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COVID-19 and Handwashing

Implications for Water Use in Sub-Saharan Africa

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COVID-19 and Handwashing: Implications for Water Use in Sub-Saharan Africa

Franklin Amuakwa-Mensah, Rebecca Afua Klege, Philip Kofi Adom, and Gunnar Köhlin*

Abstract

Because the main modes of transmission of the COVID-19 virus are respiration and contact, WHO recommends frequent washing of hands with soap under running water for at least 20 seconds. This article investigates how the level of concern about COVID-19 affects the likelihood of washing hands frequently in sub-Saharan Africa. The study makes use of a unique survey dataset from 12 sub-Saharan African countries collected in April 2020 (first round) and May 2020 (second round) and employs an extended ordered probit model with an endogenous covariate. The results show that the level of concern about the spread of the virus increases the likelihood of washing hands with soap under running water for a minimum of 20 seconds at least five times a day. The increase in the probability of handwashing due to concern about COVID-19 ranges from 1.4% for Nigeria to 7.2% for South Africa. The results also show heterogeneous effects across gender- and age-groups. Though this suggests an increase in handwashing, the sustainability of the handwashing protocol could be threatened by the severe water scarcity that exists in the region. To sustain frequent handwashing, sub-Saharan Africa needs an effective strategy for water management and supply.

Keywords: Covid-19; handwashing; water use; Sub-Saharan Africa

JEL Codes: I18, Q25

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1. Introduction

In December 2019, the city of Wuhan, in China, recorded cases of COVID-19 caused by the SARS-COV-2 virus. By January 30, 2020, the World Health Organisation (WHO) declared a virus pandemic of international concern (Desai and Patel, 2020). Since its identification in Wuhan, the virus has spread across all continents of the world, affecting more than 180 countries. In the beginning of March 2020, the total active cases stood at 109,000 with 3,800 deaths (WHO, 2020). As of May 30, the total cases globally had risen to 5,931,963 (CNN coronavirus tracker, 2020). The number of deaths as of May 30, 2020, stood at 365,051, which is 96.07 times the number recorded in March 2020. Global recoveries are more than 2 million people. In Africa, as of May 30, 2020, the total recorded cases were 135,375, with recorded recoveries of 56,401 and deaths of 3,923 (source: Africa CDC, Johns Hopkins; NcoVAfrica). Developed economies in Europe, North America and Asia have been hard hit by the pandemic. Even though Africa might still not have seen its greatest impact, already there are predictions about the possible increase in the fatality rate on the continent due to its weak social and economic infrastructure base.

The global spread of the novel COVID-19 virus has negatively affected many health systems around the globe, even the most robust ones. In addition, extended restrictions on movement and other lockdowns could trigger major social and economic crises (Loayza and Pennings, 2020). Many economies around the world have revised their 2020 year-end growth targets downwards due to the negative impact of the virus on production, distribution and consumption (Maliszewska, Mattoo, and van der Mensbrugghe (2020)). For an example in Africa, the World Bank as of 9th April, 2020 estimated that the GDP growth in sub-Saharan Africa could fall sharply by between 4% to 7.5% from 2019 level (World Bank, 2020). Without drastic measures to contain the spread of the virus, the estimated ramifications on global economies may far exceed anything we have ever witnessed.

The two main routes for the transmission of COVID-19 are respiration and personal contact. Measures recommended to contain human-to-human transmission include isolation, quarantine, social distancing and community containment (Cohen and Kupferschmidt, 2020). According to Maier and Brockmann (2020), these measures have proven to be effective in containing the spread of the virus in South Korea and China. In addition, the WHO & UNICEF (2020) have recommended some basic measures to help reduce the spread of COVID-19. They include frequent washing of hands for at least 20 seconds using water and soap.

Handwashing is effective in curbing infectious diseases. For instance, Jefferson et al. (2009 & 2011) found that handwashing reduced transmission of respiratory viruses by 45-55%. For H1N1 influenza, Saunders-Hastings et al. (2017) found that handwashing reduced transmission in human populations by 38%. Smith et al. (2015) showed that handwashing effectively reduced transmission of influenza among adults. According to the WHO & UNICEF (2020), providing water, sanitation and hygiene (WASH) are crucial to protecting human health from all forms of infections, including COVID-19. The WHO estimates that, before COVID-19, lack of access to safe drinking water and adequate sanitation hygiene increased the global incidence of disease burden by about 10%. In urban areas, the estimate showed that the return in saved medical costs and increased productivity for every US$1 investment in basic sanitation is US$2.5 (WHO & UNICEF, 2020). The amount saved for rural areas for similar investment in sanitation is US$5. Mattioli et al. (2014) reported that the quantity of water used is associated with less viral contamination of hands. Hoque (2003) estimates that 0.5 to 2 litres of daily water per person enable reduction of faecal contamination.

The above suggests that applying robust and consistent WASH programmes could effectively help contain the spread of the virus. However, while the washing of hands might be considered a routine gesture in developed economies with proper water resource infrastructure, for developing economies, such as Africa, it might be a luxurious endeavour. In Africa, a significant number of people do not have access to handwashing facilities. In sub-Saharan Africa, about 258 million people lack access to handwashing (UNICEF & WHO Joint Monitoring Programme Reports). Figure 1 below shows the plot of the coverage of people without access to handwashing facilities. It is clear from the figure that Middle, Western and Eastern African regions have the lowest levels of handwashing facilities in the world.

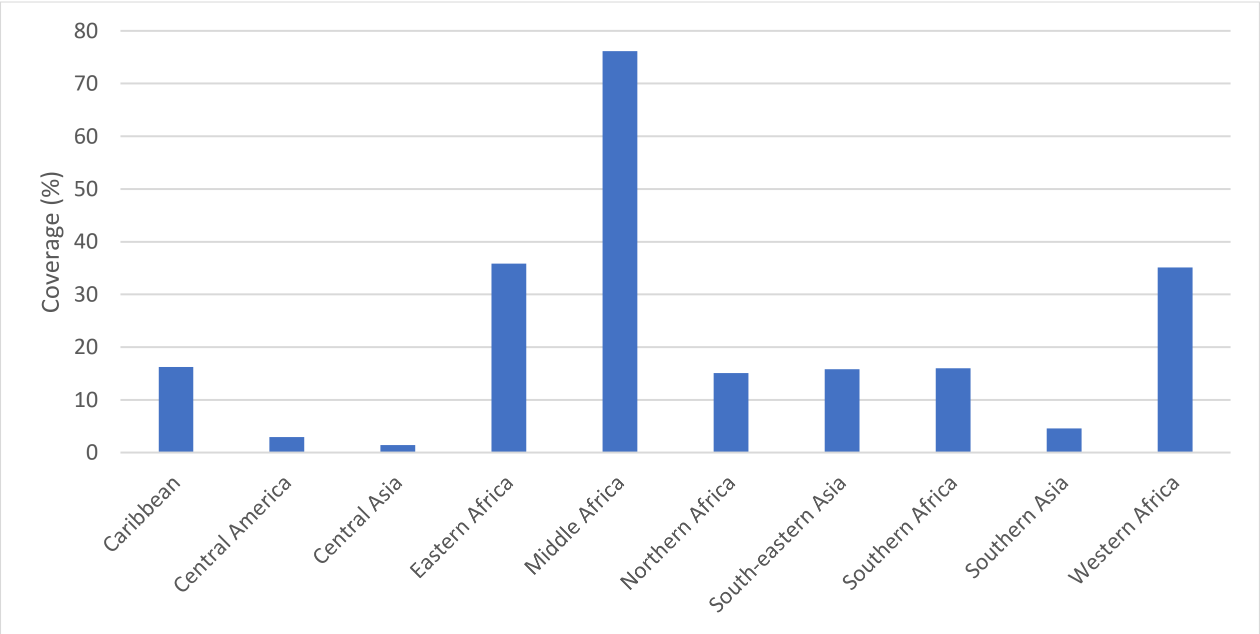

Figure 1: Percentage of people without handwashing facility, 2017
Source: Data from WHO & UNICEF Joint Monitoring Programme Report

Figure 2 reports the proportion of people without access to a handwashing station with soap and water as of 2019. Again, we see that the numbers are relatively high in Africa. One of the primary reasons is that the region has acute water shortage problems. As Baye (2020) noted for Ethiopia, the suboptimal level of access to water and soap makes adopting the recommended handwashing action difficult, especially in rural areas.

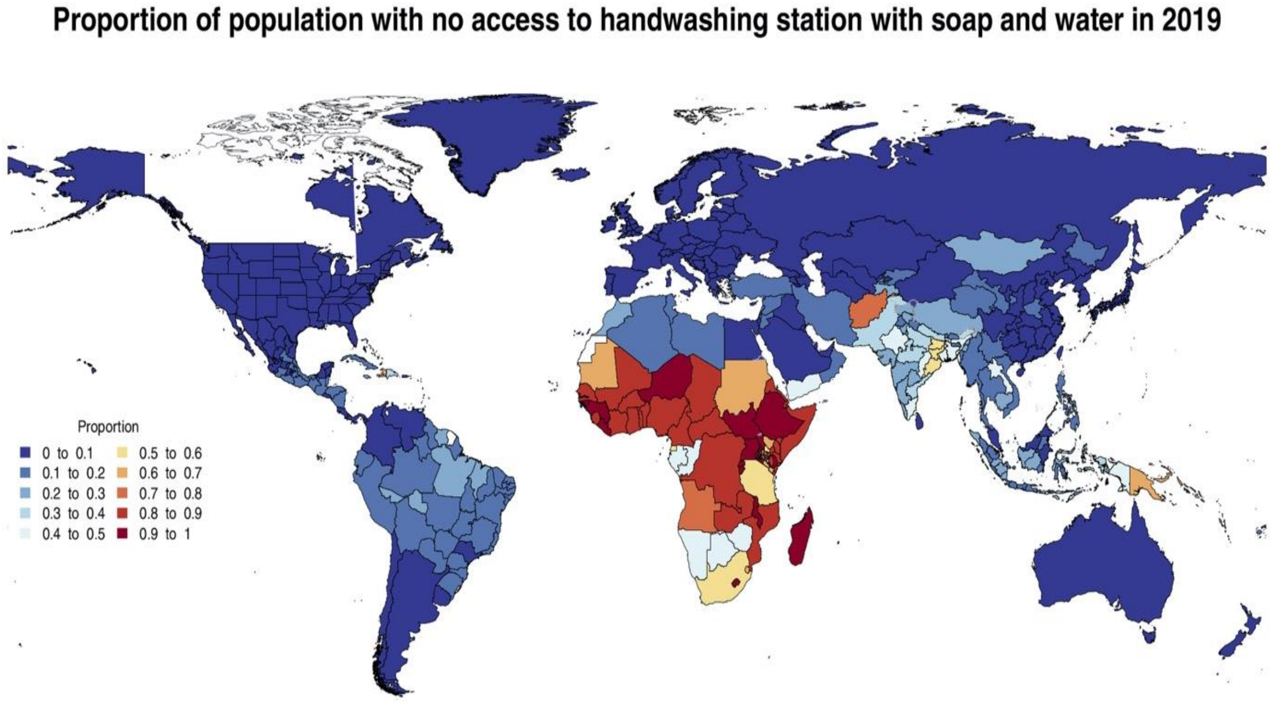

Figure 2: Estimated proportion of the population with no access to a handwashing station with soap and water in 2019.
Source: Brauer et al. (2020) https://doi.org/10.1289/EHP7200)

In such a water and handwashing facility constrained environment, it is logical to infer that positive attitudes towards the washing of hands and the frequency of handwashing could be impacted negatively. The aim of this article is to model the frequency of handwashing as a function of the level of concern about the novel COVID-19 in Africa.

There is limited economic analysis of how the level of concern about infectious disease, conditioned on other socio-demographic factors, affects the frequency of handwashing, and this is even more limited for COVID-19. For example, Brauer et al. (2020) examined access to handwashing and its implications for COVID-19 control in low-income countries. Their study focused on estimating the number of people with/without access to handwashing with soap and water. Anim and Ofori-Asenso (2020) through a letter described the link between water scarcity and COVID-19 in sub-Saharan Africa. Baye (2020), using household survey data, looked at the preventive measures against COVID-19 in Ethiopia, highlighting the constraints to basic services in Ethiopia. None of these studies looked at the relationship between the level of concern about the pandemic and the frequency of handwashing. This study fills this gap in the literature.

Our study is based on survey data from 12 Sub-Saharan African countries, collected between April 2nd and April 9th, 2020 (first-round data collection), and from April 24th to May 8th 2020 (second-round data collection) by GeoPoll. A simple random sampling technique was used by GeoPoll to select respondents from their database, which consists of a list of mobile subscribers in each country surveyed. We employed an extended ordered probit model with an endogenous covariate to address the potential endogeneity associated with concern about COVID-19. Principal component analysis was used to compute composite indexes based on the individual's sources of information about COVID-19, to serve as an instrument for the level of concern about COVID-19. We controlled for the effects of age, gender and residential type because vulnerability to water scarcity and stress and lack of handwashing facilities is not homogeneous. Moreover, demographic distributions of affected persons reveal higher vulnerabilities for certain groups of people.

The results show that the level of concern about the spread of COVID-19 significantly increases the frequency of handwashing with soap under running water for at least 20 seconds. We also observed heterogeneities of the effect of level of concern about the spread of COVID-19 on frequency of handwashing across gender, age group, and the selected sub-Saharan African countries. Given the lack of access to potable water and handwashing stations with soap and water in this region, and the projected spread and persistence of COVID-19 for at least two years, our findings generate the need for concern and policy action about water resource provision and management in the region.

The rest of the study is organised as follows. Section 2 reviews the relevant theoretical and empirical literature. Section 3 discusses the method and data. Section 4 presents the main findings with a discussion, and section 5 concludes with some policy recommendations.

2. Theoretical and Empirical Literature

Handwashing is a simple yet effective way to prevent the spread of infections and diseases (Borghi, Guinness & Curtis, 2002; Mackert, Liang & Champlin, 2013). The Health Belief Model (Janz and Becker, 1984), the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and the Theory of Planned Behavior (Ajzen,1991) and its extensions (Whitby et al., 2006) underpin most handwashing studies. The Theory of Planned Behavior (TPB) is the most widely used theoretical framework amongst these theories (Pittet et al., 2011; Sax et al., 2007; Whitby, McLaws & Ross, 2006; Pessoa-Silva et al., 2005; Jenner et al., 2002; O'Boyle, 2001). TPB suggests that intention, which can be influenced by attitudes, subjective norms and perceived behavioral controls, is a significant driver of behaviour. Based on this theory, handwashing practices are assumed to be driven by the following: positive or negative evaluations, social pressures, and the individual's assessment of the level of ease or difficulty (White et al., 2015).

Several studies on handwashing have adopted TPB by focusing only on the behavioural aspects of hand hygiene. For instance, Mackert et al. (2013) adopted TPB to design a campaign aimed at increasing handwashing behaviors among university students. Their results show that, although students' behavior towards handwashing did not change due to the campaign, more students (12%) did use soap. Kitsanapun and Yamarat (2019) also adopted TPB to assess handwashing behaviors among public health students. The authors show that, while attitudes towards handwashing are generally favourably high among public health students, they usually do not adhere to prescribed handwashing protocols. Other notable studies that have relied on the TPB framework include White et al. (2015) and Reyes Fernandez et al. (2016).

In Sub-Saharan Africa, Seimetz et al. (2017) adopted TPB to examine school handwashing programs in rural Burundi and Zimbabwe. They show that, for both countries, self-efficacy and social norms were the most effective in changing handwashing behaviours. Similarly, Curtis et al. (2009) reviewed planned, motivated and habitual hygiene behaviours in eleven countries, including six African countries (Ghana, Kenya, Tanzania, Uganda and Madagascar). Their results show that, whereas education at an early age influences improved handwashing behaviours, fear of diseases did not exist, except for occasional outbreaks of epidemics like cholera. While behavioural factors may limit handwashing practices, water scarcity, a common characteristic of many developing countries, continues to contribute to the low levels of hand hygiene behaviours (Baye, 2020). This can pose significant challenges for less developed countries during this unprecedented era of the global COVID-19 pandemic.

In a cross-sectional study conducted in Uganda, Atuyambe, Ediau, and Orach (2011) observed that water and soap were not usually available at handwashing facilities and therefore negatively impacted handwashing practices. Sheth et al. (2010), in a clinic-based study targeted at pregnant women in Malawi, demonstrate that participants in a water treatment intervention program are more likely to improve the quality of water use and additionally demonstrate better handwashing practices. Duse, Da Silva and Zietsman (2003) examine coping hygiene practices in South Africa, a water-scarce country. Results show that, although there is a need for government to expand the provision of water resources, education is vital for the promotion of food handling and handwashing practices. Pengpid and Peltzer (2012) reviewed hygiene behaviours in African countries. They concluded that knowledge and hygiene practices in African communities and healthcare settings are low, which they attributed to the availability of resources, such as water and soap. Rosen and Vincent (1999) also identified a clear path in which inadequate household water supply will lead to infectious and water-related diseases. In a systematic review of handwashing practices, Freeman et al. (2014) further highlight that handwashing reduces the risk of contracting diseases such as diarrhoea.

These studies go on to suggest that, in less developed countries, where poor health care systems, high population densities, poor sanitation, and water scarcity are the norm, a simple act of handwashing proven to limit the transmission and contraction of COVID -19 could be a challenge. Brauer et al. (2020) have already set the pace by examining global access to handwashing and the implications for COVID-19 control in low-income countries. However, that study, just like the many other studies on handwashing, is skewed towards health sciences. Our study, therefore, tackles the subject of handwashing and COVID-19 from an economic perspective, where resource availability and allocation are vital for decision-making.

3. Methodology and Data

3.1 Conceptual Framework

Conceptually, our study builds on the integrated social and economic household water model by Jorgensen et al. (2009) to include the current COVID-19 crisis and handwashing behaviours. Previous studies suggest that demographics/socioeconomic factors, and household characteristics and composition (which include household size, land area, location, income, appliances and the presence of pool facilities) influence the consumption levels of water (Domene & Sauri, 2006; Gregory & Di Leo, 2003; Renwick and Archibald, 1998). Another major determinant of water consumption is pricing. Renwick and Archibald (1998) suggest that low-income households are more likely than higher-income households to respond to price increments. Similarly, Kenney et al. (2008) show that price is an essential driver of residential water demand and additionally identify restrictions and climate/weather as contributing factors of water consumption. Past water use, habits, institutional and interpersonal trust, personal characteristics, such as social norms, behavioural control, attitudes and perceived risk of shortages can equally affect water use (Leviston et al., 2005; Heiman 2002; Beedell and Rehman, 1999; Hines et al., 1986; Lee, 1981; Lee and Warren, 1981). Jorgensen et al. (2009), in their integrated framework, discuss these factors based on the empirical model of Corral-Verdugo et al. (2003).

In Figure 3, we modify the integrated framework of Jorgensen et al. (2009) to reflect handwashing behaviours and individuals' level of concern about COVID-19. We hypothesize that an individual's level of concern about COVID-19 will positively impact handwashing, thereby increasing water use. Also, based on the theory of planned behaviour, social norms, attitudes, and perceived behavioural controls may further influence the perceptions and level of concern about COVID-19, which will affect the intention to engage in handwashing. However, these underlying behaviours will depend on exogenous factors, including the scarcity or availability of water. Given that sub-Saharan Africa is not a water-sufficient region, it is likely that the ongoing handwashing campaigns across countries due to the COVID-19 pandemic may be impacted by insufficient access to clean water resources. Our proposed framework explicitly accounts for water scarcity, as depicted in Figure 3.

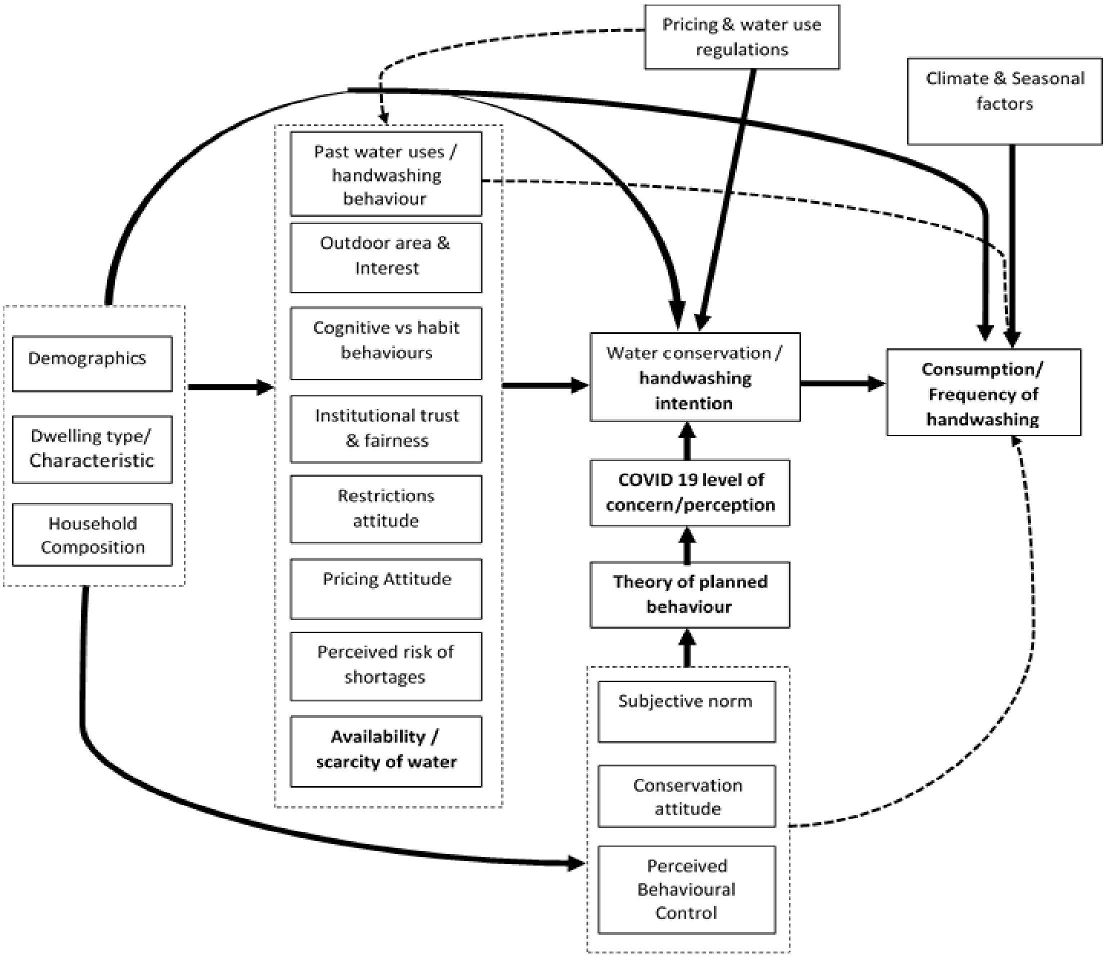

Figure 3: Extension to Jorgensen et al. (2009) integrated social and economic household water consumption model.

3.2 Empirical Estimation

Based on the reviewed literature and the conceptual framework discussed, we model the frequency of handwashing as a function of the level of concern about COVID-19, socioeconomic and demographic factors, and other control variables. Our outcome variable (that is, frequency per day of handwashing under running water with soap for 20 seconds) is ordinal in nature (that is, 0 times, 1-2 times, 3-5 times and more than 5 times). The empirical model is specified in equation 1;

$$y^*_{ijt} = \beta_0 + \beta_1 Covid\_Concern_{ijt} + \boldsymbol{X}_{ijt}\boldsymbol{\beta} + \eta_j + \gamma_t + \varepsilon_{ijt} \quad (1)$$

where the subscripts i, j and t represent the observation for each individual, country and survey wave, respectively; the outcome variable y^* is a latent variable ranging from 0 to ∞; and $Covid\_Concern$ is a variable capturing the individual's level of concern about the spread of COVID-19. On a scale of 1 to 5, with 1 being not concerned and 5 being very concerned, the individual is asked to indicate their level of concern about the spread of COVID-19 in their respective country. The vector $\boldsymbol{X}_i$ represents socioeconomic and demographic factors, and other control variables, such as gender, age, locality (that is, urban-rural), country fixed effect (η_j) and survey wave fixed effect (γ_t). The random error term is captured as ε_{ijt}.

The observed response categories of frequency of handwashing are tied to the latent variable by the measurement model below;

$$y_{ijt} = \begin{cases} 1 \Rightarrow 0\ times & if \quad y^*_{ijt} = 0 \\ 2 \Rightarrow 1 - 2\ times & if\ \ 0 < y^*_{ijt} \leq 2 \\ 3 \Rightarrow 3 - 5\ times & if\ 2 < y^*_{ijt} \leq 5 \\ 4 \Rightarrow 5\ plus\ times & if\ \ 5 < y^*_{ijt} \leq \infty \end{cases}$$

From the expression above, the observed category, y_{ijt}, changes value when the latent variable y^* crosses a threshold. Given the nature of the outcome variable, we estimate the empirical model using an extended ordered probit technique. The level of concern about COVID-19 spread is probably endogenous and this may bias our estimate if not accounted for. To resolve this potential problem, we applied the Principal Component Analysis (PCA) to generate a composite index from the various sources of information the individual receives regarding COVID-19 (that is, newspapers, TV, radio, social media, friends/family, government messages and other), and this serves as an instrument for the level of concern about COVID-19. Based on the PCA, one component had eigen value strictly greater than one (see Table A1 in the appendix) and it explained about 30% of the variation in the indicators of sources of information regarding COVID-19. The oblique rotation of PC loadings in Table A2 (in the appendix) shows that the component consists of the following information sources: friends/family, government media, newspapers, social media and radio.

This component is used as instrument for level of concern about COVID-19. Consequently, we estimate an extended order probit model with an endogenous covariate[1]. The source of information is likely to affect an individual's knowledge about COVID-19, hence influencing his/her concern about the spread of the virus. This implies that the sources of information about COVID-19 are important factors affecting an individual's level of concern about COVID-19 (thus, the relevance assumption is satisfied). Also, our instrument is likely to satisfy the exclusion restriction assumption since the source of information can only affect the frequency of handwashing if one is concerned about the spread of COVID-19 and therefore adheres to the safety protocols such as washing of hands under running water with soap to prevent infection. Thus, our composite indexes obtained from the sources of information are correlated with the level of concern about COVID-19 but uncorrelated with the frequency of handwashing.

[1] We used the eoprobit command in STATA, which uses an instrument for the endogenous covariate (that is, level of concern about COVID-19 in our case).

From existing data from the WHO, the distribution of COVID-19 infection and fatalities have some demographic dimensions. As a result, our study considers subsample analysis across gender- and age-groups. Moreover, access to running water, which is an important element for frequent handwashing, differs across rural and urban areas, hence subsample analysis focusing on these areas is relevant. As COVID-19 responses and access to running water vary across countries, we expect the effect of the level of concern about COVID-19 on the frequency of handwashing to be heterogeneous. Thus, in addition to the pooled analysis, we provide country-specific analysis of the issue.

The standard errors in our estimations are clustered at the primary administrative unit to account for possible correlation in the residual of the frequency of handwashing among individuals within the same community. Access to water and water pricing may be similar for individuals living in the same community. However, our dataset does not have information on these and other relevant factors, which may affect the frequency of handwashing and could correlate among individuals. By clustering the standard errors at the community level, we adjust the standard errors for inference.

3.3 Data and Sampling Design

The data for this study is based on an open-access survey designed and collected by GeoPoll. Two rounds of the survey were administered through SMS and mobile web. The first round occurred between April 2nd and April 9th, 2020, and the second round from April 24th to May 8th, 2020. The data comprises 12 sub-Saharan African countries: Benin, the Democratic Republic of Congo, Ghana, Ivory Coast, Kenya, Mozambique, Nigeria, Rwanda, South Africa, T-country, G-country, and Zambia[2]. The second round ran in all countries except for G-country and T-country. For the first round, a total sample of 4,788 was collected across the 12 countries in Africa, with each country having a sample of 400, except DRC, which had a sample size of 388. The second round had a sample size of 3994, with 400 from each country, with the exception of Rwanda, which had a sample size of 394. These sample sizes give a 5% margin of error and a 95% confidence interval for each round. A simple random sampling technique was used by GeoPoll to select respondents from their database, which consists of a list of mobile subscribers in each country surveyed. The sample was roughly nationally representative by age, gender and location. The survey was administered in English, French, Portuguese, Swahili, and Kinyarwanda, depending on country.

Table 1 shows descriptive statistics for the variables of interest in the econometric analysis. About 54% of the sample were washing their hands for 20 seconds more than 5 times a day prior to the survey; however, 4% did not wash their hands for 20 seconds during the same

[2] GeoPoll insists on making T-country and G-country anonymous. Interested readers can contact the authors for the identification of these countries.

period. The sample comprises about 44% females, and 67% of the total sample live in urban areas. Generally, the level of concern about the spread of COVID-19 is relatively high, with an average score of about 4.3. The age of respondents ranges from 15 to 91 years with an average age of about 31 years. The majority of individuals (that is, 72%) are aged between 15 and 35 years, and only 1.4% of the sample are aged 60 years and above.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Handwashing	9181	3.321	0.863	1	4
Female	9180	0.436	0.496	0	1
Urban	9180	0.6699	0.470	0	1
Level of concern COVID	9180	4.263	1.364	1	5
Age	9180	30.69	9.842	15	91
Handwashing frequency		(%)			
0 times		0.042			
1-2 times		0.138			
3-5 times		0.277			
More than 5 times		0.543			
Age groupings					
Age=<35		0.7188			
35<Age<60		0.267			
Age>=60		0.0139			

Source: Authors' own construction from GeoPoll data

4. Results and Discussion

In Table 2, we estimate ordered probit models with and without an endogenous covariate. In each case, we estimate the model with and without country fixed effect. However, we controlled for survey wave fixed effect in all the models. As stated earlier, the level of concern about COVID-19 is treated as endogenous and we use the derived composite index based on the individual's sources of information as an instrument. From the extended ordered probit model with an endogenous covariate, the composite index (that is, Comp1), which serve as instrumental variable for the level of concern about COVID-19, significantly explain the endogenous variable (see Table A3 in the appendix). This satisfies the relevance assumption. In addition, there exists a significant correlation between the error term of the structural model (that is, handwashing model) and the error term of the model of the level of concern about COVID-19. This indicates that the variable representing the level of concern about COVID-19 is indeed an endogenous covariate, and, as we account for the endogeneity, our estimate for the level of concern about COVID-19 approaches its true estimate[3].

Columns (1) and (2) of Table 2 do not address the problem of endogeneity associated with the level of concern about COVID-19, whereas columns (3) and (4) do. From all the models, the frequency of handwashing is significantly explained by age, level of concern about COVID-19, and gender. Our model of interest is column 4, which accounts for country and wave fixed effects, and also the endogeneity of the level of concern about COVID-19. The results show that the frequency of handwashing increases with the level of concern about COVID-19. That is, as the level of concern about the spread of COVID-19 increases, individuals tend to increase the number of times they wash their hands under running water for at least 20 seconds, as prescribed by WHO as a way of reducing infection. This corroborates the assertion by Borghi, Guinness & Curtis (2000) and Mackert, Liang & Champlin (2013) that handwashing is used to prevent the spread of infections and diseases. Our results also support the theory of planned behaviour, which suggests that intention (influenced by attitudes, subjective norms and perceived behavioural controls) is a significant driver of behaviour, which in our case is handwashing (White et al., 2015). Moreover, our results are consistent with those of Curtis et al. (2009), who, based on a review of eleven countries (with six from Africa), found that education and fear during occasional outbreaks of epidemics like cholera encourage handwashing.

[3] There is no formal test for overidentification for the extended ordered probit model with an endogenous covariate in Stata.

Table 2: Handwashing Ordered Probit Model

VARIABLES	(1) Oprobit	(2) Oprobit	(3) Eoprobit	(4) Eoprobit
Age	0.0271***	0.0247***	0.022***	0.0213***
	(0.00763)	(0.0078)	(0.007)	(0.007)
Age squared	-0.000246**	-0.00023**	-0.0002**	-0.0002**
	(9.85e-05)	(9.94e-05)	(8.8e-05)	(9.07e-05)
COVID-19 Concern	0.0863***	0.0852***	0.441***	0.393***
	(0.0118)	(0.0116)	(0.063)	(0.0596)
Female	0.212***	0.218***	0.1899***	0.204***
	(0.0309)	(0.0318)	(0.028)	(0.029)
Urban	0.00201	0.0549*	-0.014	0.0357
	(0.0301)	(0.0289)	(0.0267)	(0.0261)
Constant				
Observations	9,179	9,179	9,157	9,157
Country FE	NO	YES	NO	YES
Wave FE	YES	YES	YES	YES
Pseudo R2	0.0122	0.0213		
Wald chi2	134.1	464.6	208.8	575.99

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
The outcome variable is the frequency of handwashing in the form of an ordinal variable. Models are stepwise estimated by either controlling or not controlling for country fixed effect. We controlled for wave fixed effect in all the models. Models (1) and (2) are estimated using an ordered probit technique and (3) and (4) are based on extended ordered probit technique with an endogenous covariate. Standard errors are clustered at primary administrative unit.

Table 3 presents the marginal effect based on our estimation. It shows the marginal change in the probability of the outcome (that is, frequency of handwashing: 0 times, 1-2 times, 3-5 times and more than 5 times) resulting from marginal change of each covariate. We find that a marginal increase in the level of concern about the spread of COVID-19 decreases the probability of individuals not washing their hands with soap under running water for 20 seconds. It also decreases the probability of individuals washing their hands 1-2 times and 3-5 times. However, it increases the probability of their washing their hands more than 5 times due to the concern about the spread of COVID-19. The probability of frequency of handwashing 0 times, 1-2 times, 3-5 times and more than 5 times changes on the order of -0.007, -0.014, -0.011 and 0.032, respectively, with a marginal increase in level of concern about the spread of COVID-19. It should be noted that across all categories of frequency of handwashing, the average marginal effects must sum to zero. This is because any increase in the probability of one category must be offset by a decrease in another category.

In the case of age, we find a non-linear relationship between age and the frequency of handwashing (see Table 2). Thus, the frequency of handwashing increases with age and later reduces after a certain threshold. The marginal effect evaluated at the sample mean suggests that a marginal increase in age decreases the probability of not washing hands and of washing hands 1-2 times and 3-5 times, but increases the probability of handwashing more than 5 times (see Table 3).

In the case of gender, the results show a significant difference between females and males in the frequency of handwashing. Females wash their hands relatively more frequently than males (see Table 2). From the marginal effect estimation in Table 3, a change from male to female decreases the probability of not washing hands, or washing hands 1-2 times and 3-5 times, but increases the probability of handwashing more than 5 times. In most developing countries, women and girls are responsible for collecting water and are the main users and managers of water, as they are mainly responsible for cooking, laundry and other household chores like fetching water (UNICEF, 2003). Moreover, women are responsible for enforcing hygienic practices in home environments. This may explain why females frequently wash their hands relative to males.

Table 3: Marginal Effect

VARIABLES	(1) 0 times	(2) 1-2 times	(3) 3-5 times	(4) More than 5 times
Age	-0.001***	-0.002***	-0.001***	0.004***
COVID-19 Concern	-0.007***	-0.014***	-0.011***	0.032***
Female vs Male	-0.018***	-0.036***	-0.029***	0.084 ***

*** p<0.01, ** p<0.05, * p<0.1

4.1 Heterogeneous Effects of Level of Concern about COVID-19 on Frequency of Handwashing

COVID-19 infections and fatalities have demographic dimensions varying across gender and age groups. As a result, we estimate the model for different gender and age groups, and also based on locality (that is, urban/rural). From Table 4, we find a significant effect of level of concern about the spread of COVID-19 on the frequency of handwashing across all categories, with variability in the magnitude of the effects. For gender, we observed this effect is higher for females relative to males. However, there is no statiscally significent different between effect for males and females as shown by the Hausman’s test. There is therefore more potential for both males and females to increase their hand washing due to COVID-19 concerns.

The age group analysis shows that the effect of the level of concern about the spread of COVID-19 on the frequency of handwashing increases with age. Because old age is associated with the severity and mortality of patients with COVID-19 (Jin et al., 2020), and most older individuals have underlying health conditions, especially in sub-Saharan Africa, they tend to be more concerned about the spread of the virus (this is observed from our data). Given their relatively high risk level, it is reassuring to see that older individuals tend to adhere more to the protocols prescribed by health authorities in preventing infections from COVID-19, hence washing their hands more frequently with soap under running water for at least 20 seconds.

Although the level of concern about the spread of COVID-19 increases the frequency of handwashing in both rural and urban areas, surprisingly, the effect is relatively higher in rural areas. This could be due to several reasons. First, the frequent washing of hands may be seen as a critical preventive measure for COVID-19 in rural areas, where they mostly either lack or have deficient health infrastructure. Currently, most treatment centres in sub-Saharan Africa are located in urban areas. Second, the poor economic status of most rural residents could make it more challenging if not impossible to acquire protective equipment, such as hand sanitisers, face masks and personal protective equipment. In China, a survey conducted in January 2020 revealed that about 63.3% of rural communities either could not buy or had difficulty in buying face masks (Thomala, 2020; Liu et al., 2020). Third, the elderly population is likely to be larger in rural areas than in urban areas, which could increase the risk levels in rural areas.

4.2 Country-Specific Analysis

Given that COVID-19 infection and fatality rates, government response, and access to water differ across countries, we examined the effect of the level of concern about the spread of COVID-19 on the frequency of handwashing for each of the 12 sub-Saharan African countries in this study. The results of the ordered probit estimation are shown in Table 5. With the exception of Mozambique, T-country and G-country, we find that frequency of handwashing with soap under running water for at least 20 seconds increases with an increase in the level of concern about the spread of COVID-19 for all the other countries under study. This suggests that individuals in these countries, in an attempt to prevent infection, tend to follow the prescribed protocol of frequent handwashing with soap under running water. For all the countries with significant impact of level of concern of COVID-19 on handwashing, the marginal effect estimation in Table 6 shows that an increase in the level of concern about the spread of COVID-19 decreases the probability of not washing hands, and washing hands 1-2 times and 3-5 times, but increases the probability of handwashing more than 5 times. However, there is variation of the impact across countries. The increase in the probability of handwashing more than 5 times resulting from an increase in the level of concern about COVID-19, for example, ranges from 1.4% for Nigeria to 7.2% for South Africa.

4.3 Implications for Water Usage

From the results, as the level of conern about COVID-19 rises, the likelihood for people to wash their hands multiple times increases. With no sign of decline in COVID-19, our first important deduction is that water usage is increasing. There is a risk of inefficient water management in this pandemic era, when most governments in Africa subsidise the ability of households to gain access to and afford water. For example, the government of Ghana has absorbed all water bills for all Ghanaians for three months from April to June. For households with no home connection to water, the government supplies water to their homes. Also, the government of Ivory Coast paid all water bills for 1 million low-income households in April and May. Furthermore, the government of South Africa during the period of the lockdown established hotline support for areas in need of water.

Second, though we found the level of concern about COVID-19 raises the likelihood of a person washing his/her hands frequently, limited access and the severe water scarcity in sub-Saharan Africa could be an important constraint to sustain the practice, especially among very vulnerable groups, such as the old, rural populations, and women. As shown in columns 5-7 of Table 6, an average of 67% of the population in these countries have access to at least basic drinking water and an average of 23% of the population have access to basic handwashing facilities including soap and water. Even for South Africa, which has relatively higher access to basic drinking water (about 93%) and handwashing facilities (that is, 44%), the country has been faced with a water crisis in the recent past (2017-2018), when they resorted to water-saving campaigns to manage the crisis (Booysen et al., 2019).

A simple correlation test between mean frequency of handwash at the national level and access to water shows a positive statistically significant value of 0.65, implying that an increase in access to water has the potential to increase the frequency of handwashing which is a preventive measure to most viral infection. Given the low access to basic handwashing facilities including soap and water in sub-Sahara Africa, there is a need for proper water resource management and an increase in investment to boost water supply in order to avert potential water crisis. With an increase in water supply and frequent handwashing, other diseases like cholera which are prevalent in region could be prevented.

Table 4: Extended Ordered Probit Model with Endogenous Covariate: Heterogeneous Effects

VARIABLES	(1) Female	(2) Male	(3) Rural	(4) Urban	(5) Age=<35	(6) 35<Age<60	(7) Age>=45[A]
Covid-19 Concern	0.422***	0.369***	0.448***	0.362***	0.37***	0.49***	0.66***
	(0.098)	(0.0762)	(0.112)	(0.065)	(0.072)	(0.11)	(0.142)
Observations	3,995	5,162	3,015	6,142	6,580	2,450	127
Country FE	YES	YES	YES	YES	YES	YES	YES
Wave FE	YES	YES	YES	YES	YES	YES	YES
Wald chi2	333.73	355.5	247.63	437.86	354.59	311.64	210.35
Hausman's test, chi2	0.975		210.39***				

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. The outcome variable is the frequency of handwashing in the form of an ordinal variable. Models are estimated by extended ordered probit with an endogenous covariate. We controlled for age, age squared and locality in the gender models. For the locality models, we controlled for gender, age and age squared. The age-group models controlled for gender and locality. In all the models, we account for country and wave fixed effect. Standard errors are clustered at primary administrative unit. (A) the model could not converge for sub-sample above 60 and also above 50.

Table 5: Country Specific Estimation

VARIABLES	(1) Benin	(2) DR. Congo	(3) Ghana	(4) Ivory Coast	(5) Kenya	(6) Mozambique	(7) Nigeria	(8) Rwanda	(9) South Africa	(10) T-country	(11) G-country	(12) Zambia
Covid Concern	0.080**	0.045*	0.154**	0.091***	0.852***	0.030	0.702***	0.107***	0.204***	0.027	0.074	0.147***
	(0.032)	(0.023)	(0.064)	(0.029)	(0.134)	(0.024)	(0.259)	(0.037)	(0.044)	(0.030)	(0.051)	(0.039)
Observations	822	796	835	854	832	857	904	826	851	400	400	802
Wave FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	NO	YES

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. The outcome variable is the frequency of handwashing in the form of an ordinal variable. We controlled for wave fixed effect in all the models, except G-country and T-country models, which had only one wave. In all models, we controlled for age, age squared, gender and locality (urban dummy). Due to convergence issues and no evidence of endogeneity of level of concern about COVID-19, we estimated all models by an ordered probit technique, except for Kenya, Nigeria and South Africa, where we used an extended ordered probit model with an endogenous covariate. Standard errors are clustered at primary administrative unit.

Table 6: Marginal Effect of Level of Concern about COVID-19 by Country and Proportion of Population with Access to Water

VARIABLES	(1) 0 times	(2) 1-2 times	(3) 3-5 times	(4) More than 5 times	(5) Access to basic drinking water (%)	(6) Safely managed drinking water (%)	(7) Access to HSWS (%)
Benin	-0.008	-0.013	-0.010	0.032	66.41		11.03
DR. Congo	-0.004	-0.008	-0.004	0.017	43.24		4.47
Ghana	-0.007	-0.023	-0.029	0.059	81.45	36.41	41.05
Ivory Coast	-0.010	-0.016	-0.008	0.035	72.86	36.55	19.35
Kenya	-0.006	-0.013	-0.018	0.036	58.92		24.65
Nigeria	-0.002	-0.006	-0.005	0.014	71.38	20.13	41.95
Rwanda	-0.009	-0.014	-0.018	0.041	57.71		4.62
South Africa	-0.011	-0.023	-0.039	0.072	92.68		43.99
Zambia	-0.016	-0.024	-0.017	0.057	59.96		13.94

Columns (1) to (4) are the marginal effect of level of concern about COVID-19 on frequency of handwashing based on the estimations in Table 5. The marginal effect is calculated only for countries with statistically significant effects. Columns (5), (6) and (7), respectively, represent the proportion of the population with access to at least basic drinking water, safely managed drinking water and basic handwashing facilities including soap and water (HSWS). The data for columns (5) to (7) are sourced from the World Bank's World Development Indicators.

5. Conclusion

This study uses a unique dataset from 12 sub-Saharan African countries to investigate the effect of the level of concern about the spread of COVID-19 on the frequency of handwashing with soap under running water for a minimum of 20 seconds. Because the infection and fatality rates of COVID-19 have demographic dimensions, we also considered gender- and age-group analysis. We found that the level of concern about the spread of COVID-19 significantly increases the frequency of handwashing more than 5 times a day. We observed that, on a normal day, females typically wash their hands more frequently than males; however, of the concern about the spread of COVID-19, no statistically significant difference between females and males was found. The effect of the level of concern about the spread of COVID-19 on frequency of handwashing is high for older individuals. This could be attributed to the fact that fatalities caused by COVID-19 are mostly centered in older age groups who are most likely to suffer from underlying medical conditions. The country-specific analysis shows a significant effect of concern about the spread of COVID-19 on frequency of handwashing for nine out of the twelve countries. COVID-19 concerns make individuals in these countries more likely to wash their hands with soap under running water for a minimum of 20 seconds more than 5 times a day, with a probability ranging from 1.4% for Nigeria to 7.2% for South Africa.

Given that access to safe drinking water is a major problem in Sub-Saharan Africa, there is a major concern about the sustainability of the prescribed handwashing protocol and water resources in the region.

COVID-19 impact has also pushed more individuals into poverty given the restrictions on movement and the economic downturn. This may imply that there will be an increase in the number of people who will depend on environmental resources for their livelihood. Consequences may include increasing deforestation, which reduces the ecosystem benefits of the forest to waterbodies, and illegal mining, which would pollute waterbodies in the region. Women and girls are negatively impacted more than men when there is a water crisis since they are the main providers of water in most African homes. In most African countries, women and girls carry water over a long distance each day to make sure that water is available for the household. This activity deprives girls of sufficient time for education. With the projected water scarcity and pollution of waterbodies, the plight of individuals living in sub-Saharan Africa (especially women and girls) will be worsened. The situation in sub-Saharan Africa calls for urgent and effective water management and supply strategies in the region.

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Appendix

Table A1: Eigenvalues from Principal Component Analysis

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.107	1.092	0.301	0.301
Comp2	1.015	0.031	0.145	0.446
Comp3	0.983	0.054	0.140	0.586
Comp4	0.929	0.180	0.133	0.719
Comp5	0.749	0.094	0.107	0.826
Comp6	0.655	0.093	0.094	0.920
Comp7	0.562		0.080	1.000
Kaiser-Meyer-Olkin (KMO)				0.7094
Bartlett test of sphericity (Chi2)				5662.6***

Table A2: PC Loadings for Exploratory Component Analysis with Oblique Rotation

Variable	Comp1	Unexplained
Friends/family	**0.514**	0.442
Government media	**0.443**	0.586
Newspapers	**0.487**	0.50
Othermedia	0.095	0.981
Radio	**0.306**	0.803
SocialMedia	**0.345**	0.749
TV	0.282	0.833

Note: Factor loadings >0.30 in bold

Table A3: Full Results from Extended Ordered Probit Regression with Endogenous Covariate

VARIABLES	(1) Handwashing	(2) Covid concern
Age	0.0213***	
	(0.007)	
Age squared	-0.0002**	
	(9.07e-05)	
Female	0.204***	
	(0.029)	
Urban	0.0357	
	(0.026)	
Covid concern	0.393***	
	(0.0596)	
Comp1		0.0781***
		(0.0118)
Media consumption (ref: consuming less)		
Consuming more		0.276***
		(0.051)
No change in consumption		0.106**
		(0.048)
Constant		4.062***
		(0.064)
/Handwashing		
cut1	0.679	
	(0.351)	
cut2	1.441***	
	(0.3197)	
cut3	2.194***	
	(0.294)	
var(e. Covid concern)		1.834***
		(0.101)
corr(e. Covid concern,e.Handwashing)	-0.432***	
	(0.0798)	
Observations	9,157	9,157
Country FE	YES	YES
Wave FE	YES	YES
Wald chi2	575.99	575.99

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The outcome variable is the frequency of handwashing in the form of an ordinal variable. The model is estimated using an extended ordered probit technique with an endogenous covariate (where level of concern about COVID 19 is endogenous). The principal component (Comp1), derived from the sources of information about COVID 19, is used as an instrument for the variable representing level of concern about COVID 19. We controlled for country and wave fixed effect in the model. Standard errors are clustered at primary administrative unit.