared that this problem often challenges

their capacity building potential in two major ways. First, they stated that poor internet connectivity often limits their engagements in eLearning, for example, in situations where there was a complete lack of internet services in their workplaces or homes, even when they still had adequate data bundles for internet connectivity. Second, they also mentioned that their lack of access to good internet bandwidth in their countries reduces the effectiveness of eLearning for their capacity building, for example, in instances where they experienced multiple internet disconnections during an ongoing training session.

“Whether it is for example, internet-based, it depends on how much access to internet this particular individual has based on the environment or location, if not, they wouldn't want to do it based on the experience that we have from conducting trainings. Like in a IDSR, WHO training, we invited a lot of the fieldworkers to participate and attend on scheduled period, but some will register and then may not end up attending the meeting because they didn't have the facilities available to make them attend. Not that they were not willing to but they because the environment was not feasible for them”.

-Male public health specialist ID1

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Table 9. Factors, themes, and meta-inferences associated with workplace ICT availability for MOT among public health workers in West Africa, 2023.

Characteristic	Workplace ICT Availability			
	Bivariate†	Multivariate¶		
	p-value	aOR	95% CI	p-value
Country	**<.0001**			
Benin		2.48	0.32-18.93	0.1404
Burkina Faso		0.37	0.06-2.26	0.5335
Cabo Verde		2.53	0.44-14.63	0.0648
Cote d'Ivoire		0.21	0.03-1.43	0.2342
Ghana		0.14	0.02-1.20	0.1337
Guinea		0.67	0.12-3.70	0.8885
Guinea-Bissau		0.46	0.06-3.48	0.7576
Liberia		0.92	0.13-6.41	0.6318
Mali		0.31	0.03-2.95	0.5283
Mauritania		3.75	0.59-23.83	0.0800
Niger		0.65	0.12-3.50	0.9265
Nigeria		0.37	0.12-1.17	0.3042
Senegal		0.11	0.002-5.736	0.3627
Sierra Leone		1.35	0.22-8.53	0.3439
The Gambia		0.39	0.10-1.43	0.4183
Togo		Ref	Ref	Ref
Area	**0.0009**			
Rural		2.57	1.22-5.40	**0.0128**
Urban		Ref	Ref	Ref
Age (yrs)	**<.0001**			
≤ 29		0.65	0.20-2.12	0.8056
30-39		Ref	Ref	Ref
40-49		0.49	0.22-1.11	0.5632
50-59		0.37	0.12-1.11	0.2573
Sex	**<.0001**			
Female		2.18	0.99-4.79	0.0527
Male		Ref	Ref	Ref

Bold p-value indicate statistically significant (p<0.05). aOR= adjusted odds ratio. CI= confidence interval. †From simple logistic regression. ¶From multiple logistic regression. yrs= years. ∞= infinity.

Characteristic	Workplace ICT Availability			
	Bivariate†	**Multivariate**¶		
	p-value	aOR	95% CI	p-value
Discipline	**<.0001**			
Environmental health scientist/technician		2.41	0.56-10.40	0.8841
Laboratory scientist/technician		1.99	0.52-7.64	0.8515
Nurse		3.04	0.87-10.57	0.5659
Physician		2.21	0.68-7.19	0.9994
Public health specialist		Ref	Ref	Ref
Veterinarian/assistant veterinarian		7.09	1.14-44.25	0.1290
Others		1.13	0.20-6.50	0.3685
Sector	**0.0001**			
Animal		0.58	0.10-3.24	0.8148
Environment		0.49	0.12-2.09	0.5476
Human		Ref	Ref	Ref
Setting	**<.0001**	–	–	–
Performance expectancy	**0.0443**	–	–	–
Attitude	**0.0137**	–	–	–
Previous eLearning	**<.0001**	–	–	–

Theme	Meta-inference
Training resources accessibility	**Expansion**: survey showed high MOT workplace ICT availability, and interviews added internet connectivity issues.
	Expansion: survey showed association with training resources accessibility by work area, and interviews added country.

Table 9 (cont'd 1). Bold p-value indicate statistically significant (p<0.05). aOR= adjusted odds ratio. CI= confidence interval. †From simple logistic regression. ¶From multiple logistic regression. yrs= years. ∞= infinity. Setting was not included in the multiple regression model due to persistent complete separation despite the use of Firth's Penalized Likelihood regression technique. Performance expectancy, attitude, and previous eLearning were not included in the multiple regression model due to multicollinearity. – means not applicable.

5.10 Contextual fit of MOT among Public Health Workers Overall, and by Country

Overall, the quantitative findings on preference and acceptability of multi-communication, online training (MOT) among public health workers from 16 West African countries as extrapolated in **Table 10**, with their confirmation and expansion from qualitative findings suggests that MOT is of “somewhat contextual fit” among public health workers in West Africa. MOT contextual fit varied by country, from the highest (strong fit) in Benin and Senegal to the lowest (weak fit) in Guinea-Bissau and The Gambia (**Table 10 and Figure 9**). In the multivariate analysis, only work area and age were found to have statistically significant associations with both MOT preference (area, p = <.0001; age, p = <.0001) and acceptability (area, p = 0.0023; age, p = 0.0009) in **Table 3** and **Table 5** respectively, which could be inferred as major predictors of MOT contextual fit among public health workers in West Africa. Other factors including sex, attitude, previous eLearning, and workplace internet funding that demonstrated statistical significance in either case of preference or acceptability were considered as minor-moderate predictors of MOT contextual fit.

Table 10. Contextual fit ranking of multi-communication, online training (MOT) among public health workers in West Africa, 2023.

Characteristic	MOT Preference %w (rank)	MOT Acceptability %w (rank)	MOT CONTEXTUAL FIT score (rank)
West Africa			
Overall	29.6 (moderate)	96.0 (high)	2 (somewhat fit)
Country			
Benin	50.0 (high)	100.0 (high)	3 (strong fit)
Burkina Faso	18.2 (low)	90.9 (moderate)	2 (somewhat fit)
Cabo Verde	55.6 (high)	77.8 (low)	2 (somewhat fit)
Cote d'Ivoire	7.7 (low)	100.0 (high)	2 (somewhat fit)
Ghana	33.3 (moderate)	100.0 (high)	2 (somewhat fit)
Guinea	60.0 (high)	80.0 (low)	2 (somewhat fit)
Guinea-Bissau	11.1 (low)	77.8 (low)	1 (weak fit)
Liberia	33. (moderate)	100.0 (high)	2 (somewhat fit)
Mali	33.3 (moderate)	100.0 (high)	2 (somewhat fit)
Mauritania	87.5 (high)	87.5 (low)	2 (somewhat fit)
Niger	22.2 (low)	100.0 (high)	2 (somewhat fit)
Nigeria	27.5 (moderate)	95.0 (moderate)	2 (somewhat fit)
Senegal	66.7 (high)	100.0 (high)	3 (strong fit)
Sierra Leone	37.5 (moderate)	87.5 (low)	2 (somewhat fit)
The Gambia	14.3 (low)	85.7 (low)	1 (weak fit)
Togo	16.1 (low)	92.9 (moderate)	2 (somewhat fit)

%w= weighted proportion of participants that indicated yes to MOT preference and acceptability among all participants with the same characteristic. %w is rounded off to 1 decimal place. Contextual fit ranks are extrapolated using the study proposed scoring system from table A.

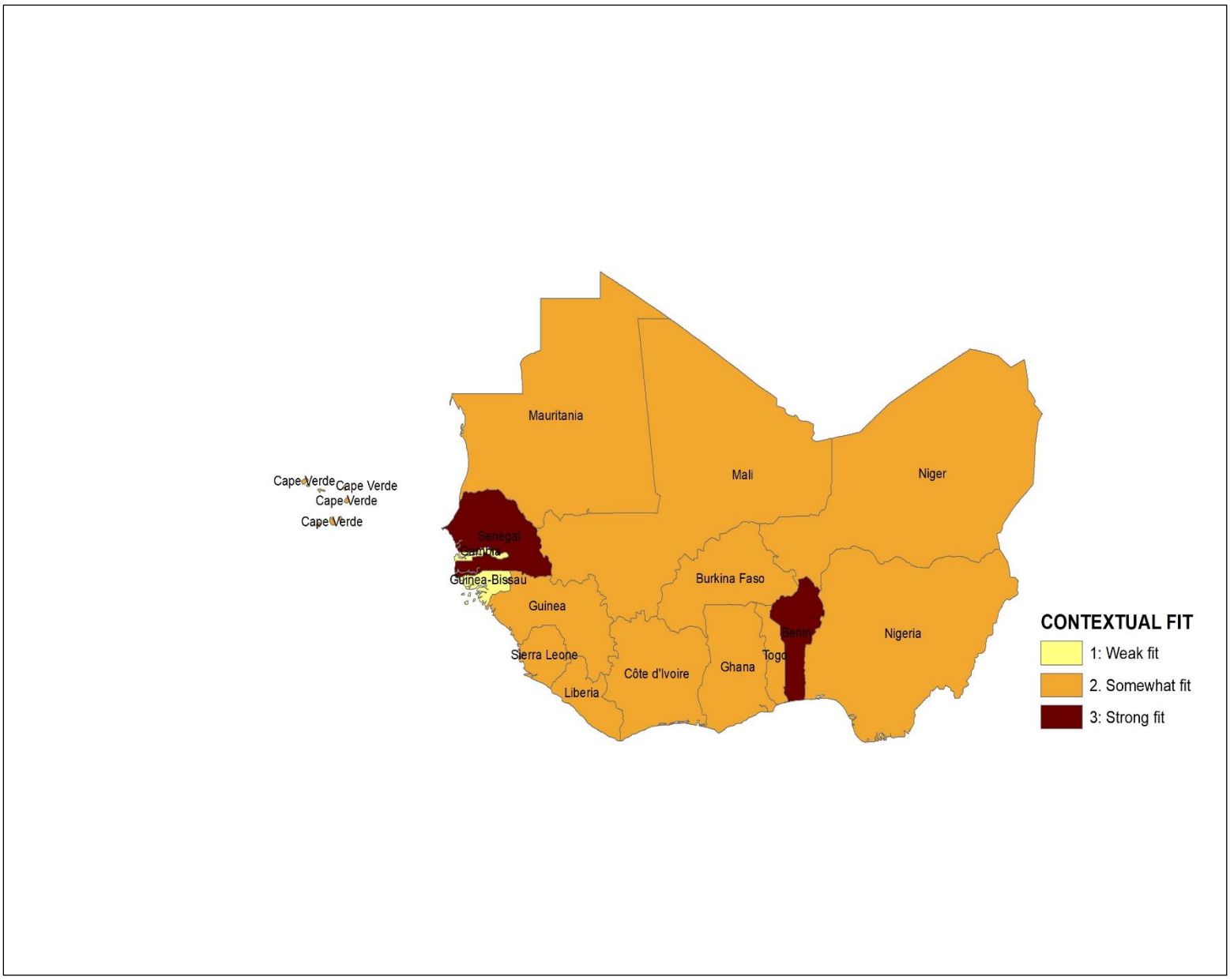

Figure 9. Geospatial distribution of contextual fit of multi-communication, online training (MOT) among public health workers in West Africa, 2023.

5.11 Feasibility of MOT among Public Health Workers Overall, and by Country

Overall, the quantitative findings on willingness to use and workplace ICT availability for multi-communication, online training (MOT) among public health workers from 16 West African countries as extrapolated in **Table 11**, with their confirmation and expansion from qualitative findings suggests that MOT has “strong feasibility” among public health workers in West Africa. MOT feasibility varied by country, from the highest (strong feasibility) in Ghana, Mali and Senegal to the lowest (weak feasibility) in Mauritania (**Table 11 and Figure 10**). In the multivariate analysis, only work area (rural or urban) was found to have statistically significant associations with both MOT willingness to use and workplace ICT availability (MOT willingness to use, $p = 0.0092$; workplace ICT availability, $p = 0.0128$) in **Table 7** and **Table 9** respectively, which could be inferred as a major predictor of MOT feasibility among public health workers in West Africa. Other factor including work experience that demonstrated statistical significance in either case of MOT willingness to use or workplace ICT availability was considered as minor-moderate predictors of MOT feasibility.

Table 11. Feasibility ranking of multi-communication, online training (MOT) among public health workers in West Africa, 2023.

Characteristic	**MOT Willingness to Use** %w (rank)	**Workplace ICT Availability** %w (rank)	**MOT FEASIBILITY** score (rank)
West Africa			
Overall	95.6 (high)	82.1 (high)	3 (strong feasibility)
Country			
Benin	100.0 (high)	33.3 (low)	2 (somewhat feasibility)
Burkina Faso	81.8 (low)	72.7 (moderate)	2 (somewhat feasibility)
Cabo Verde	100.0 (high)	33.3 (low)	2 (somewhat feasibility)
Cote d'Ivoire	92.3 (low)	92.3 (high)	2 (somewhat feasibility)
Ghana	100.0 (high)	88.9 (high)	3 (strong feasibility)
Guinea	80.0 (low)	70.0 (moderate)	2 (somewhat feasibility)
Guinea-Bissau	77.8 (low)	77.8 (high)	2 (somewhat feasibility)
Liberia	83.3 (low)	66.7 (moderate)	2 (somewhat feasibility)
Mali	100.0 (high)	83.3 (high)	3 (strong feasibility)
Mauritania	87.5 (low)	25.0 (low)	1 (weak feasibility)
Niger	100.0 (high)	66.7 (moderate)	2 (somewhat feasibility)
Nigeria	95.0 (moderate)	80.0 (high)	2 (somewhat feasibility)
Senegal	100.0 (high)	100.0 (high)	3 (strong feasibility)
Sierra Leone	100.0 (high)	37.5 (low)	2 (somewhat feasibility)
The Gambia	92.9 (moderate)	82.1 (high)	2 (somewhat feasibility)
Togo	92.9 (moderate)	55.4 (moderate)	2 (somewhat feasibility)

%w= weighted proportion of participants that indicated yes to MOT use willingness and workplace ICT availability among all participants with the same characteristic. %w is rounded off to 1 decimal place. Feasibility ranks are extrapolated using the study proposed scoring system from table A.

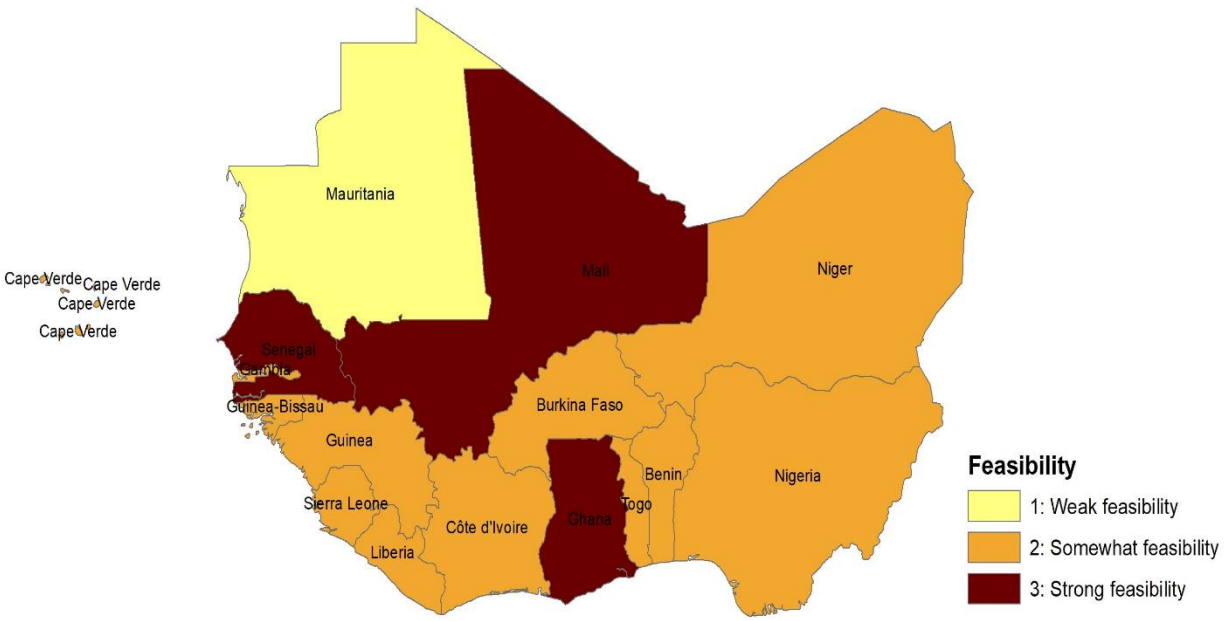

Figure 10. Geospatial distribution of feasibility of multi-communication, online training (MOT) among public health workers in West Africa, 2023.

5.12 Perceived Constraints for MOT among Public Health Workers

Of a total of 825 responses from the quantitative survey, findings showed that perceived constraints for MOT were highest for internet connectivity problems (n = 178, 21.6%), followed by high internet costs (n = 122, 14.8%), unreliable electricity (n = 108, 13.0%), lack of workplace ICT policies (n = 83, 10.0%) and limited ICT access (n = 69, 8.4%), and were lowest for others (n = 6, 1.0%), followed by inadequate digital literacy (n = 17, 2.0%), lack of conducive workspace (n = 56, 6.8%), poor training design and contents (n = 60, 7.2%), and complex training navigation processes (n = 60, 7.2%).

Triangulation of quantitative and qualitative findings on perceived constraints showed meta-inferences with **confirmation**, where both survey and interviews showed unreliable electricity, inadequate ICT access, poor internet connectivity, limited digital literacy, lack of protected work time and training content issues, as well as **expansion**, where besides the confirmed constraints, survey found lack of workplace policies, complex training navigation processes, low audio-visual quality of training recordings, high internet costs and lack of access to training materials, and interviews added lack of relevant and experienced trainers, gender gap, disparities in training eligibility criteria, lack of consensual training schedule and weak feedback system.

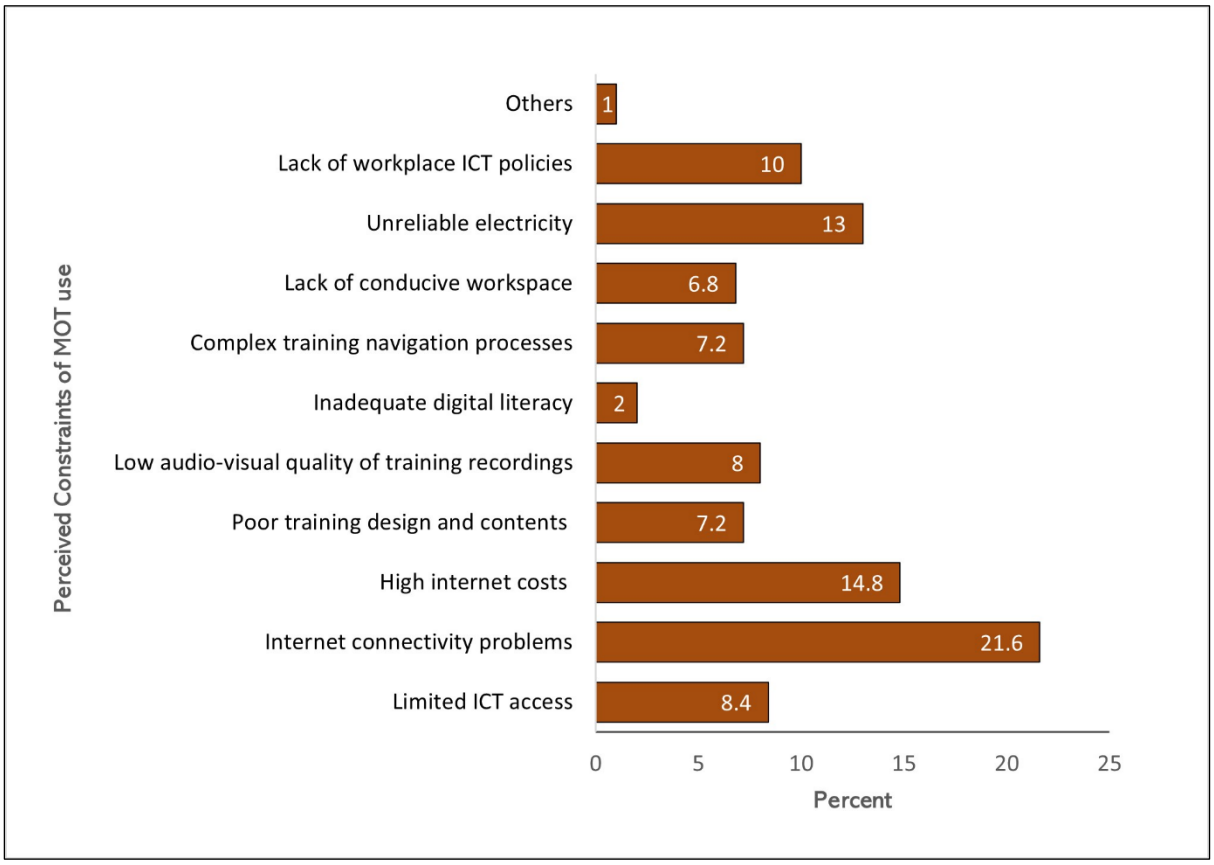

Figure 11. Perceived constraints of multi-communication, online training (MOT) among public health workers in West Africa, 2023. Others include lack of protected work time during training, and lack of access to online training materials. ICT= information and communication technology (Note: perceived constraints is a multiple response question).

5.13 Perceived Enablers for MOT among Public Health Workers

Of a total of 699 responses from the quantitative survey, findings showed that perceived enablers for MOT were highest for workplace ICT access (n = 139, 19.9%), followed by delivery of training in preferred language (n = 136, 19.5%), availability of context-specific training contents (n = 132, 18.8%), existence of workplace ICT policies (n = 117, 16.7%) and personal ICT access (n = 109, 15.6%), and were lowest for others (n = 9, 1.3%) and previous eLearning (n = 57, 8.2%).

Triangulation of quantitative and qualitative findings on perceived enablers showed meta-inferences with **confirmation**, where both survey and interviews showed stable electricity, personal and workplace ICT access, context-specific training contents and previous eLearning (COVID-19), as well as **expansion**, where besides the confirmed enablers, survey found existence of workplace ICT policies, delivery of training in preferred languages, ICT training, training certification, flexible training timing and accessibility to mentors, and interviews added improved internet bandwidth, training through existing recognized platforms, multisectoral and integrated training, short training session time (≤ 2 hrs per session) and protected work time for training.

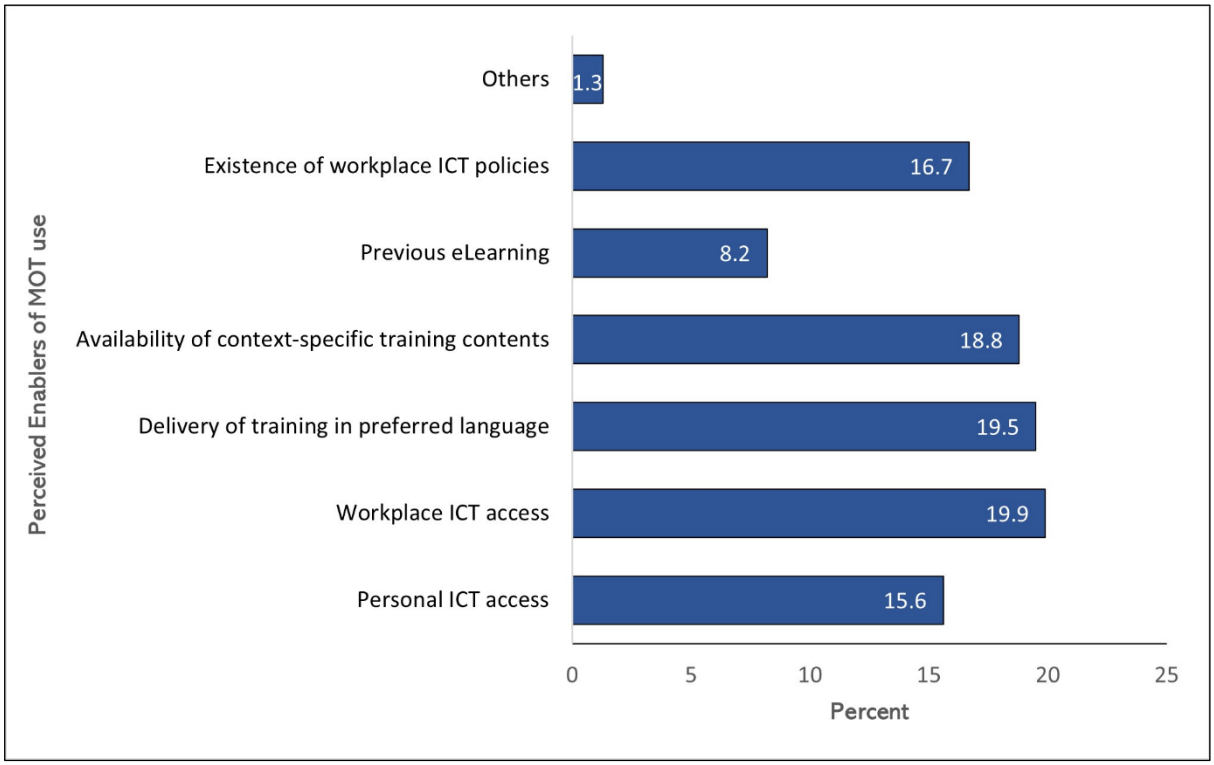

Figure 12. Perceived enablers of multi-communication, online training (MOT) among public health workers in West Africa, 2023. Others include training certification, ICT training, accessibility to mentors, flexible training timing, and stable electricity. ICT= information and communication technology (Note: perceived enablers is a multiple response question).

5.14 Recommendations of Public Health Workers for MOT

Of a total of 73 responses from the quantitative survey, findings showed that recommendations for MOT were highest for protected work time for training (n = 15, 20.5%), followed by contextual practice-based training (n = 11, 15.1%), consensual training schedule (n = 10, 13.7%), interactive and engaging training (n = 8, 11.0%), short training session time (n = 7, 9.6%), modular or multi-session training (n = 5, 6.8%) and training co-design and delivery with indigenous experts (n = 5, 6.8%) and were lowest for high quality training audio-visuals (n = 1, 1.4%), strong training feedback system (n = 3, 4.1%), training follow up with in-person meeting (n = 4, 5.5%) and unrestricted access to training materials (n = 4, 5.5%).

Triangulation of quantitative and qualitative findings on recommendations showed a meta-inference with **confirmation**, where both survey and interviews showed short training session time (≤ 2 hrs per session), training follow up with in-person meeting, modular or multisession training, interactive and engaging training, contextual practice-based training, consensual training schedule, training co-design and delivery with indigenous experts and strong training feedback system.

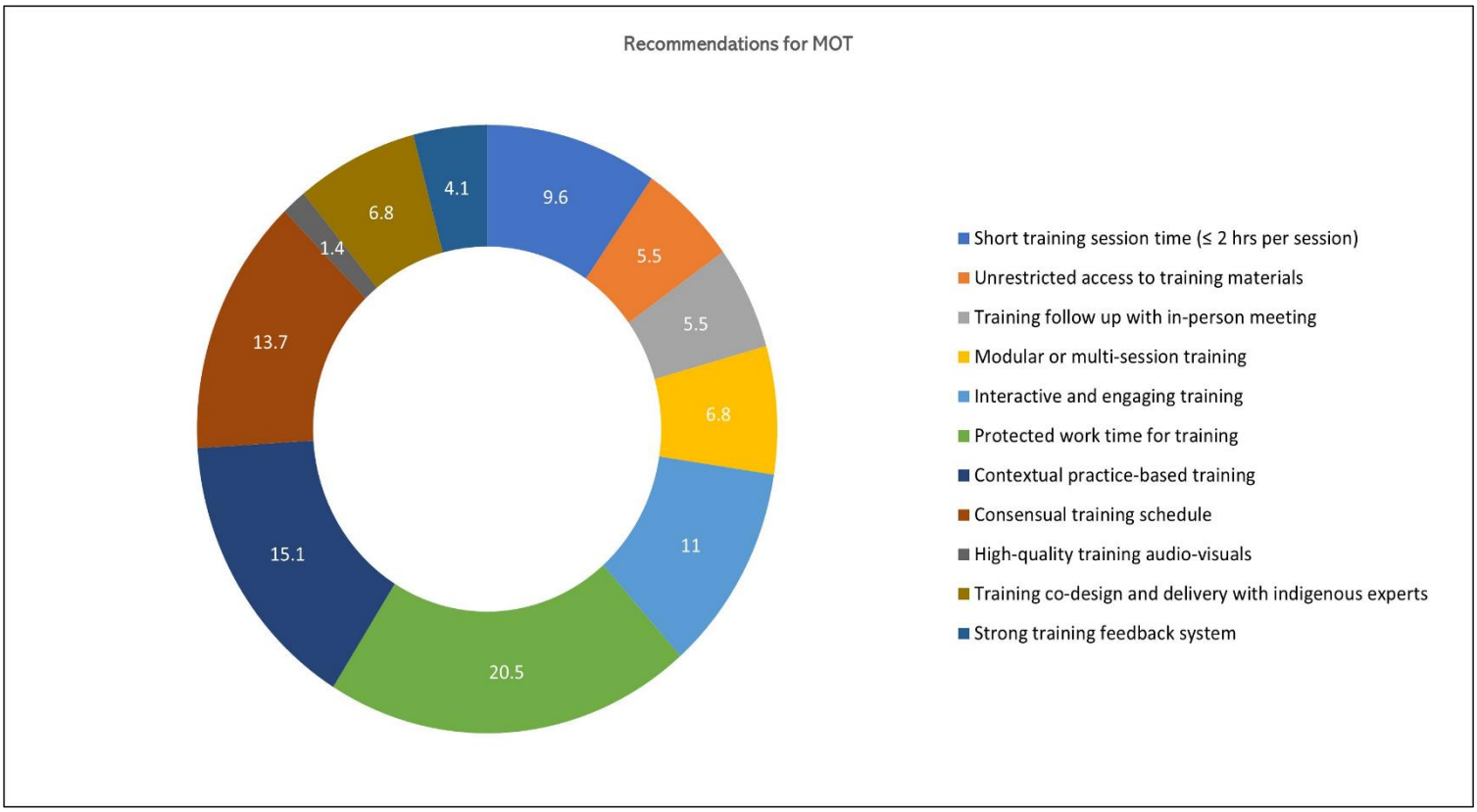

Figure 13. Recommendations of public health workers for implementation of multi-communication, online training (MOT) in West Africa, 2023.

Chapter 6: Discussion, Conclusion and Public Health Implications

6.1 Discussion

While evidence suggests the increasing use of digital solutions (e.g., eLearning) in Africa for training of public health workers on core competencies such as emergency preparedness and response (EPR) given its convenience and cost-effectiveness, research shows that implementation of these interventions remains a major challenge in this setting, where the need is greatest due to their infectious disease vulnerability and health workers shortage. [2, 5, 6, 7, 8, 11, 30, 34, 35] Therefore, understanding the contextual fit and feasibility of evidence-based interventions for public health workers capacity development could improve policies and programs to support their implementation for maximum impact on global health security. In this study, we evaluated the contextual fit (with outcomes on preference and acceptability) and feasibility (with outcomes on willingness to use and workplace ICT availability) of multi-communication, online training (MOT) for global health security among public health workers in 16 West African countries, in addition to perceived constraints, enablers and recommendations using a mixed-methods design and a newly proposed scoring system developed based on implementation science.

Overall, triangulating the quantitative and qualitative findings, we found that MOT is of “somewhat” contextual fit and has a “strong feasibility” for implementation among the public health workforce in a resource-limited setting like West Africa, though with variability across countries and some challenges that could be in part due to differences in the structural determinants such as economic strength, technology, and policies of the countries that affect the living or working conditions and behavioural choices of the population.

In this study, the “somewhat” contextual fit for MOT was explained by a combined ranking of MOT preference rate of 29.6% (ranked as moderate) and MOT acceptability rate of 96.0% (ranked as high), which were both found to be significantly associated with work area and age and were inferred as major predictors of contextual fit. In addition, we found other factors that were determined as minor-moderate predictors, including sex, attitude towards information and communication technology [ICT]), previous eLearning, and workplace internet funding that demonstrated statistical significance in either case of preference or acceptability. These findings are consistent with results found in the African region and comparable to results from other regions of the world. [31, 37, 66, 90, 91]

We further found that many public health managers, trainers, and policy makers attributed the contextual factors associated with preference and acceptability of MOT among public health workers to themes around training resources accessibility (electricity, and training cost); training characteristics (self-efficacy, effort expectancy, performance expectancy, and training instruction clarity); and training environment (family and work obligations) that could have influenced our results, especially for the suboptimal level of MOT preference observed. Specific insights shared by many of them included, for example, interruptions in eLearning due to erratic electricity, or how public health workers with higher work obligations are likely to prefer eLearning than other modalities and are unable to effectively use eLearning due to distractions from work. Overall, our findings support the body of knowledge on preference and acceptability of eLearning, where similar associations have been established and remains inconclusive. [31, 37, 66, 90, 91] The variability in findings could be probably due to differences in settings, target populations, and existing social policies in the country, sample size, and research methodology employed.

Specifically, in our study we found that the likelihoods of preference and acceptability of MOT were lower for public health workers in rural areas when compared to those in urban areas, which could be attributed to lower access to ICT resources (e.g., computer, internet) and differences in inadequate digital literacy that have been reported in similar settings. Contrary to general knowledge, we found that those who are young (≤ 29 years) were more likely to have preference for MOT and less likely to accept MOT compared to public health workers aged 30-39 years. This finding provides new insights that having preference for a digital intervention might not correlates with the acceptability for such intervention due to some several factors. One of the explanations for this, could be that, while young public health workers demonstrated a higher preference for MOT maybe due to its added benefits (e.g., convenience, cost-effectiveness) and their well-known technological proficiency with ICT tools, they might have found MOT unacceptable based on disagreement with the current form in which eLearning interventions are being currently designed (e.g., lack of context-specific content) and delivered (e.g., poor interactivity and engagement) in the African setting. This finding suggests the need for more research among this subpopulation to better understand the factors associated with acceptability for eLearning for better adaptation of related interventions. Further, it emphasises the importance of using robust methodology that concurrently measures both preference and acceptability of evidence-based interventions like MOT to assess their contextual fit other than basing this assessment on only either preference or acceptability, as is usually the case.

These findings on preference and acceptability of MOT align with existing evidence, for example, a meta-analysis by Dedeilia et al that was performed to assess the modalities of training among healthcare workers between 2020 and 2022 across six

World Health Organization (WHO) regions showed that 29.7% of African healthcare worker subgroup preferred eLearning, which is similar to 29.6% reported in this study. [31] On the other hand, our finding on MOT acceptability with a rate of 96.0% is slightly higher but comparable to the result from a scoping review on training modalities conducted among public health workers between 2000 and 2019 with articles including African countries the eLearning acceptability was reported at 90.5%. [37] Some of the reasons that could provide explanation for the observed increase in the acceptability of MOT, include first, the increased use of eLearning during the COVID-19 pandemic due to social distancing measures (e.g., lockdown) that restricted movements of people to participate in the conventional face-to-face training modality, where it is likely that the self-efficacy, effort expectancy and performance expectancy of public health workers towards eLearning could have increased. Second, is the possibility that the inherent characteristics of MOT with multiple options, including a training that incorporates a combination of synchronous and asynchronous online methods with a wide range of ICT-enabled approaches such as facilitated learning, digital simulation-based learning and social media-based learning might be perceived by public health workers as more user-friendly and more responsive to their busy work environment, thus generating more acceptability. Nevertheless, our results shed more light on the complexity associated with individual or population decision making towards acceptability and use of evidence-based interventions or technologies in the African context. Putting all these findings together, we believe this study underscores the importance of engaging potential users of any digital interventions like MOT for better understanding of the contextual issues to inform “context-specific” and “people-centered” policies and programs for

public health workforce capacity building, improved job performance, and return on investment in the areas of health, education and economic growth.

Similar to MOT contextual fit, the “strong feasibility” of MOT was explained by a combined ranking of MOT willingness to use rate of 95.6% (ranked as high) and workplace ICT availability rate of 82.1% (ranked as high), which were both found to be significantly associated with work area and was inferred as a major predictor of feasibility. Work experience was determined as a minor-moderate predictor given that it demonstrated statistical significance in either case of MOT willingness to use or workplace ICT availability. These findings are similar to what were reported in previous studies. [31, 37, 66, 90, 91]

We further found that many public health managers, trainers, and policy makers attributed the contextual factors associated with MOT willingness to use and workplace ICT availability among public health workers to themes around training resources accessibility (electricity, training cost, and country); training characteristics (training relevance, and training content); and training environment (family and work obligations) that could have influenced our results. Specific views reported by many of them included, for example, their inability to access ICT resources to participate in eLearning despite their willingness to engage in such capacity development activities.

Our findings on willingness to use MOT is higher than 49.5% reported in the same meta-analysis by Dedeilia et al. [31] Similar to the observed increase in acceptability for eLearning as found in our study, we opine that improvement in the self-efficacy, and perhaps the performance expectancy of public health workers towards eLearning from sustained use during the COVID-19 pandemic might be some of the

factors responsible for this increase. In the same vein, this reason might be attributed to the high rate of workplace ICT availability observed in our study from increasing investments in digital technology driven by the need to keep public health workers educated despite the pandemic.

In addition, our study showed that MOT contextual fit varied by country, from the highest (strong fit) in Benin and Senegal to the lowest (weak fit) in Guinea-Bissau and The Gambia. This variability may be attributed to differences in the economic power of public health workers in these countries to access to ICT resources (e.g., computer, internet) personally or in their workplaces, where a report in 2018 indicated higher gross domestic product (GDP) per capital in Benin ($2,220) and Senegal ($2,617) versus Guinea-Bissau ($1,500) and The Gambia ($1,882). [82] Another possible explanation for this variance could be the difference in digital literacy and skills among public health workers as proximate effects of workplace and/or national digital policies in these countries. In fact, according to a World Bank report in 2019, Benin was said to have received a grant of $100 million to expand its digital technology services with a particular focus on rural areas in addition to the existence of national digital policies in the country as well as in Senegal. [82, 92, 93] Whereas for MOT feasibility, we found Ghana, Mali, and Senegal to have strong feasibility, and a weak feasibility in Mauritania. Similarly, from the economic perspective, evidence suggests that GDP per capital is not only high in the countries with strong feasibility (Ghana, $4,267; Mali, $1,667; and Senegal, $2,617), but digital technology investments are high as well. [67, 82, 93] For example, Mali was said to have launched its 5G network in 2022, which could mean better internet connectivity and improved preference or acceptability of MOT among its public health workforce [67]. These findings could also help trainers and policy makers prioritize scarce

resources in digital infrastructure strengthening efforts, with a particular focus on countries with weak contextual fit and weak feasibility.

Despite our findings on favourable contextual fit and feasibility outcomes, we found that some challenges and opportunities exist to improve the implementation of MOT among the public health workforce in the African setting. Precisely, we found internet connectivity problems; high internet costs; unreliable electricity; lack of workplace ICT policies; and limited ICT access as the top five perceived constraints that could limit MOT implementation. This finding agrees with the literature, [11, 12, 30, 58, 61, 62, 64, 65] and suggest the need for proactive actions from all relevant stakeholders, including public and private sectors to strengthen social infrastructures in addition to the provision of effective digital solutions in this technologically advancing world.

On the other hand, we found perceived enablers to be highest for workplace ICT access; delivery of training in preferred language; availability of context-specific training contents; existence of workplace ICT policies; and personal ICT access, which further supports our findings on the perceived constraints.

Regarding recommendations, our study showed top five new insights, including protected work time for training (i.e., provision of policies that would prevent distractions from their work obligations during online trainings); contextual practice-based training (i.e., design of relevant online trainings that meet local needs and resources); consensual training schedule (i.e., prior communication with potential trainees for commonly agreed training time); interactive and engaging training (i.e., creation of a user-friendly learning environment with problem-posing pedagogy using online features for polls, quizzes, and discussions); and short training session time (i.e., delivery of online trainings with no more than 2 hours per session).

6.1.1 Strengths and Limitations

Strengths

Our study has some strengths. First, to our knowledge, this is the first sub-regional study that assessed contextual fit and feasibility of an eLearning intervention in all the West African countries among professionally, culturally, and linguistically diverse public health workforce population. Second, our study used a mixed-methods design and implementation science that accounted for robust explanatory variables at the population and setting levels. Third, we performed statistical weighting at the country level using data from a 2018 WHO report on health workforce in the African region to make our results more sub-regionally representative. Fourth, we used SAS PROC Survey methodology that accounted for the study design and clustering to reduce analytical bias from inaccurate standard errors estimation.

Limitations

Our study has some limitations. First, there is a possibility of selection bias due to lack of complete public health workforce database, in which we were unable to apply a random sampling approach and public health workers that chose to participate in this study might have had a greater interest and opinion in the topic, which could have led to the overestimation of our outcome variables. Another possibility for selection bias is from the low participation of public health workers from rural areas, but our finding with a rural-urban ratio of 1:2 is consistent with what is obtainable in most physical surveys. Second, our findings could have been limited by information bias due to our inability to provide explanations to any participants that might need further clarifications to better answer the survey questionnaire given that the quantitative survey in study was conducted online, but this was limited with the design of our questionnaire in simple languages. Third, despite statistical weighting,

some countries had low participation in the survey, but efforts were made to promote widespread national participation through emails, social media, official websites and newsletter of our sub-regional network, the West African Health Organization (WAHO) in partnership with the Africa Centers for Disease Control and Prevention (CDC), and African Field Epidemiology Network (AFENET). Fourth, response rate could not be estimated and adjusted for due to anonymity of online survey data collected through emails and the impossibility to determine a sampling frame from responses collected via social media. While the rate of non-response could not be ascertained nor baseline characteristics of responders and non-responders be compared due to our survey design and sampling limitations, the effect of a possible response bias is likely to be low given that our sample was weighted, and the responses are likely to be missing at random. Fifth, our study could not account for social desirability response bias, whereby participants prefer to select the best answer over the true answer. Sixth, there was lack of post-stratification weights for all relevant population characteristics due to lack of data from our reference population that could have resulted in residual bias. Seventh, we had a low in-depth interview (IDIs) sample size due to non-availability of participants and time constraints and we were unable to accommodate participants from Portuguese speaking countries in the IDIs due to language barrier among the research team, which could have resulted in unbalanced perspectives, but given some similarity in culture with French and English-speaking countries, our findings could be said to be representative. Eight, we had one public health worker from the environment sector that volunteered to participate in the IDIs, and most interviewees were working in the government and academia as at the time of the interview. However, a sufficient

number of them reported work experiences that span the breadth and length of private sector health institutions and non-governmental organizations (NGOs).

In summary, these findings highlight the need for equity-focused policies to increase investments in digital solutions like MOT using a “whole-of-government” approach to bridge the existing economic and digital gaps for improved learning among the public health workforce for global health security. An example of these approaches could be establishing transparent and collaborative partnerships between the public health sector, relevant non-health sectors (e.g., telecommunication, private institutions) and public health workers to co-design, co-deliver, and co-manage digital platforms for effective and efficient learning.

6.2 Conclusion

The study findings suggest that MOT has some contextual fit and is strongly feasible for capacity building among public health workers in resource-limited settings like West Africa, but substantial geographic disparities, challenges, and opportunities exist. The constraints on limited access to ICT including internet and unstable electricity, with recommendations for protected work time and better training delivery highlight the need for equity-focused workplace policy and increased investments in social infrastructure to improve the public health workforce capacity for global health security.

6.3 Public Health Implications

6.3.1 Research

1. Our study outlines a formative assessment methodology that could be replicated in Africa and other relevant settings for academics and policy makers seeking to address similar questions.
2. Our study demonstrates the need for sub-regional infrastructures like WAHO to strengthen its public health workforce database with emails to enable random sampling strategy and non-response estimation, and feedback to participants with any questions on the survey questionnaire in future research.
3. Our study provides a novel scoring system that can be used to better assess, and compare contextual fit and feasibility with rates measures on preference, acceptability, and willingness to use towards any evidence-based interventions in public health and other related field.
4. Our study extends the body of knowledge on unified theory of acceptance and use of technology (UTAUT), which were mostly used in the clinical setting.
5. Our study demonstrates that online method could be a feasible strategy to conduct complex survey and qualitative interviews in situations where there might be budgetary and time constraints, provided it is carefully planned, and statistical refinement of data is performed.
6. Our study shows that there is a need for more research among young public health workers subpopulation to better understand the factors associated with acceptability of eLearning for adaptation of related interventions.

6.3.2 Policy and Practice

1. Our study provides baseline evidence to public health workers, managers, trainers and policy makers to guide their decision making in translating evidence-based interventions such as multi-communication, online training (MOT) into practice through existing training platforms such as Field Epidemiology Training Program (FETP), and Points of Entry Master Training Program (POE MTP), including the new WHO Global Field Epidemiology Partnership (GFEP) for cohesive and equitable global health learning in Africa and other similar settings.
2. Our study identified gaps in public data and suggests the need for WHO to publish distribution of public health workforce other than by country and job discipline for future formative assessment and implementation evaluation purposes.
3. Our study demonstrated the feasibility of implementation of One Health framework with the inclusion and shared perspectives of public health workers across the human, animal, and environment sectors.
4. Our study provided an opportunity to sensitize the public health workforce about MOT intervention to promote its ownership for sustainability implications.
5. The recommendations provided by public health workers in our study provides a knowledge base to inform the design and delivery of a “context-specific” and “people-centered” eLearning interventions backed up with equity-focused workplace policy and increased investments in social infrastructure for better uptake and potential scale-up among public health workers, particularly those in rural areas.

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Appendix 1. Survey Instrument (English)

Developing an Institute for Workforce Development with Multi-communication, Online Training for the Public Health Workforce in West Africa

To the Public Health Workers,

A team from the *West African Health Organization (WAHO)* and *Emory University* invite your help to understand the preferences and needs of public health workers to implement an Institute for Workforce Development (IWD) with multi-communication, online training (i.e., synchronous and asynchronous e-learning). Your responses will improve WAHO's programs and services in capacity building to strengthen public health systems and protect global health security.
All responses are confidential, and your participation is voluntary. The survey should take ≤ **15 minutes** to complete.

* Indicates required question

1. **Informed Consent** *

Mark only one oval.

- ◯ Yes, I understand my participation is voluntary, all responses will be kept confidential, and I agree to participate *Skip to question 2*
- ◯ No, I do not wish to participate *Skip to section 3 (**Participation Declined**)*

Survey Questions

2. Job discipline *

Mark only one oval.

- ◯ Public health specialist
- ◯ Physician
- ◯ Nurse
- ◯ Environmental health scientist/technician
- ◯ Laboratory scientist/technician
- ◯ Veterinarian/assistant veterinarian
- ◯ Other: _____

3. Age [*enter response*] *

_____

4. Sex *

Mark only one oval.

- ◯ Male
- ◯ Female

5. Years of experience [*enter response*] *

_____

6. Work setting *

Mark only one oval.

- ◯ Government public health institution
- ◯ Private public health institution
- ◯ Human hospital/clinic (public or private)
- ◯ Academia (public or private)
- ◯ Non-governmental organization
- ◯ Community-based organization
- ◯ Faith-based organization
- ◯ Government animal health institution
- ◯ Private animal health institution
- ◯ Government environment health institution
- ◯ Private environment health institution
- ◯ Animal hospital/clinic (public or private)
- ◯ Other: _____

7. Work sector *

Mark only one oval.

- ◯ Human
- ◯ Animal
- ◯ Environment

8. Work area *

Mark only one oval.

- ◯ Urban
- ◯ Rural

9. Work country *

Mark only one oval.

- Benin
- Burkina Faso
- Cabo Verde
- Cote d'Ivoire
- The Gambia
- Ghana
- Guinea
- Guinea-Bissau
- Liberia
- Mali
- Mauritania
- Niger
- Nigeria
- Senegal
- Sierra Leone
- Togo

10. Which Information Communication Technology (ICT) resources is personally accessible to you? *

Mark only one oval.

- Smartphone and internet
- Computer and internet
- Smartphone, computer, and internet
- Non-smartphone, computer, and internet

11. Which Information Communication Technology (ICT) resources is accessible to you at your workplace? *

Mark only one oval.

- ◯ Computer
- ◯ Computer, and internet
- ◯ None

12. Which training method do you prefer? *

Mark only one oval.

- ◯ Face-to-face (physical)
- ◯ Online (e-learning)
- ◯ Face-to-face and online (Hybrid)

13. Have you ever completed any work-related or personal online training? *

Mark only one oval.

- ◯ No
- ◯ Yes

14. Do you have any assurance that your workplace will give you financial incentives for internet cost associated with any work-related online training that you complete using your personal computer or smartphone? *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Not sure

15. Do you believe that you have the ability to use any ICT resources (e.g., smartphone, computer, internet) for an online training? *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Not sure

16. Do you believe that you would find it easy to use any ICT resources (e.g., smartphone, computer, internet) for an online training? *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Not sure

17. Do you believe that an online training would help you to better understand the training learning objectives? *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Not sure

18. Do you believe that online trainings have the potential to improve the effectiveness and efficiency of trainings? *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Not sure

19. Do you think that your colleagues would support the use of online training for capacity building? *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Not sure

20. Do you consider a synchronous (live) and asynchronous (recorded) online training as an acceptable method for your capacity building? *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Not sure

21. Would you be willing to use a synchronous (live) and asynchronous (recorded) online training in the future? *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Not sure

22. What are the challenges that would hinder you from using a synchronous (live) and asynchronous (recorded) online training? [*check all that apply*] *

Check all that apply.

- [ ] Limited access to ICT resources (e.g., smartphone, computer, internet)
- [ ] Internet connectivity problems
- [ ] High cost of internet services
- [ ] Poor design and contents of training materials
- [ ] Low video and audio quality of training recordings
- [ ] Limited knowledge about digital technologies
- [ ] Complex training navigation processes
- [ ] Lack of conducive workspace
- [ ] Unreliable electricity
- [ ] Lack of workplace ICT policies (e.g., ICT support services, internet financial incentives)
- [ ] Other: _____

23. What are the factors that would motivate you to use a synchronous (live) and asynchronous (recorded) online training? [*check all that apply*] *

Check all that apply.

- [ ] Personal access to ICT resources (e.g., smartphone, computer, internet)
- [ ] Workplace access to ICT resources (e.g., smartphone, computer, internet)
- [ ] Delivery of training in preferred language
- [ ] Availability of context-specific training content
- [ ] Previous similar experience
- [ ] Availability of workplace ICT policies (e.g., ICT support services, internet financial incentives)
- [ ] Other: _____

24. What other information would you like to share that could help us know why online training may be useful for your current job, and how would you like the online trainings to be delivered? *

Participation Declined

You have chosen not to participate, you can click the submit or simply close the browser

Appendix 2. Survey Instrument (French)

Développer un institut pour le développement du personnel avec une formation en ligne multi-communication pour le personnel de santé publique en Afrique de l'Ouest

Aux agents de santé publique,

Une équipe de l' *Organisation Ouest Africaine de la Santé (OOAS)* et *l'Université Emory* sollicite votre aide à comprendre les préférences et les besoins des agents de santé publique pour mettre en œuvre un Institut pour le développement de la main-d'œuvre (IWD) avec une formation en ligne multi-communication (c'est-à-dire, apprentissage en ligne synchrone et asynchrone). Vos réponses amélioreront les programmes et services de l'OOAS en matière de renforcement des capacités pour renforcer les systèmes de santé publique et protéger la sécurité sanitaire mondiale.

Toutes les réponses sont confidentielles et votre participation est volontaire. L'enquête devrait prendre ≤ **15 minutes** à remplir.

* Indicates required question

1. **Consentement éclairé** *

Mark only one oval.

- ◯ Oui, Je comprends que ma participation est volontaire, toutes les réponses resteront confidentielles et j'accepte de participer *Skip to question 2*
- ◯ Non, je ne souhaite pas participer *Skip to section 3 (**Participation refusée**)*

Questions de l'enquête

2. Discipline du travail *

Mark only one oval.

- ◯ Spécialiste de la santé publique
- ◯ Médecin
- ◯ Infirmière
- ◯ Scientifique/technicien en santé environnementale
- ◯ Scientifique/technicien de laboratoire
- ◯ Vétérinaire/assistante vétérinaire
- ◯ Other: _____

3. Âge [*entrer la réponse*] *

_____

4. Sexe *

Mark only one oval.

- ◯ Homme
- ◯ Femme

5. Années d'expérience [*entrez la réponse*] *

_____

6. Milieu de travail *

Mark only one oval.

- ◯ Établissement de santé publique gouvernemental
- ◯ Établissement public de santé privé
- ◯ Hôpital/clinique pour humains (public ou privé)
- ◯ Milieu universitaire (public ou privé)
- ◯ Organisation non gouvernementale
- ◯ Organisation communautaire
- ◯ Organisation confessionnelle
- ◯ Institution gouvernementale de santé animale
- ◯ Etablissement privé de santé animale
- ◯ Etablissement public de santé environnement
- ◯ Etablissement privé de santé environnement
- ◯ Hôpital/clinique vétérinaire (public ou privé)
- ◯ Other: _____

7. Secteur de travail *

Mark only one oval.

- ◯ Humain
- ◯ Animal
- ◯ Environnement

8. Zone de travail *

Mark only one oval.

- ◯ Urbain
- ◯ Rural

9. Pays de travail *

Mark only one oval.

- ◯ Bénin
- ◯ Burkina Faso
- ◯ Cap-Vert
- ◯ Côte d'Ivoire
- ◯ La Gambie
- ◯ Ghana
- ◯ Guinée
- ◯ Guinée-Bissau
- ◯ Libéria
- ◯ Mali
- ◯ Mauritanie
- ◯ Niger
- ◯ Nigeria
- ◯ Sénégal
- ◯ Sierra Leone
- ◯ Togo

10. Quelles sont les ressources des technologies de l'information et de la communication (TIC) auxquelles vous avez personnellement accès? *

Mark only one oval.

- ◯ Smartphone et Internet
- ◯ Ordinateur et internet
- ◯ Smartphone, ordinateur et internet
- ◯ Non-smartphone, ordinateur et Internet

11. Quelles sont les ressources des technologies de l'information et de la communication (TIC) auxquelles vous avez accès sur votre lieu de travail? *

Mark only one oval.

- ◯ Ordinateur
- ◯ Ordinateur et internet
- ◯ Aucun

12. Quelle méthode d'entraînement préférez-vous? *

Mark only one oval.

- ◯ Face à face (physique)
- ◯ En ligne (apprentissage en ligne)
- ◯ en face à face et en ligne (hybride)

13. Avez-vous déjà suivi une formation en ligne liée au travail ou personnelle? *

Mark only one oval.

- ◯ Non
- ◯ Oui

14. Avez-vous l'assurance que votre lieu de travail vous offrira des incitations financières pour les coûts Internet associés à toute formation en ligne liée au travail que vous suivez à l'aide de votre ordinateur personnel ou de votre smartphone? *

Mark only one oval.

- ◯ Non
- ◯ Oui
- ◯ Pas certain

15. Pensez-vous que vous avez la capacité d'utiliser des ressources TIC (par exemple, smartphone, ordinateur, Internet) pour une formation en ligne? *

Mark only one oval.

- Non
- Oui
- Pas certain

16. Pensez-vous qu'il vous serait facile d'utiliser n'importe quelle ressource TIC (par exemple, smartphone, ordinateur, Internet) pour une formation en ligne? *

Mark only one oval.

- Non
- Oui
- Pas certain

17. Pensez-vous qu'une formation en ligne vous aiderait à mieux comprendre les objectifs d'apprentissage de la formation? *

Mark only one oval.

- Non
- Oui
- Pas certain

18. Pensez-vous que les formations en ligne ont le potentiel d'améliorer l'efficacité et l'efficience des formations? *

Mark only one oval.

- Non
- Oui
- Pas certain

19. Pensez-vous que vos collègues soutiendraient l'utilisation de la formation en ligne pour le renforcement des capacités? *

Mark only one oval.

- Non
- Oui
- Pas certain

20. Considérez-vous une formation en ligne synchrone (en direct) et asynchrone (enregistrée) comme une méthode acceptable pour votre renforcement des capacités? *

Mark only one oval.

- Non
- Oui
- Pas certain

21. Seriez-vous prêt à utiliser une formation en ligne synchrone (en direct) et asynchrone (enregistrée) à l'avenir? *

Mark only one oval.

- Non
- Oui
- Pas certain

22. Quels sont les défis qui vous empêcheraient d'utiliser une formation en ligne synchrone (en direct) et asynchrone (enregistrée)? [*cochez tout ce qui s'applique*] *

Check all that apply.

- [ ] Accès limité aux ressources TIC (par exemple, smartphone, ordinateur, Internet)
- [ ] Problèmes de connectivité Internet
- [ ] Coût élevé des services Internet
- [ ] Mauvaise conception et contenu des supports de formation
- [ ] Faible qualité vidéo et audio des enregistrements de formation
- [ ] Connaissance limitée des technologies numériques
- [ ] Processus de navigation de formation complexes
- [ ] Manque d'espace de travail propice
- [ ] Électricité peu fiable
- [ ] Absence de politiques TIC sur le lieu de travail (par exemple, services de soutien TIC, incitations financières sur Internet)
- [ ] Other: _____

23. Quels sont les facteurs qui vous motiveraient à utiliser une formation en ligne synchrone (en direct) et asynchrone (enregistrée)? [*cochez tout ce qui s'applique*] *

Check all that apply.

- [ ] Accès personnel aux ressources TIC (par exemple, smartphone, ordinateur, Internet)
- [ ] Accès au lieu de travail aux ressources TIC (par exemple, smartphone, ordinateur, Internet)
- [ ] Prestation de la formation dans la langue de votre choix
- [ ] Disponibilité de contenu de formation spécifique au contexte
- [ ] Expérience similaire antérieure
- [ ] Disponibilité des politiques TIC sur le lieu de travail (par exemple, services de soutien TIC, incitations financières sur Internet)
- [ ] Other: _____

24. Quelles autres informations aimeriez-vous partager qui pourraient nous aider à savoir pourquoi la formation en ligne peut être utile pour votre travail actuel, et comment aimeriez-vous que les formations en ligne soient dispensées? *

Participation refusée

Vous avez choisi de ne pas participer, vous pouvez cliquer sur soumettre ou simplement fermer le navigateur

Appendix 3. Survey Instrument (Portuguese)

Desenvolvimento de um Instituto para o Desenvolvimento da mão-de-obra com formação online multi-comunicação para a mão-de-obra da saúde pública na África Ocidental

Aos Trabalhadores da Saúde Pública,

Uma equipa da Organização Oeste Africana da Saúde (OOAS) e da Universidade de Emory solicita a vossa ajuda para compreender as preferências e as necessidades dos trabalhadores da saúde pública para implementar um Instituto de Desenvolvimento da Mão-de-obra (IDM) com formação multi-comunicação online (ou seja, e-learning síncrono e assíncrono). As suas respostas irão melhorar os programas e serviços da OOAS em matéria de reforço das capacidades para fortalecer os sistemas de saúde pública e proteger a segurança sanitária mundial.

Todas as respostas são confidenciais e a sua participação é voluntária. O inquérito deve demorar ≤ **15 minutos** a ser concluído.

* Indicates required question

1. **Consentimento informado** *

Mark only one oval.

- ◯ Sim, compreendo que a minha participação é voluntária, todas as respostas serão mantidas confidenciais e concordo em participar *Skip to question 2*
- ◯ Não, não desejo participar *Skip to section 3 (**Participação recusada**)*

Perguntas do inquérito

2. Área profissional *

Mark only one oval.

- ◯ Especialista da saúde pública
- ◯ Médico
- ◯ Enfermeiro
- ◯ Cientista/Técnico da saúde ambiental
- ◯ Cientista/Técnico de laboratório
- ◯ Veterinário/Assistente de veterinária
- ◯ Other: _____

3. Idade [*introduzir a resposta*] *

_____

4. Sexo *

Mark only one oval.

- ◯ Masculino
- ◯ Feminino

5. Anos de experiência [*introduzir a resposta*] *

_____

6. Local de trabalho *

Mark only one oval.

- ◯ Instituição governamental de saúde pública
- ◯ Instituição privada de saúde pública
- ◯ Hospital/clínica humana (pública ou privada)
- ◯ Academia (pública ou privada)
- ◯ Organização não-governamental
- ◯ Organização de base comunitária
- ◯ Organização religiosa
- ◯ Instituição governamental de saúde animal
- ◯ Instituição privada de saúde animal
- ◯ Instituição governamental de saúde ambiental
- ◯ Instituição privada de saúde ambiental
- ◯ Hospital/clínica animal (pública ou privada)
- ◯ Other: _____

7. Sector de trabalho *

Mark only one oval.

- ◯ Humano
- ◯ Animal
- ◯ Ambiente

8. Área de trabalho *

Mark only one oval.

- ◯ Urbana
- ◯ Rural

9. País de trabalho *

Mark only one oval.

- Benim
- Burkina Faso
- Cabo Verde
- Côte d'Ivoire
- Gâmbia
- Gana
- Guiné (República da)
- Guiné-Bissau
- Libéria
- Mali
- Mauritânia
- Níger
- Nigéria
- Senegal
- Serra Leoa
- Togo

10. Que recursos das tecnologias da informação e da comunicação (TIC) lhe são pessoalmente acessíveis? *

Mark only one oval.

- Smartphone e internet
- Computador e internet
- Smartphone, computador e internet
- Telemóvel (não smartphone), computador e internet

11. Que recursos das tecnologias da informação e da comunicação (TIC) lhe são acessíveis no local de trabalho? *

Mark only one oval.

- ◯ Computador
- ◯ Computador e internet
- ◯ Nenhum

12. Qual o método de formação que prefere? *

Mark only one oval.

- ◯ Presencial (físico)
- ◯ Online (e-learning)
- ◯ Presencial e online (híbrido)

13. Alguma vez concluiu uma formação online relacionada com o trabalho ou pessoal? *

Mark only one oval.

- ◯ Não
- ◯ Sim

14. Tem alguma garantia de que o seu local de trabalho lhe dará incentivos financeiros para os custos de Internet associados a qualquer formação online relacionada com o trabalho que conclua utilizando o seu computador pessoal ou smartphone? *

Mark only one oval.

- ◯ Não
- ◯ Sim
- ◯ Não tenho certeza

15. Considera que tem a capacidade de utilizar quaisquer recursos TIC (por exemplo, smartphone, computador, Internet) para uma formação online? *

Mark only one oval.

- Não
- Sim
- Não tenho certeza

16. Considera que seria fácil utilizar quaisquer recursos TIC (por exemplo, smartphone, computador, Internet) para uma formação online? *

Mark only one oval.

- Não
- Sim
- Não tenho certeza

17. Considera que uma formação online o ajudaria a compreender melhor os objectivos de aprendizagem da formação? *

Mark only one oval.

- Não
- Sim
- Não tenho certeza

18. Considera que as formações online têm potencial para melhorar a eficácia e a eficiência das formações? *

Mark only one oval.

- Não
- Sim
- Não tenho certeza

19. Acha que os seus colegas apoiariam a utilização da formação online para o reforço das capacidades? *

Mark only one oval.

- Não
- Sim
- Não tenho certeza

20. Considera que uma formação online síncrona (em directo) e assíncrona (gravada) é um método aceitável para o seu reforço de capacidades? *

Mark only one oval.

- Não
- Sim
- Não tenho certeza

21. Estaria disposto a utilizar uma formação online síncrona (em directo) e assíncrona (gravada) no futuro? *

Mark only one oval.

- Não
- Sim
- Não tenho certeza

22. Quais são os desafios que o impediriam de utilizar uma formação online síncrona (em directo) e assíncrona (gravada)? [assinale todas as opções aplicáveis] *

Check all that apply.

- [ ] Acesso limitado a recursos TIC (por exemplo, smartphone, computador, Internet)
- [ ] Problemas de conectividade à Internet
- [ ] Custo elevado dos serviços de Internet
- [ ] Má concepção e conteúdo dos materiais de formação
- [ ] Baixa qualidade de vídeo e áudio das gravações de formação
- [ ] Conhecimentos limitados sobre tecnologias digitais
- [ ] Processos complexos de navegação na formação
- [ ] Falta de espaço de trabalho propício
- [ ] Electricidade não fiável
- [ ] Falta de políticas de TIC no local de trabalho (por exemplo, serviços de apoio às TIC, incentivos financeiros para a Internet)
- [ ] Other: _____

23. Quais são os factores que o motivariam a utilizar uma formação online síncrona (em directo) e assíncrona (gravada)? *[assinale todas as opções aplicáveis]* *

Check all that apply.

- [ ] Acesso pessoal a recursos TIC (por exemplo, smartphone, computador, Internet)
- [ ] Acesso a recursos TIC no local de trabalho (por exemplo, smartphone, computador, Internet)
- [ ] Realização da formação na língua preferida
- [ ] Disponibilidade de conteúdos de formação específicos ao contexto
- [ ] Experiência anterior semelhante
- [ ] Disponibilidade de políticas de TIC no local de trabalho (por exemplo, serviços de apoio às TIC, incentivos financeiros para a Internet)
- [ ] Other: _____

24. Que outras informações gostaria de partilhar que nos poderiam ajudar a saber por que razão a formação online pode ser útil para o seu emprego actual e como gostaria que as formações online fossem ministradas? *

Participação recusada

Você optou por não participar, você pode clicar em enviar ou simplesmente fechar o navegador

Appendix 4. In-Depth Interview Guide (English)

In-depth Interview Guide

Introduction/Informed Consent:

Hi, [interviewee's name]. My name is [your name], and I will be your interviewer today. We are asking you to participate in this interview for the *Public Health, Animal Health, and Environmental (PAE) Health Workforce eLearning Initiative* for Global Health Security that is led by the West African Health Organization and Emory University.

As you are already aware, the purpose of this project is to better understand the **contextual fit** and **feasibility** of a multi-communication, online training intervention among public health workers across the human, animal, and environmental health sectors in West Africa. As a part of this project, we would like to talk to you about your experiences as an active practitioner in your field based on your direct work engagements and your interactions with your colleagues, and for you to share your opinions on what you think might be the values, challenges and opportunities, and needs for the implementation of the *PAE Health Workforce eLearning Initiative* in the subregion.

The interview will last about 1 hour. Your participation is completely voluntary, and you may leave at any time or choose not to answer any questions that you do not wish to answer. With your permission, we would like to record this interview to make sure we do not miss anything. We will also take notes throughout the interview. No one except members of our research team will listen to the recording or see our notes. All information that you provide will be kept confidential, and your name and any other identifying information will not be included in our final report.

Do you have any questions about what I have discussed so far?

With all this information, would you like to participate in this interview today?

Do I have your permission to record this session?

Warm-up Questions:
Practitioner's Experiences

- Tell me about your work experience.
    - [If not stated] How many years have you been working in your field?
- Tell me what you know about the various methods used in training practitioners in your field?
- Can you describe a particular training modality that is mostly used in your workplace?
    - On average, how many on-the-job trainings do you have every 6 months?
- Can you describe how familiar you are, with the different Information and Communication Technology (ICT) approaches that could be used for advancing your learning?
    - If they ask for examples: computer-assisted learning, social media-based learning etc.

Main Questions (including follow-ups):

Practitioner's Training Preferences (Contextual Fit)

- Could you share what you perceive might be the preferred training modality(ies) for practitioners in your field based on your experience?
    - How do you think training modality preferences would differ among practitioners in your field?
    - Can you tell what you consider as the relationship between training modality preferences and its uptake?

Practitioner's Multi-communication, Online Training Acceptability (Contextual Fit)

- What are your thoughts on the acceptability of a multi-communication, online training (i.e., an intervention that incorporates a combination of live and self-paced online training design with a wide range of ICT-enabled approaches such as facilitated learning, digital-simulation-based learning, social media-based learning) among practitioners in your field?
    - Could you describe what you think are some of the factors that may influence the acceptance of a multi-communication, online training among practitioners in your field?
    - What are some of the fundamental principles that you assume practitioners in your field would assess to make informed decisions about the acceptability of a multi-communication, online training?

Practitioner's Multi-communication, Online Training Willingness to Use (Feasibility)

- How would you describe the willingness of practitioners in your field to use a multi-communication, online training in the future?

Constraints and Enablers for Multi-communication, Online Training (Feasibility)

- Drawing from your experience, could you tell me what you think are the existing issues that might prevent the successful implementation of a multi-communication, online training for practitioners like you in the West African subregion?
- Could you share what you expect to be the motivating factors for practitioners in your field to be willing to use a multi-communication, online training?

Recommendations for Multi-communication, Online Training

- What other information would you like to share that could help us know why you think online training may be useful for your current job?
- How would you like the online trainings to be delivered?

Appendix 5. In-Depth Interview Guide (French)

Guide d'entretien approfondi

Introduction/Consentement éclairé :

Bonjour, [nom de la personne interrogée]. Je m'appelle [votre nom] et je serai votre intervieweur aujourd'hui. Nous vous demandons de participer à cet entretien pour l' *Initiative d'apprentissage en ligne pour les personnels de santé de santé publique, de santé animale et environnementale (PAE)* pour la sécurité sanitaire mondiale, dirigée par l'Organisation ouest-africaine de la santé et l'Université Emory.

Comme vous le savez déjà, le but de ce projet est de mieux comprendre l' **adéquation contextuelle** et **la faisabilité** d'une intervention de formation en ligne multi-communication parmi les agents de santé publique des secteurs de la santé humaine, animale et environnementale en Afrique de l'Ouest. Dans le cadre de ce projet, nous aimerions vous parler de vos expériences en tant que praticien actif dans votre domaine, basées sur vos engagements de travail directs et vos interactions avec vos collègues, et que vous partagiez vos opinions sur ce que vous pensez être. les valeurs, les défis, les opportunités et les besoins pour la mise en œuvre du *PAE Initiative d'apprentissage en ligne pour les personnels de santé* dans la sous-région.

L'entretien durera environ 1 heure. Votre participation est entièrement volontaire et vous pouvez quitter à tout moment ou choisir de ne pas répondre aux questions auxquelles vous ne souhaitez pas répondre.
Avec votre permission, nous souhaitons enregistrer cette interview pour être sûrs de ne rien manquer. Nous prendrons également des notes tout au long de l'entretien. Personne, à l'exception des membres de notre équipe de recherche, n'écoutera l'enregistrement ou ne verra nos notes. Toutes les informations que vous fournissez resteront confidentielles et votre nom et toute autre information d'identification ne seront pas inclus dans notre rapport final.

Avez-vous des questions sur ce dont j'ai discuté jusqu'à présent ?

Avec toutes ces informations, souhaiteriez-vous participer à cette interview aujourd'hui ?

Ai-je votre autorisation pour enregistrer cette session ?

Questions d'échauffement :
Expériences du praticien

- Parlez-moi de votre expérience professionnelle.
    - [Si non précisé] Depuis combien d'années travaillez-vous dans votre domaine ?
- Dites-moi ce que vous savez des différentes méthodes utilisées pour former les praticiens dans votre domaine ?
- Pouvez-vous décrire une modalité de formation particulière qui est principalement utilisée sur votre lieu de travail ?
    - En moyenne, combien de formations sur le terrain suivez-vous tous les 6 mois ?

- Pouvez-vous décrire dans quelle mesure vous êtes familier avec les différentes approches des technologies de l'information et de la communication (TIC) qui pourraient être utilisées pour faire progresser votre apprentissage ?
    - S'ils demandent des exemples : apprentissage assisté par ordinateur, apprentissage basé sur les médias sociaux, etc.

Questions principales (y compris les suivis) :

Préférences de formation du praticien (ajustement contextuel)

- Pourriez-vous nous dire ce que vous pensez être la ou les modalités de formation préférées pour les praticiens de votre domaine, en fonction de votre expérience ?
    - Selon vous, dans quelle mesure les préférences en matière de modalités de formation différeraient-elles parmi les praticiens de votre domaine ?
    - Pouvez-vous nous dire ce que vous considérez comme la relation entre les préférences en matière de modalités de formation et leur adoption ?

Multi-communication du praticien, acceptabilité de la formation en ligne (ajustement contextuel)

- Que pensez-vous de l'acceptabilité d'une formation en ligne multi-communications (c'est-à-dire une intervention qui intègre une combinaison de conception de formation en ligne en direct et à votre rythme avec un large éventail d'approches basées sur les TIC telles que l'apprentissage facilité, la simulation numérique) (apprentissage basé sur les réseaux sociaux, apprentissage basé sur les médias sociaux) parmi les praticiens de votre domaine ?
    - Pourriez-vous décrire ce que vous pensez être certains des facteurs qui peuvent influencer l'acceptation d'une formation en ligne multi-communications parmi les praticiens de votre domaine ?
    - Quels sont certains des principes fondamentaux que, selon vous, les praticiens de votre domaine évalueraient pour prendre des décisions éclairées sur l'acceptabilité d'une formation en ligne multi-communications ?

Volonté d'utilisation de la formation en ligne multi-communication du praticien (faisabilité)

- Comment décririez-vous la volonté des praticiens de votre domaine d'utiliser une formation en ligne multi-communications à l'avenir ?

Contraintes et catalyseurs de la multi-communication, formation en ligne (faisabilité)

- En vous appuyant sur votre expérience, pourriez-vous me dire quels sont, selon vous, les problèmes existants qui pourraient empêcher la mise en œuvre réussie d'une formation en ligne multi-communication pour les praticiens comme vous dans la sous-région de l'Afrique de l'Ouest ?
- Pourriez-vous nous dire quels sont, selon vous, les facteurs de motivation qui incitent les praticiens de votre domaine à être disposés à utiliser une formation en ligne multi-communications ?

Recommandations pour la formation multi-communication en ligne

- Quelles autres informations souhaiteriez-vous partager qui pourraient nous aider à comprendre pourquoi vous pensez qu'une formation en ligne peut être utile pour votre emploi actuel ?
- Comment souhaiteriez-vous que les formations en ligne soient dispensées ?

Appendix 6. Distribution of West Africa's Public Health Workforce Density, Economy, and Global Health Security Index Score.

	Total Population[1] (2018) n	**Public Health Workers**[2] (2018) n		**PH:P Ratio** (2018)	**GDP per capita**[3] (2018) $	**GHS Score Index**[4] (2019)
Subregion						
West Africa	390,953,045	1,054,042		1:371	2,594	32.3
			Proportion of PH %			
Country						
Benin	11,940,683	10,630	1.01	1:1,124	2,220	28.8
Burkina Faso	20,392,723	26,305	2.50	1:776	1,590	30.1
Cabo Verde	571,202	3,537	0.34	1:162	6,831	29.3
Cote d'Ivoire	25,493,988	76,376	7.25	1:334	3,714	35.5
Ghana	30,870,641	122,183	11.59	1:253	4,267	35.5
Guinea	12,554,864	27,857	2.64	1:451	1,606	32.7
Guinea-Bissau	1,924,955	7,890	0.75	1:244	1,501	20.0
Liberia	5,193,416	24,620	2.34	1:211	818	35.1
Mali	21,904,983	26,976	2.56	1:812	1,667	29.0
Mauritania	4,614,974	9,454	0.90	1:489	3,458	27.5
Niger	22,577,058	8,554	0.81	1:2,640	965	32.2
Nigeria	198,387,623	632,325	60.0	1:314	5,238	37.8
Senegal	15,574,909	41,781	3.96	1:373	2,617	37.9
Sierra Leone	7,861,281	8,054	0.76	1:976	1,684	38.2
The Gambia	2,444,916	3,924	0.37	1:623	1,882	34.2
Togo	8,644,829	23,576	2.24	1:367	1,451	32.5

n= frequency; %= percentage of public health workers in each country among all public health workers; $= international dollar, PH:P= Public Health Worker-Population, GDP= Gross Domestic Product, and GHS= Global Health Security Index. Note that PH:P, GDP per capita, and GHS score index for West Africa were calculated as average of their values for respective countries.

References

1. The World Bank. Population, total- Sub-saharan Africa. 2018. https://data.worldbank.org/indicator/SP.POP.TOTL?locations=ZG.

2. World Health Organization (WHO). The State of the Health Workforce in the WHO African Region, 2021. 2021. Available from: https://apps.who.int/iris/bitstream/handle/10665/348855/9789290234555-eng.pdf?sequence=1

3. Our World in Data. GDP per capita, 2018. https://ourworldindata.org/grapher/gdp-per-capita-maddison?tab=table&region=Africa

4. Nuclear Threat Initiative. 2019 Global Health Security Index. 2019. https://www.ghsindex.org/wp-content/uploads/2019/10/2019-Global-Health-Security-Index.pdf

Appendix 7. Balance Assessment, and Sample Weights Computation.

To improve representativeness of the aggregated results, two statistical weighting strategies were employed. First, an inverse probability weighting was employed to account for unequal probability of selection of participants due to lack of a sampling frame based on the non-probability sampling technique (i.e., virtual snowball sampling) used in this study.

Second, given evidence of unequal distributions of the sample population's baseline characteristic (country) to the target population in **figure a** below, we performed post-stratification weighting at the country level using the cell weighting method in SAS version 9.4 (SAS Institute, Cary, North Carolina, USA).

The distribution for the country level was based on data from the WHO report on health workforce in the African region in 2018,[1] which is summarized in ***appendix 6***. Country variable was only included because of lack of distribution of the health workforce by other important sociodemographic characteristics (e.g., age, sex, sector) in the report. Nonetheless, country is considered to be highly correlated to our study objectives based on how differences in culture, national priorities, and economic strength is likely to influence acceptability and use of technology, hence, constructing post-stratification weights for it would help to minimize any potential selection bias from the study.

Final weights (*Wfinal*) were computed as a product of inverse probability weight (*Wipw*) and post-stratification weight (*Wpsw*)

Inverse probability weight (*Wipw*)

$$\pi_{scp} = (\pi_{c|s})\,(\pi_{p|cs})$$

When:

$\pi_{c|s}$: probability of selecting a country given a language group. Calculated as the number of countries sampled in respective language strata divided by the total number of countries in the language strata.

$\pi_{p|s}$ was assigned as 1 for each country since all the 16 countries of the West African subregion were represented in the online survey.

$\pi_{p|cs}$: probability of selecting a public health worker given a country and language group. Calculated as the number of public health workers sampled in a country divided by the total number of public health workers in the country.

$$Wipw = \frac{1}{\pi_{scp}}$$

Post-stratification weight (*Wpsw*)

$$Wpsw = \frac{Subregional\ population\ \%}{Sample\ population\ \%}$$

$Subregional\ population\ \%$: proportion of the subregional population of public health workers (i.e., target population) in each country. Calculated as the number of public health workers in each country divided the total number of public health workers in the subregional population multiplied by 100.

$Sample\ population\ \%$: proportion of the sample population of public health workers (i.e., study population) in each country. Calculated as the number of public health workers in each country divided the total number of public health workers in the sample population multiplied by 100.

Final weights (*Wfinal*)

$$Wfinal = Wipw\ x\ Wpsw$$

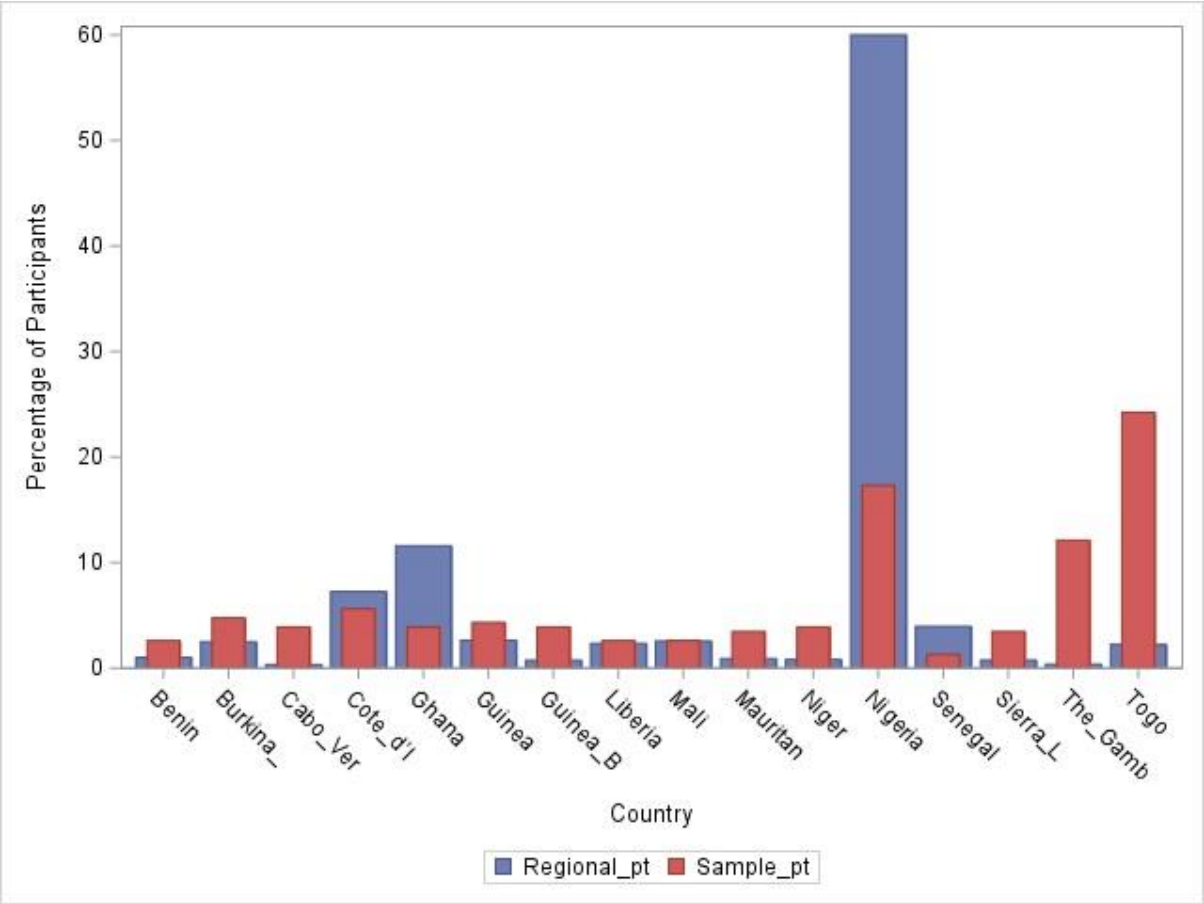
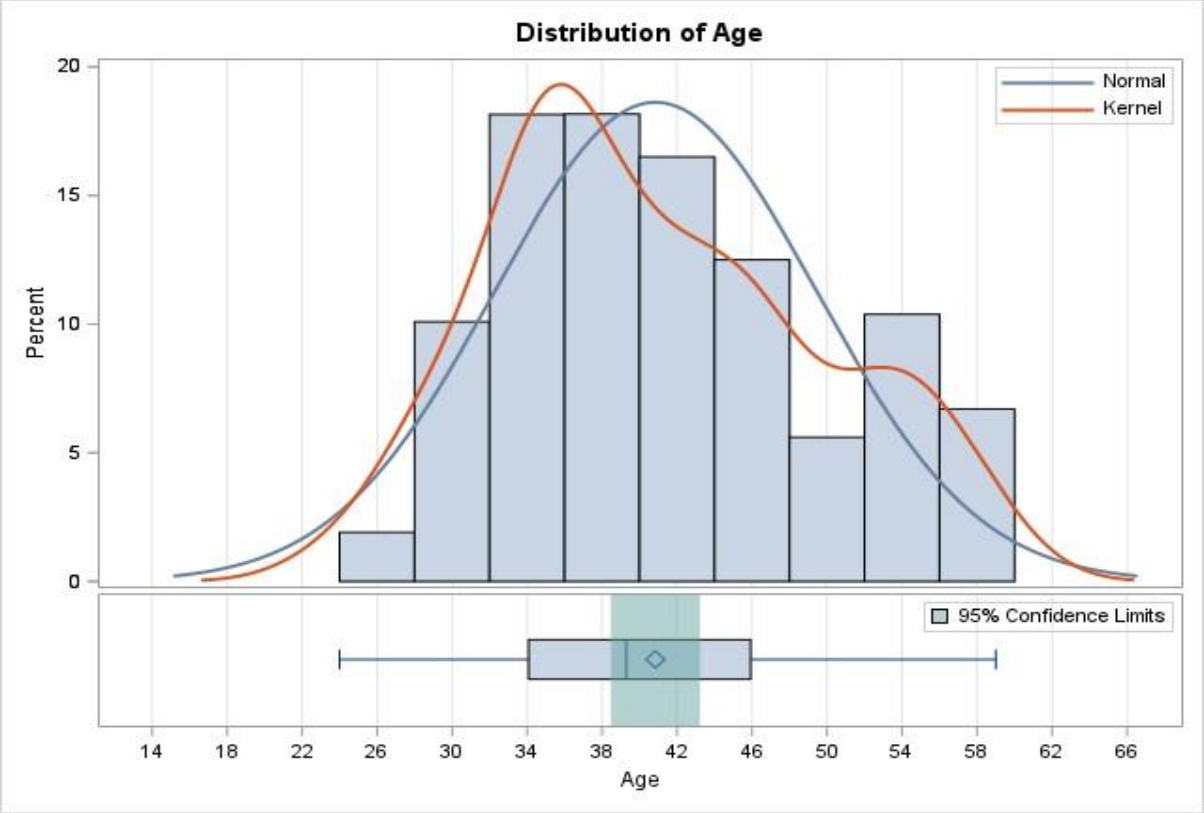


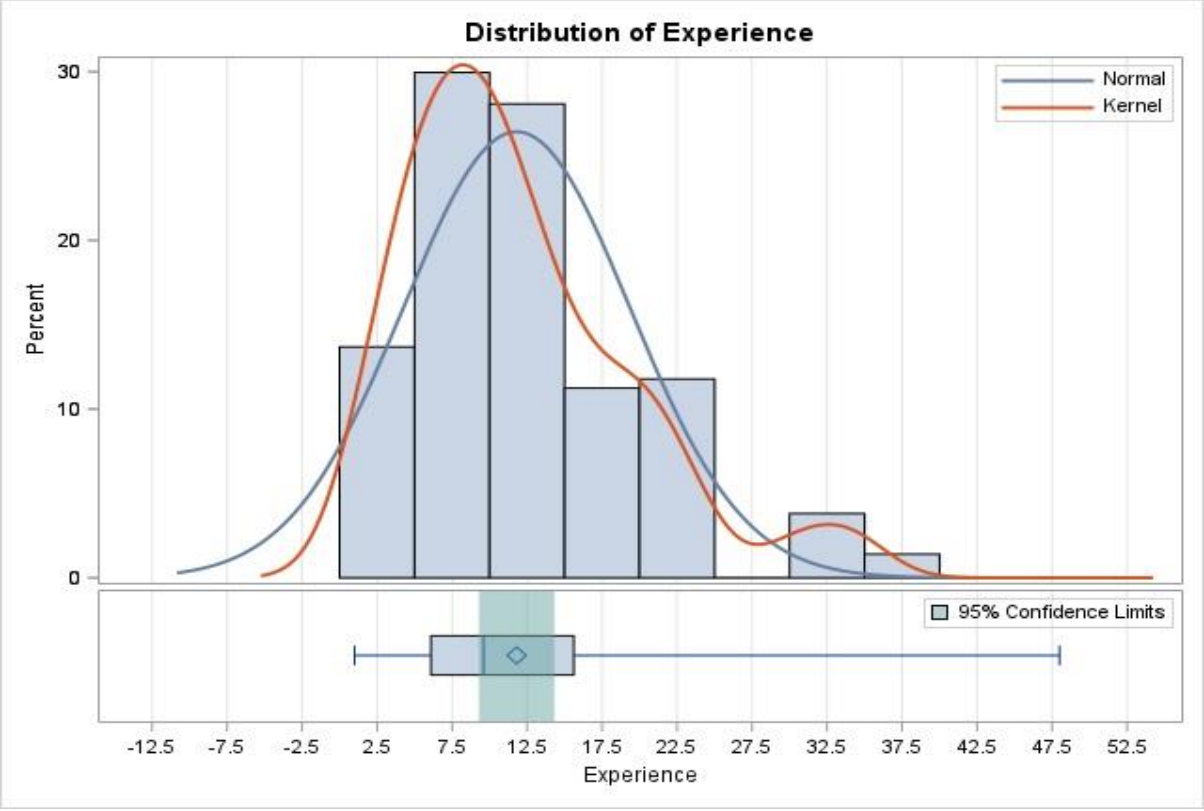
Figure a. Baseline assessment of study population distribution by country to the West African public health workers population.

References

1. World Health Organization (WHO). The State of the Health Workforce in the WHO African Region, 2021. 2021. Available from: https://apps.who.int/iris/bitstream/handle/10665/348855/9789290234555-eng.pdf?sequence=1

Appendix 8. Normality Tests





Appendix 9. Braun and Clarke 15-Point Checklist of Criteria for Good Thematic Analysis Process

Process	No	Criteria	Response
Transcription	1.	The data have been transcribed to an appropriate level of detail, and the transcripts have been checked against the tapes for 'accuracy'.	All seven in-depth interviews transcribed to an appropriate level of detail and checked against tapes.
Coding	2.	Each data item has been given equal attention in the coding process.	We reviewed all quotations to generate coding.
	3.	Themes have not been generated from a few vivid examples (an anecdotal approach) but, instead, the coding process has been thorough, inclusive and comprehensive.	Themes, and the findings described herein were developed from a complete coding process of the entire dataset. The coding process was thorough, inclusive and robust, as all quotations were used to generate codes, and develop themes. Each theme was developed based on numerous codes gathered across a range of participants quotations.
	4.	All relevant extracts for all each theme have been collated.	Yes.
	5.	Themes have been checked against each other and back to the original data set.	Yes.
	6.	Themes are internally coherent, consistent, and distinctive.	Yes.
Analysis	7.	Data have been analysed rather than just paraphrased or described.	Yes.
	8.	Analysis and data match each other – the extracts illustrate the analytic claims.	Yes.
	9.	Analysis tells a convincing and well-organised story about the data and topic.	Yes.
	10.	A good balance between analytic narrative and illustrative extracts is provided.	Yes.
Overall	11.	Enough time has been allocated to complete all phases of the analysis adequately, without rushing a phase or giving it a once-over-.lightly.	Yes.
Written report	12.	The assumptions about thematic analysis are clearly explicated.	Yes.
	13.	There is a good fit between what you claim you do, and what you show you have done – ie, described method and reported analysis are consistent.	Yes.
	14.	The language and concepts used in the report are consistent with the epistemological position of the analysis.	Yes.
	15.	The researcher is positioned as *active* in the research process; themes do not just 'emerge'.	Yes.

Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol.* 2006;3:77–101.

Appendix 10. Good Reporting of a Mixed Methods Study (GRAMMS) Checklist

Guideline	Section: Page
Justification to use a mixed methods approach to the research question	Chapter 4: Methods p. 36
Articulation of the design in terms of purpose, priority, and sequence of methods	Chapter 4: Methods p. 39-43
Describe each method in terms of sampling, data collection and analysis	Chapter 4: Methods p. 39-43 Chapter 4: Methods p. 44-48
Delineate where and how integration occurs and who has participated in it	Chapter 4: Methods p. 49
Describe any limitation of one method associated with the presence of another	Chapter 6: Discussion, Conclusion, and Public Health Implications p. 112-113
Describe insights gained from mixing or integrating methods	Chapter 5: Results p. 52-103 Chapter 6: Discussion, Conclusion, and Public Health Implications p. 104-115

O'Cathain A, Murphy E, Nicholl J. The quality of mixed methods studies in health services research. *J Health Serv Res Policy*. 2008;13:92–98.