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Handwashing and Household Health Expenditures Under COVID-19: Evidence from Cameroon

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Abstract

Handwashing is one of the recommended measures during the COVID-19 period to limit the spread of the disease and also contributes to the prevention of WASH-related illnesses. The objective of this study is to analyze the impact of using a handwashing device on household healthcare expenditures in Cameroon, particularly during the period of strict COVID-19 strict restrictions. The data used were collected in September 2021 from 604 Cameroonian households in the Centre and Littoral regions as part of a study funded by the International Development Research Centre (IDRC). To account for unobserved heterogeneity affecting both the decision to use a handwashing device and household healthcare expenditures, an Endogenous Switching Regression (ESR) model was employed. The results highlight that the main determinants of a household's decision to use handwashing devices include environmental factors such as the region, given its importance in the implementation of communication strategies, as well as specific characteristics of the household head. Furthermore, the use of this device leads to a reduction of approximately 52% in healthcare expenditures for households that used it, which corresponds to an average amount of 12,900 CFA francs.

Keywords: COVID-19; healthcare expenditures; handwashing; WASH (Water, Sanitation, and Hygiene); Endogenous Switching Regression (ESR)

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1. Introduction

Following the detection of the first COVID-19 case on 6 March 2020, the Cameroonian government implemented a series of measures to curb the virus's spread. These measures evolved progressively in response to the epidemiological situation. Strict restrictions were introduced on 17 March 2020, marking the beginning of a high-restriction period in the country. These included the closure of land, air, and maritime borders; limits on urban and intercity travel and the number of passengers in public transport; the shutdown of schools and universities; and a ban on gatherings of more than fifty people. Bars and restaurants were also required to close by 6 p.m. On 9 April 2020, additional measures were enforced, such as mandatory facemask use in public spaces and heightened surveillance. A gradual easing began on 30 April 2020, permitting restaurants and bars to reopen after 6 p.m. under

specific conditions and lifting passenger limits in public transport, while maintaining the facemask mandate.

Alongside these government measures, public health recommendations were issued, primarily based on World Health Organization (WHO) guidelines. These include handwashing, wearing masks, and practicing physical distancing. Unlike mask-wearing and physical distancing, which mainly reduce the risk of human-to-human transmission, handwashing directly removes the virus from hands, thereby preventing its transfer to the face and contaminated surfaces. However, the effectiveness of handwashing in preventing COVID-19 transmission appears to be limited in community settings (Gozdzielewska et al., 2022). In many Sub-Saharan African countries, including Cameroon, health authorities and various organizations intensified efforts to promote this practice during the pandemic. Handwashing facilities were installed not only in public spaces but also at the entrances of homes to ensure that everyone entering could wash their hands beforehand. Awareness campaigns were also conducted to promote their use.

However, for this measure to be truly effective, at least at their level, populations must have adequate access to handwashing facilities. An integrative review examining hand hygiene determinants revealed that the presence of handwashing equipment in a household significantly influences occupants' handwashing behavior (White et al., 2020). Furthermore, Wolf et al. (2019) demonstrated that individuals with access to handwashing facilities were 2.6 times more likely to wash their hands with soap than those without access. Yet access to handwashing facilities was not guaranteed for many households, particularly the most economically disadvantaged, as this equipment was not included in free distributions of sanitary materials, unlike masks and hand sanitizers.

The benefits of handwashing extend far beyond COVID-19 prevention. Numerous studies demonstrate that handwashing plays a crucial role in disease prevention, thereby reducing related healthcare expenditures. A randomized controlled trial conducted in Peru (Bowen et al., 2007) revealed that handwashing with soap led to a 45% reduction in acute respiratory infections. Similarly, a systematic review assessing the effectiveness of personal protective measures against H1N1 pandemic influenza transmission found a 38% reduction attributed to handwashing, while mask-wearing appeared less effective (Saunders-Hastings et al., 2017). Regarding influenza transmission among adults, Smith et al. (2015) also concluded that handwashing effectively reduced transmission rates.

Furthermore, studies have reported that proper hand hygiene is associated with lower hospitalization rates (Godoy et al., 2012) and reduced school absenteeism during flu season (Azor-Martínez et al., 2014). Jefferson et al. (2011) demonstrated handwashing's effectiveness through meta-analysis, estimating a 45–55% reduction in disease transmission. Additionally, handwashing provides protection against non-endemic diseases, including diarrhea (Luby et al., 2005; Wolf et al., 2019), lower respiratory tract infections (Mbakaya et al., 2017; Rabie & Curtis, 2006), and skin infections (Dreibelbis et al., 2016).

Although the reduced disease prevalence associated with handwashing suggests potential economic implications for households, existing studies have focused primarily on morbidity outcomes without examining the resulting economic consequences. Furthermore, these studies fail to account for healthcare crisis contexts where hygiene behaviors and healthcare access were substantially altered. This study addresses this gap by specifically analyzing the impact of handwashing device use on household healthcare expenditures in Cameroon, with particular focus on the period of stringent pandemic-related restrictions.

To account for unobserved heterogeneity that might simultaneously influence both handwashing device use decisions and healthcare expenditures, this analysis employed an Endogenous Switching Regression (ESR) model (Lokshin & Sajaia, 2004). The study utilizes data from a September 2021 survey conducted in Cameroon's Centre and Littoral

regions, as part of a broader investigation into the impacts of COVID-19 public policies on businesses and vulnerable populations.

This study contributes to the literature by expanding existing research on handwashing's role in disease prevention (Azor-Martínez et al., 2014; Bowen et al., 2007; Jefferson et al., 2011; Luby et al., 2005; Smith et al., 2015). While previous studies have primarily focused on morbidity reduction, this work specifically examines the impact on healthcare expenditures.

The article is structured as follows: Section 2 describes the methodology including data. Section 3 presents the results, followed by a discussion in Section 4 and conclusion in Section 5.

2. Methodology

2.1. Theoretical Background

The analytical foundation for examining the relationship between handwashing facilities and household health expenditures stems from the household health production model framework. Following Rosenzweig and Schultz (1983), household preferences regarding health status H, n consumption goods X, and $m - n$ other health-affecting commodities Y can be represented by a utility function of the form

$$U = U(X_i, Y_j, H)\ i = 1, ..., n;\ j = n + 1, ..., m \tag{1}$$

Building on this framework, Grossman's (1972) model of health production—where individuals act as producers of their own health—yields the following household health production function:

$$H = \Gamma(Y_j, I_k, \mu)\ k = m + 1, ..., r \tag{2}$$

where $(r - m)$ I represents health inputs that only affect utility through their impact on (e.g., healthcare services). Y_j is a subset of Y that both influences health and directly contributes to utility (e.g., smoking, exercise, handwashing); X_i denotes goods that solely affect utility; and μ captures household-specific health endowments—unobservable, known but uncontrolled factors like genetic traits or environmental conditions. Both Y_j and I_k in Equation (2) are subsets of Y, meaning they all serve as inputs in the health production function.

All these goods are acquired using an exogenous monetary income F, such that the household's budget constraint for procuring r goods is given by

$$F = \sum_t Z_t p_t\ t = 1, ..., r \tag{3}$$

With p_t denotes the vector of exogenous prices and Z_t represents the bundle of all purchased goods (i.e., the union of all X, Y, and I market-acquired commodities).

The reduced-form household demand function for r goods, including $r - n$ health inputs derived from maximizing Equation (1) subject to constraints (2) and (3), takes the following form:

$$Z_t = S_t(p, F, \mu)\ t = 1, ..., r \tag{4}$$

Similarly, the reduced-form health demand function is expressed as

$$H = \varphi(p, F, \mu) \tag{5}$$

Empirical studies on healthcare and health production have primarily focused on estimating either health input functions (4) or health human capital demand Equation (5) (Acton, 1975; Deri, 2005; Leonard, 2003; Mwabu, 1989; Schneider & Hanson, 2006). However, these studies often overlook the lack of causal linkage between health input utilization and

health capital production. To establish this causal relationship, Rosenzweig and Schultz (1983) proposed a hybrid formulation of the theoretical health production model, combining Equations (2), (4), and (5) as follows:

$$H = \theta(Y_m, p_l, F, \mu)\ l = 1, ..., m-1,\ m+1, ..., r \tag{6}$$

The variables H, Y_m, F and μ retain their standard definitions; H denotes health status, Y_m represents preventive health inputs (including handwashing), F is exogenous income, μ captures unobservable household-specific health capital, and p_l determines input prices. Unlike Equation (2), Equation (6) explicitly accounts for all preventive health inputs in Y_m. Here, handwashing is formalized as both (i) a preventive measure and (ii) a health investment with intertemporal returns. Critically, Y_m is endogenous—jointly determined by current health status H and the household head's deliberate health-protection strategies. This specification addresses the causal linkage absent in prior studies (Rosenzweig & Schultz, 1983), where preventive inputs were often treated as exogenous.

According to the theory of planned behavior developed by Ajzen (1991), this intention, manifested through the use of a handwashing system, is influenced by attitudes, subjective norms, and perceived behavioral control. This implies that the use of a handwashing device results from an evaluation based on individuals' beliefs regarding: (1) the benefits of handwashing, (2) the necessity arising from the context, and (3) the feasibility of its implementation (this results in the endogenous and unobservable nature of Y_m and μ).

Furthermore, Equation (6) admits multiple interpretations depending on the functional role assigned to its arguments (Mwabu, 2008). When conditioned on exogenous income F—with other covariates treated as shift factors—it effectively represents a health demand function (health Engel curve). In this framework, Equation (6) can operationalize household health expenditure analysis, following the approach of Crémieux et al. (1999).

2.2. Method

The endogeneity of preventive health behaviors, as derived from Ajzen's (1991) Theory of Planned Behavior, implies that the effect of handwashing facility use on health expenditures is assessed using a two-step approach: the first step estimates the selection equation for the use of a handwashing facility, while the second step evaluates its impact on health expenditures.

2.2.1. The Use of a Handwashing Device

Following Cohen (1984), individuals' preferences for preventive health measures can be represented by a utility function, since preventive actions are considered as consumption goods that affect disease risk. According to Ajzen's (1991) theory of planned behavior, this utility function is based on individuals' beliefs about the benefits A_{1i} and costs A_{2i} of handwashing. Let A^* represent the difference in expected utility for the household i. A household would use a handwashing device if $A_i^* = A_{1i} - A_{2i} > 0$. Although the utility difference (A^*) is unobservable, it can be specified in terms of observable factors within a latent variable framework as follows:

$$A_i^* = Z_i\alpha + \varepsilon_i \text{with } A_i = \begin{cases} 1\ if\ A_i^* > 0 \\ 0\ otherwise \end{cases} \tag{7}$$

where A_i is a binary decision indicator equal to 1 if the household i uses a handwashing device and 0 otherwise; α denotes a vector of unknown parameters to be estimated; ε_i is the error term; and Z_i represents a vector of observable factors. These variables are related to

the environmental characteristics of the household as well as those of the household head. The probability that a household uses a handwashing device is specified as follows:

$$\Pr(A_i = 1) = \Pr(A_i^* > 0) = \Pr(\varepsilon_i > -Z_i\alpha) = 1 - F(-Z_i\alpha) \quad (8)$$

where F is the cumulative distribution function of ε_i.

This first step employs a probit model to estimate the variables that predict the household's use of a handwashing device.

2.2.2. Effect of Handwashing Device Use on Healthcare Expenditures

The decision to use a handwashing device may be influenced by household members' level of risk aversion and their motivation, as presented by the theory of planned behavior, which are not directly observable. According to this theory developed by Ajzen (1991), the use of a handwashing device depends on individuals' beliefs and their perception of government-led prevention campaigns disseminated through the media. As this theory highlights the existence of unobservable heterogeneity, it provides a rationale for employing an endogenous regime-switching regression model.

In this model, households face two regimes: [1] using a handwashing device and [2] not using a handwashing device. The analytical framework follows the model of Abdulai and Huffman (2014), and is specified as follows:

$$\begin{cases} \text{Using a handwashing device (regime 1)} : Y_{1i} = X_{1i}\beta_1 + \mu_{1i} \text{ if } A_i = 1 & \text{(a)} \\ \text{Non} - \text{using a handwashing device (regime 2)} : Y_{2i} = X_{2i}\beta_2 + \mu_{2i} \text{ if } A_i = 0 & \text{(b)} \end{cases} \quad (9)$$

where $i = 1, 2, \ldots, n$ represents households; A_i denotes the decision to use a handwashing device ($A_i = 1$) or not ($A_i = 0$); Y_{1i} and Y_{2i} represent healthcare expenditures under regimes 1 and 2, respectively; X_{1i} and X_{2i} are vectors of explanatory variables in regimes 1 and 2; β_1 and β_2 are the corresponding vectors of parameters to be estimated. The error terms ε_i, μ_{1i} and μ_{2i} in the selection Equation (7) and in the healthcare expenditure Equation (9) are assumed to follow a trivariate normal distribution with zero mean and covariance matrix $\sum$. That is $(\varepsilon, \mu_1, \mu_2) \sim N(0, \sum)$, with

$$\sum = \begin{pmatrix} \sigma^2{}_\varepsilon & \sigma_{\varepsilon\mu_1} & \sigma_{\varepsilon\mu_2} \\ \sigma_{\mu_1\varepsilon} & \sigma^2{}_{\mu_1} & . \\ \sigma_{\mu_2\varepsilon} & . & \sigma^2{}_{\mu_2} \end{pmatrix} \quad (10)$$

where $\sigma^2{}_\varepsilon$ is the variance of the error term in the selection Equation (7), which can be assumed to equal 1 since the coefficients can only be estimated up to a scale factor (Maddala, 1983); $\sigma^2_{\mu_1}$ and $\sigma^2_{\mu_2}$ are the variances of the error terms μ_{1i} and μ_{2i} in the healthcare expenditure functions (9a) and (9b), respectively; $\sigma_{\mu_1\varepsilon}$ and $\sigma_{\mu_2\varepsilon}$ denote the covariances between ε_i, μ_{1i} and μ_{2i}. Since Y_{1i} and Y_{2i} are not observed simultaneously, the covariance between μ_{1i} and μ_{2i} is not defined. Given the error term in the selection Equation (7), an important implication of the error structure is that ε_i is correlated with the error terms of the healthcare expenditure equations μ_{1i} and μ_{2i}. The expected values of μ_{1i} and μ_{2i} conditional on sample selection are given by

$$\begin{cases} E[\mu_{1i}|A_i = 1] = \sigma_{\mu_1\varepsilon}\frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)} = \sigma_{\mu_1\varepsilon}\lambda_{1i} \\ E[\mu_{2i}|A_i = 0] = \sigma_{\mu_2\varepsilon}\frac{\phi(Z_i\alpha)}{1-\Phi(Z_i\alpha)} = \sigma_{\mu_2\varepsilon}\lambda_{2i} \end{cases} \quad (11)$$

where $\phi(.)$ is the standard normal probability density function, and $\Phi(.)$ is the cumulative normal distribution function. If the estimated covariances $\hat{\sigma}_{\mu_1\varepsilon}$ and $\hat{\sigma}_{\mu_2\varepsilon}$ are statistically

significant, then the decision to use a handwashing device and household healthcare expenditures are correlated. Thus, the function (Y_i) to be estimated is

$$\ln Y_i = \sum_{i=1}^{N} A_i \left[\ln \Phi\left(\frac{\mu_{1i}}{\sigma_{\mu_1}}\right) - \ln \sigma_{\mu_1} + \ln \Phi(\theta_{1i}) \right] + (1 - A_i) \left[\ln \Phi\left(\frac{\mu_{2i}}{\sigma_{\mu_2}}\right) - \ln \sigma_{\mu_2} + \ln(1 - \Phi(\theta_{2i})) \right] \quad (12)$$

where $\theta_{\tau i} = \frac{(Z_i\alpha + \rho_\tau \mu_{ji}/\sigma_\tau)}{\sqrt{1-\rho_\tau{}^2}}$, $\tau = 1,2$ (τ indicating the regime), with ρ_τ represents the correlation coefficient between the error term ε_i from the selection Equation (7) and $\mu_{\tau i}$ from Equations (9a) and (9b), respectively.

Using post-estimation analysis, this model compares the healthcare expenditures of households that use a handwashing device (a) with those that do not (b), and estimates the expected healthcare expenditures under hypothetical counterfactuals (c) for households that did not use a handwashing device but would have if they had, and (d) for households that used a handwashing device but would not have if they had not. These conditional expectations of household healthcare expenditures in the four cases are defined as follows:

$$\begin{cases} E(Y_{1i}/A_i = 1) = X_{1i}\beta_1 + \sigma_{\mu_1\varepsilon}\lambda_{1i}, & \text{(a)} \\ E(Y_{2i}/A_i = 0) = X_{2i}\beta_2 + \sigma_{\mu_2\varepsilon}\lambda_{2i}, & \text{(b)} \\ E(Y_{2i}/A_i = 1) = X_{1i}\beta_2 + \sigma_{\mu_2\varepsilon}\lambda_{1i}, & \text{(c)} \\ E(Y_{1i}/A_i = 0) = X_{2i}\beta_1 + \sigma_{\mu_1\varepsilon}\lambda_{2i}, & \text{(d)} \end{cases} \quad (13)$$

Cases (13a) and (13b) represent the actual observed outcomes in the sample, while cases (13c) and (13d) correspond to the expected counterfactual outcomes. According to Heckman et al. (2001) and Di Falco et al. (2011), the Average Treatment Effect on the Treated (ATT) is calculated as the difference between (13a) and (13c). This difference captures the effect of using a handwashing device on healthcare expenditures among households that adopted this measure to protect themselves against COVID-19.

$$ATT = E(Y_{1i}|A_i = 1) - E(Y_{2i}|A_i = 1) = X_{1i}(\beta_1 - \beta_2) + (\sigma_{\mu_1\varepsilon} - \sigma_{\mu_2\varepsilon})\lambda_{1i} \quad (14)$$

This study incorporates several control variables commonly recognized in the literature as potential determinants of household expenditures. These variables include region, place of residence, household size, and various characteristics of the household head, such as age, gender, education level, marital status, religion, and employment sector (Okunade et al., 2010; Sen, 2005; Wagstaff et al., 1991; Xu et al., 2003).

Unlike studies that rely on automatically generated values due to the non-linearity of the selection model to control for endogeneity (Fu et al., 2018), this research adopts an exclusion restriction method for model identification (Abdulai & Huffman, 2014; Takam-Fongang et al., 2019). This restriction requires that certain variables directly affecting the selection variable (use of a handwashing device) must not be included in the household healthcare expenditure equation. Two instruments are used for this purpose: a binary variable reflecting individuals' access to social digital networks as their main source of information, and another binary variable reflecting individuals' knowledge of preventive measures to respond to the COVID-19 pandemic. One of the reasons for selecting these variables is that information during the COVID-19 period was primarily disseminated through social media. The validity of these instruments is supported by a falsification test (Di Falco et al., 2011).

The Endogenous Switching Regression (ESR) model accounts for unobserved heterogeneity without requiring the treated and untreated groups to be identical. Thus, households that adopted a handwashing device may differ from those that did not in terms of observable characteristics that influence both the decision to use the device and

healthcare expenditures. Alternative methods for estimating average treatment effects include Propensity Score Matching (PSM) and Inverse Probability Weighted Regression Adjustment (IPWRA). Both methods rely on the propensity score to create comparable groups. However, beyond the well-known issue of the curse of dimensionality affecting propensity score methods, as highlighted by Rosenbaum and Rubin (1983), their application is conditional on the unconfoundedness assumption—that is, the absence of bias from unobserved factors. By applying the ESR model and estimating separate regressions for each regime as specified in Equation (9), this study addresses endogeneity concerns arising from unobserved heterogeneity (Liu et al., 2021; Lokshin & Sajaia, 2004). The PSM and IPWRA models are then employed for robustness checks, aiming to balance the two groups.

2.3. Data and Summary Statistics

The data used in this study come from a survey conducted as part of a research project funded by the International Development Research Centre (IDRC), focusing on the impact of public policies related to the COVID-19 pandemic in Cameroon. The survey was primarily carried out in the Centre and Littoral regions, with technical support from the National Institute of Statistics (INS). These regions were selected due to their significant health and economic impact during the pandemic. The high number of infections in these areas led to the suspension of various activities, and mobility restrictions further worsened the economic situation.

The minimum household sample size was determined following Cochran's (1977) guidelines for sample size estimation with continuous data, as follows:

$$n_{\min} = \xi^2 * \frac{p(1-p)}{\varepsilon^2} \tag{15}$$

$n_{\min}$ is the minimum required sample size; ξ is the standard normal statistic, set at 1.96 for a 95% confidence level; ε is the margin of error, set at 5%; p is the assumed proportion indicator, set at 50%. After adjustments to account for non-response rates, the final minimum sample size was set at 400 households.

To obtain a representative sample of households, a two-stage stratified sampling approach was employed. First, Enumeration Areas (EAs) were selected to ensure a balanced representation between the Centre and Littoral regions, reflecting their significance to the study. Subsequently, households were selected using a systematic sampling method with a skip interval of three, starting from multiple entry points within the selected EAs. Within each household, all individuals aged fifteen and above were interviewed using a structured questionnaire comprising eight sections. The survey was conducted in September 2021, and during the fieldwork, a total of 604 households and 2223 individuals aged over fifteen were visited. Of these, 574 household heads and 2126 individuals agreed to participate in the interviews.

2.4. Description of Variables

Questions related to household expenditures were primarily addressed to the head of the household. Health expenditures were collected for two distinct periods: before the pandemic (October 2019–February 2020) and during the strict lockdown phase ((March–May 2020). For each of these periods, respondents were asked the following question: *"What is your household's estimated average monthly health expenditure during the following period?"* This question was also asked regarding consumption, education, and other household expenditures, including water and electricity bills... The health expenditures considered refer to curative healthcare services. Table 1 presents the main categories of monthly household expenditures before the pandemic and during the strict restriction period.

Average monthly expenditures declined from 232,710 CFA francs before the pandemic to 184,991 CFA francs during the restriction period—representing a decrease of approximately 20%. This overall decline masks increasing disparities at the extremes of the distribution. The reduction is largely attributable to items such as consumption and education, which dropped by an average of 12,000 CFA francs and 40,000 CFA francs, respectively. However, health expenditures increased by approximately 23% compared to their pre-pandemic level.

Table 1. Evolution of the various items of monthly expenditure of households.

Expenditure Items	Before			During		
	Mean	Min	Max.	Mean	Min	Max.
Health expenditure	23,532.266	0	650,000	28,958.936	0	420,500
Consumption expenditure	60,943.370	2500	550,000	48,878.942	2500	600,000
Education expenditure	142,763.862	0	1,500,000	104,308.511	0	1,500,000
Other expenses	20,073.570	1000	567,500	21,485.891	1000	1,646,000
Overall expenditure	232,710.659	7500	1,646,000	184,999.695	8500	1,713,000

Note: Author's calculation based on survey data.

According to the United Nations, in line with Sustainable Development Goal 6.2.2, handwashing devices are defined as 'a sink with running water, as well as other devices that contain, transport, or regulate the flow of water. Examples include buckets with taps, tipping taps, and portable basins. Bar soap, liquid soap, powder detergent, and soapy water are all considered soap for monitoring purposes (WHO & UNICEF, 2017). The possession of a handwashing device can serve as an indicator of the actual practice of handwashing, as it is more accurate than other indirect measures such as self-reported handwashing (Brauer et al., 2020). During data collection, enumerators were instructed to identify the presence of a permanent handwashing device in the household and ensure that water and soap were also available. In most cases, the device was placed at the entrance of the homes, as recommended by the government. Thus, the variable 'Possession of a Handwashing Facility' takes the value of 1 if the household has one, and 0 otherwise.

Other control variables include factors likely to explain the standard of living and household expenditures, as demonstrated by the studies of Okunade et al. (2010), Sen (2005), Wagstaff and Van Doorslaer (2000), and Xu et al. (2003). These factors include region, place of residence, household size, and characteristics of the household's head, like age, gender, education level, marital status, religion, and employment sector. Exposure to social media and knowledge of barrier measures were used as instruments for identification purposes.

The descriptive statistics presented in Table 2 reveal that approximately 23% of households in the sample possess a handwashing device to protect themselves against COVID-19. The average age of the heads of households in the sample is 45 years. Furthermore, 30% of household heads are women, and 57.7% use social media. Regarding education, a minority has attained a primary level of education (16.8%), while the majority has completed secondary school (54.3%). Additionally, just over 20% of households have members who have performed a COVID-19 test. Table 2 also highlights several notable findings. First, the average health expenditure is 8000 CFA francs higher among handwashing device users compared to non-users, potentially reflecting the users' higher risk aversion to illness. However, the average differences presented may mask the actual distinctions between users and non-users.

Table 2. Definition of variables and descriptive statistics of the sample.

Variables	Description	Overall	With Handwashing Device	Without Handwashing Device	Difference ¥
Used a hand-washing device	1 if the household used the handwashing device; 0 else	0.232 (0.423)	-	-	-
Health expenditure	Health expenditures during COVID-19 restrictions (in XAF)	28,958.936 (40,008.91)	29,726.89 (45,842.85)	21,655.03 (36,138.38)	−8071.86 **
Region (Centre)	1 if the household is in the Central region; 0 else	0.487 (0.500)	0.592 (0.493)	0.456 (0.499)	−0.136 ***
Place of residence (Rural)	1 if the household is in rural area; 0 else	0.250 (0.433)	0.108 (0.311)	0.293 (0.456)	0.185 ***
Household size	Number of persons living in the household	6.030 (3.005)	6.692 (3.082)	5.83 (2.955)	−0.862 ***
Characteristics of household's head					
Age	Age of head of household in years	45.607 (13.604)	48.369 (13.251)	44.772 (13.614)	−3.597 ***
Gender (Female)	1 if the head of household is a woman; 0 else	0.302 (0.459)	0.292 (0.457)	0.305 (0.461)	0.0123
Level of education (Primary)	1 if the head of household has a Primary level; 0 else	0.168 (0.374)	0.162 (0.369)	0.17 (0.376)	0.008
Level of education (Secondary)	1 if the head of household has a Secondary level; 0 else	0.543 (0.499)	0.562 (0.498)	0.537 (0.499)	−0.024
Level of education (Higher)	1 if the head of household has a higher level of education; 0 else	0.241 (0.428)	0.269 (0.445)	0.233 (0.423)	−0.037
Marital status (Couple)	1 if the head of household lives with a spouse; 0 else	0.668 (0.471)	0.700 (0.460)	0.658 (0.475)	−0.042
Religion (Catholic)	1 if the head of the household is from the Catholic religion; 0 else	0.552 (0.498)	0.546 (0.500)	0.553 (0.498)	0.007
Sector of activity (Public/Association)	1 if the head of household works in the Public/Association sector; 0 else	0.136 (0.343)	0.208 (0.407)	0.114 (0.318)	−0.094 ***
Sector of activity (Formal Private)	1 if the head of household works in the formal private sector; 0 else	0.179 (0.383)	0.192 (0.396)	0.174 (0.380)	−0.018
Sector of activity (Informal private)	1 if the head of household works in the informal private sector; 0 else	0.382 (0.486)	0.300 (0.46)	0.407 (0.492)	0.107 **
Test COVID-19	1 if at least one household member has performed the COVID-19 test: 0 else	0.229 (0.420)	0.269 (0.445)	0.216 (0.412)	−0.053
Instruments					
Using social networks	1 if the head of household uses social networks; 0 else	0.577 (0.495)	0.631 (0.484)	0.56 (0.497)	−0.070 *
Level of knowledge of measurements	Number of barrier measures known by the head of household	4.984 (2.311)	4.877 (2.157)	5.016 (2.357)	0.139

Notes: Author's calculation based on survey data. Standard Deviation in parentheses. ¥ a mean difference test has been performed. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Secondly, disparities emerge between the two groups of households in terms of region, place of residence, household size, age of the head of household, and employment sector. Specifically, users are more numerous in the Central region compared to the Littoral region. Furthermore, although only 10.8% of households using a handwashing device live in rural areas, this figure rises to 29.3% for non-users. Additionally, there are variations between users and non-users in terms of household size. It is worth noting that the level of knowledge of barrier measures is statistically similar between the two groups, with an average of about 5 measures known.

3. Results

Although the analyses conducted above reveal significant differences between users and non-users in terms of health expenditures, knowledge of average differences is not sufficient to explain the decisions to use among the sampled households, as it does not account for discrimination based on household characteristics.

3.1. The Probability of Using a Handwashing Device

Column (1) of Table 3 presents the results of the estimation of Equation (7) using the Probit model. Overall, these results align with the predictions of the analytical model. Notably, households located in the Central region are more likely to use a handwashing device in their homes. This finding highlights the importance of this region, as it hosts the country's main institutions. Compliance with pandemic-related restrictions was stricter, even within administrative frameworks. Moreover, the COVID-19 information campaign led by the media was more intensively implemented in this region compared to the Littoral region, which hosts the country's economic capital. In contrast, households in rural areas are less inclined to use handwashing devices, indicating that the campaign did not consider the distinct characteristics of rural areas in its national awareness efforts. Furthermore, rural areas appeared to be less affected by the COVID-19 pandemic, leading residents to neglect preventive measures due to the perceived low prevalence of the virus.

The probability of using a handwashing device increases with the age of the household head. Older individuals took more precautions against the pandemic, likely influenced by the widespread belief that COVID-19 disproportionately affected older age groups. This behavioral response to COVID-19 aligns with Grossman's (1972) theory of health demand, which posits that health-seeking behavior intensifies with age. However, the negative and statistically significant coefficient of the squared age variable suggests the existence of a threshold effect. Beyond a certain age threshold, the probability of owning a handwashing device decreases. This phenomenon could be attributed to the economic challenges faced by older individuals. Implementing a handwashing device, even a basic one, requires a minimal financial investment, while the country's social security system may not adequately address the needs of the elderly.

Moreover, the results indicate that the household head's use of social media (as an identification variable) increases the probability of using a handwashing device. Throughout the COVID-19 pandemic, social media platforms played a central role in disseminating information about the state of the pandemic. This information may have shaped individuals' perceptions of the pandemic's prevalence, influencing their attitudes towards preventive measures. However, the coefficient associated with the knowledge of various preventive measures is negative and significantly different from zero. This suggests that being well-informed about multiple preventive measures decreases the likelihood of owning a handwashing device compared to other measures.

The likelihood ratio test examining the joint independence of the three equations (Wald test) indicates that these equations are dependent. An interesting observation arises from the sign and significance of the correlation coefficients. In particular, the correlation coefficient for non-users is statistically significant, indicating the presence of positive selection bias for households that did not use the handwashing device. This suggests that the unobserved factors that led these households not to use the device are also associated with higher health expenditures. These households might be constrained, for example, by limited access to water, preventing them from using the device while simultaneously increasing their health expenditures due to more frequent illnesses. In contrast, the non-significance of the correlation coefficient for users indicates the absence of selection bias for this group of households. This implies that the decision to use the device does not appear to be influenced by unobserved factors affecting health expenditures. These households may have used the device due to observable factors such as better education or access to health information.

Table 3. Endogeneity Switching Regression Model results.

Variables	Possessed a Handwashing Device (1)	Health Expenditure	
		Non-Owner (2)	Owner (3)
Region (Centre)	0.405 (−0.15) ***	−0.288 (−0.168) *	−0.249 (−0.239)
Place of residence (Rural)	−0.855 (−0.199) ***	0.292 (−0.210)	−0.051 (−0.347)
Household size	0.036 (−0.024)	0.065 (−0.025) ***	0.048 (−0.036)
Age of HH	0.084 (−0.037) **	−0.031 (−0.039)	0.079 (−0.068)
Age of HH squared	−0.069 (−0.038) *	0.042 (−0.039)	−0.079 (−0.065)
Gender of HH (Female)	0.050 (−0.186)	0.214 (−0.200)	−0.093 (−0.257)
Educational level			
Primary	0.225 (−0.483)	0.061 (−0.347)	0.644 (−0.413)
Secondary	0.441 (−0.438)	0.342 (−0.293)	1.007 (−0.379) ***
Higher	0.283 (−0.471)	0.747 (−0.336) **	1.740 (−0.393) ***
Marital status (in couple)	−0.0591 (−0.199)	0.521 (−0.206) **	0.259 (−0.264)
Religion (Catholic)	−0.114 (−0.144)	0.062 (−0.152)	0.223 (−0.197)
Sector of activity			
Public/Association	0.379 (−0.243)	−0.247 (−0.281)	−0.825 (−0.330) **
Formal Private	0.046 (−0.202)	−0.077 (−0.229)	−0.383 (−0.316)
Informal private	−0.056 (−0.185)	−0.118 (−0.178)	−0.554 (−0.244) **
Test COVID-19	−0.28 (−0.2)	0.502 (−0.193) ***	0.331 (−0.217)
Using social networks	0.404 (−0.145) ***		
Knowledge of barrier measures	−0.053 (−0.028) *		
Constant	−3.417 (−1.008) ***	8.241 (−0.956) ***	6.879 (−2.016) ***
lns0		0.272 (−0.095) ***	
Rho(0)		−1.209 (−0.493) **	
lns1			−0.042 (−0.089)
Rho(1)			−0.28 (−0.344)
Log pseudolikelihood	−836.073		
Wald test of independence of equations (Chi2)	6.93 **		

Notes: Author's calculation based on survey data. Robust standard errors in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%.

3.2. Handwashing and Healthcare Expenditures

Columns (2) and (3) of Table 3 reveal the influence of several factors on the healthcare expenditures of households that either used or not a handwashing facility. The results indicate that healthcare expenditures increase with the size of households that do not used a handwashing facility. This suggests that larger households face a higher risk of illness due to their size. Interestingly, the age of the head of the household does not seem to have a significant impact on healthcare expenditures for either group. However, education appears to be an essential factor in explaining healthcare expenditures for households, regardless of whether they use a handwashing facility. The positive and statistically significant coefficients suggest that individuals with higher levels of education tend to incur higher

healthcare expenditures, possibly reflecting a greater tendency to seek and access medical care when needed. They are also more aware of the health risks they face, which makes them more likely to engage in preventive behaviors, considering the opportunity cost of illness for them.

Table 4 provides estimates of the average treatment effects derived from the Endogenous Switching Regression (ESR) model. These effects outline the impact of using a handwashing facility on healthcare expenditures. Unlike the mean differences presented in Table 2, which do not account for the difference between the two groups in terms of observables and unobservables, these treatment effects consider these discriminations. This bias arises from systematic differences between households that used or not a handwashing facility.

Table 4. Estimated treatment effects based on the ESR model.

Index	Proportion	Value
Average Treatment Effect on the Treated (ATT)	−0.5263 (0.0531) ***	−12,898.58 (1726.217) ***
Average Treatment Effect on the Untreated (ATU)	0.3313 (0.0228) ***	6333.276 (547.628) ***
Average Treatment Effect (ATE)	0.1322 (0.0263) ***	1868.739 (674.0174) ***

Notes: Author's calculation based on survey data. Robust standard errors are in parentheses. *** significant at 1%.

The results show that using a handwashing facility significantly reduces healthcare expenditures for households during periods of strict restrictions. Specifically, the causal effect of using a handwashing facility during this period, in terms of reducing healthcare expenditures, amounts to 12,898 CFA francs, representing a 52.63% reduction in healthcare expenses for households that used it. It is, however, important to note that, based on raw figures, descriptive statistics (Table 2) show that households with a hand-washing device have higher average health expenditures (29,726 CFA francs) than those without one (28,958 CFA francs). Taken on its own, this finding might suggest that the use of a hand-washing device does not have a protective effect. However, these raw averages do not account for socio-economic differences between households that use a handwashing device and those that do not, which introduces a selection bias. Thus, by correcting for this bias using the endogenous selection model (ESR), the results show that, with comparable characteristics, households that used a hand-washing device spent on average 12,898 FCFA francs less on healthcare than they would have if they had not used the device.

In addition to chronic diseases primarily affecting the elderly, for which age was controlled in the structural equation, the most common diseases in the study's context include malaria and diseases associated with water, hygiene, and sanitation (WASH). However, during the COVID-19 pandemic, the strict regulation of quinine, which is also used to relieve malaria symptoms, stemmed from its perceived role in treating COVID-19. As a result, individuals showing symptoms of malaria increasingly turned to traditional medicine, fearing they would be considered potential COVID-19 cases, as the symptoms of both diseases were similar.

Moreover, the positive sign of the ATU (Average Treatment Effect on the Untreated) indicates that if non-user households had used a handwashing device, their healthcare expenses would have increased. This can be explained by the economic or structural constraints that limit the effectiveness of the handwashing device for these households. For example, even with a handwashing device, they might continue to face high health risks due to limited access to water or healthcare services.

3.3. Robustness

Propensity score matching (PSM) techniques and Inverse Probability Weighted Regression Adjustment (IPWRA) were used to ensure the robustness of the analysis. The simplest approach to assess the impact of using a handwashing device on healthcare expenditures would be to introduce a binary variable, set to 1 if the household uses it, and then apply ordinary least squares. However, this method assumes that the use of a handwashing device is exogenous, whereas in reality, it may be endogenous. The decision to use or not use a handwashing device is voluntary and based on both observable and unobservable factors.

For comparison purposes, Table 5 presents three sets of estimates of the average treatment effect. Row (1) shows the treatment effect obtained from Table 4 using the ESR model. Row (2) shows the treatment effect obtained from PSM, where Equation (7) is used to create a group of non-users similar to those who use the handwashing device. Finally, row (3) presents the result of an IPWRA derived from Equation (7), along with the corresponding treatment effect. The full results tables of the PSM and IPWRA(Tables A1 and A2) and validation graphs demonstrating the quality of the matching (Figures A1 and A2) are presented in Appendix A.

Table 5. Estimated treatment effects based on ESR, PSM, and IPWRA.

Model	ATT	Standard Error.	T-Stat
(1) ESR	−0.526 ***	0.053	−9.91
(2) PSM	0.197	0.181	1.09
(3) IPWRA	0.034	0.117	0.29

Notes: Author's calculation based on survey data. Robust standard errors are in parentheses. *** significant at 1%.

The results in Table 5 indicate that the three models provide significantly different estimates of the impact of handwashing on healthcare expenditures. In general, the positive effects highlighted by the PSM are considerably larger than those suggested by the IPWRA. For example, when analyzed using PSM, it is estimated that the use of a handwashing device increases healthcare expenditures by 19% for households that use it, compared to 3.4% when analyzed with IPWRA. However, the effect of using a handwashing device may vary depending on unobserved characteristics such as motivation, access to water, or the quality of information received. This unaccounted heterogeneity may explain the differences between the results of PSM, IPWRA, and ESR. The results from ESR, being more robust and correcting for more biases, should be favored for analyzing the effect of handwashing device use on healthcare expenditures.

4. Discussion

The results of this study highlight several important aspects regarding the use of handwashing devices and their impact on household healthcare expenditures, particularly in the context of the COVID-19 pandemic. These findings align with previous research while offering specific nuances to the studied context, revealing complex dynamics related to health behaviors, regional disparities, and the socio-economic characteristics of households.

The results show that households located in the Central region are more likely to use a handwashing device, which can be explained by the presence of the country's main institutions and stricter enforcement of health measures. This observation is consistent with studies by Saksena et al. (2014) and Kuwawenaruwa et al. (2020), which highlight regional disparities in access to healthcare services and the adoption of preventive behaviors. The Central region, as the administrative and economic heart of the country, benefited from more intensive awareness campaigns and better dissemination of health information, which

facilitated the using of handwashing devices. In contrast, rural households are less likely to use these devices due to a reduced perception of the risks associated with COVID-19. This suggests that public health campaigns need to be tailored in rural contexts to improve their effectiveness. Rural areas, often characterized by limited access to sanitation infrastructure and less exposure to media campaigns, require targeted approaches that consider their cultural and socio-economic specificities.

The age of the household head plays a significant role in the use of handwashing devices, with an increased likelihood among older individuals. This result aligns with Grossman's (1972) theory of the demand for health, which posits that individuals invest more in their health as they age. Older individuals, being more vulnerable to the complications of COVID-19, were likely more motivated to use preventive measures to protect their health. However, the observed threshold effect, where the likelihood of use decreases beyond a certain age, may be attributed to the economic constraints faced by older individuals. As studies on social health inequalities (Pfefferbaum & North, 2020) suggest, older people, particularly those with low income, may not have the resources to invest in handwashing devices, despite their motivation to protect themselves. Moreover, the use of social media by the household head increases the likelihood of using handwashing devices, confirming the central role of social media in the dissemination of health information, as shown by Moorhead et al. (2013) and Lee Ventola (2014). Social media platforms played a key role during the pandemic in shaping individuals' perceptions and influencing their preventive behaviors. Households with access to these information channels were likely more aware of health risks and preventive measures, which facilitated the use of handwashing devices.

The use of a handwashing device significantly reduces household health expenditures, with an estimated decrease of 52.62% for households that used it. This result aligns with the studies by Curtis and Cairncross (2003) and Ejemot-Nwadiaro et al. (2021), which demonstrate that handwashing reduces the incidence of infectious diseases, leading to a reduction in health expenditures. By preventing waterborne, sanitation, and hygiene-related (WASH) diseases, handwashing devices help reduce medical consultations, medication purchases, and hospitalizations, resulting in a significant reduction in health expenses. However, the results also show that larger households without a handwashing device have higher health expenditures, highlighting the importance of promoting these devices in high-density households. Larger households face an increased risk of infectious disease transmission due to their size, which raises their health costs in the absence of adequate preventive measures. This emphasizes the need to target these households with specific interventions, such as subsidies for the purchase of handwashing devices or awareness campaigns tailored to their needs.

5. Conclusions

The aim of this study was to analyze the impact of using a handwashing device on health expenditures in the context of the COVID-19 pandemic. The data used comes from a survey conducted in September 2021 as part of a study on the effects of public policies related to the COVID-19 pandemic on businesses and vulnerable populations. The Endogenous Switching Regression (ESR) model was employed to account for unobserved heterogeneity affecting both the use of the handwashing device and household health expenditures. The analysis revealed that the main factors influencing households' decisions to use a handwashing device in response to the COVID-19 pandemic include region, place of residence, and certain characteristics of the household head. On the other hand, accounting for the counterfactual, it was found that using a handwashing device reduces health expenditures for households that used it by approximately 52% compared to if they had not used it, which corresponds to an average amount of about 12,900 CFA

francs. Comparison with other models, such as PSM and IPWRA, confirms the existence of unobserved heterogeneity.

However, this study has some limitations. First, the survey was only conducted in two regions out of ten in Cameroon, which may limit the generalizability of the findings to the entire country. Regional disparities in access to healthcare infrastructure, handwashing devices, and health behaviors may influence the results. Second, the main variable, which is ownership of a handwashing device, is used here as a proxy for household handwashing behavior as recommended by Brauer et al. (2020), but it does not reflect the consistency or quality of handwashing practices (frequency, duration or adherence to recommended practices). Therefore, the results should be interpreted with caution in this regard. Another limitation of this study is the absence of a direct measure of household income in the dataset. Because household economic capacity may influence both the likelihood of owning and then using a handwashing device and healthcare expenditures, the lack of an explicit income variable could introduce residual confounding. To address this issue, the education level of the household head was used as a proxy for long-term socioeconomic status, and the ESR model was employed to eliminate potential selection bias due to unobserved heterogeneity that may simultaneously affect both the ownership of a handwashing device and healthcare expenditures.

The study suggests that obtaining a handwashing device may impose a financial burden on households in Cameroon. Consequently, the results emphasize the need for policymakers to assist households, particularly the most vulnerable, in acquiring handwashing facilities. This can be achieved by providing financial assistance in the form of subsidies, grants, or microfinance alternatives to ensure the affordability of handwashing devices. Additionally, they can encourage partnerships with businesses, manufacturers, and local suppliers to ensure a constant supply of affordable handwashing devices.

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Data Availability Statement: The datasets presented in this article are not readily available because the data are part of an ongoing study. Requests to access the datasets should be directed to the corresponding author.

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Abbreviations

The following abbreviations are used in this manuscript:

ESR	Endogenous Switching Regression
PSM	Propensity Score Matching
IPWRA	Inverse Probability Weighted Regression Adjustment

Appendix A

Table A1. Propensity Score Matching (PSM) Estimation.

Variables	Used a Handwashing Device
Region (Centre)	0.571 (2.39) **
Place of residence (Rural)	−1.313 (4.07) ***
Household size	0.054 (1.46)
Age of HH	0.123 (2.02) **
Age of HH squared	−0.097 (1.58)
Gender of HH (Female)	0.122 (0.36)
Educational level	
Primary	1.423 (1.33)
Secondary	1.568 (1.49)
Higher	1.408 (1.30)
Marital status (In couple)	0.066 (0.20)
Religion (Catholic)	−0.251 (1.14)
Sector of activity	
Public/Association	0.443 (1.15)
Formal Private	0.235 (0.70)
Informal private	−0.138 (0.48)
Test COVID-19	−0.060 (0.23)
Using social networks	0.442 (1.70) *
Knowledge of barrier measures	−0.036 (0.75)
Constant	−6.594 (3.72) ***
LR chi2(17)	59.04 ***
Observations	560

Notes: Author's calculation based on survey data. Robust standard errors in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%.

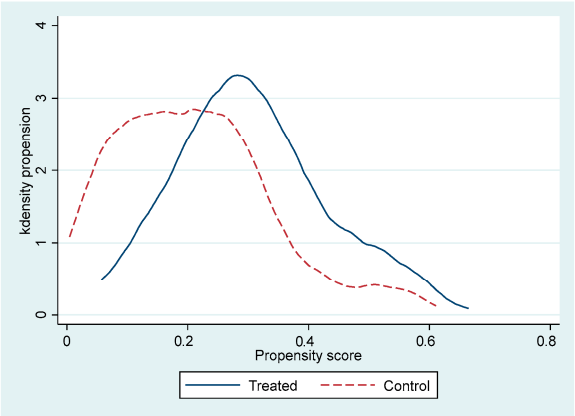


Figure A1. Representation of the common support before matching. Note: Authors' elaboration based on survey data.

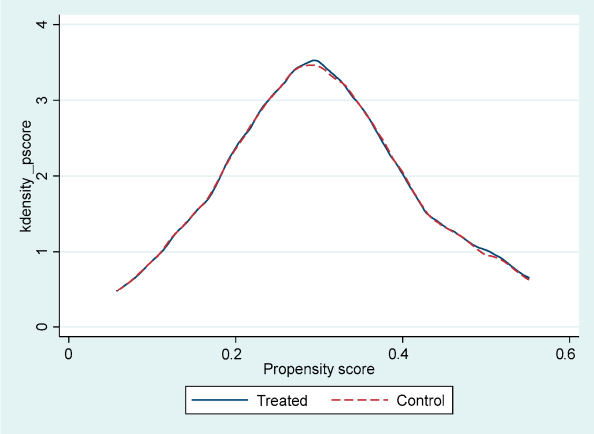


Figure A2. Representation of the common support after matching. Note: Authors' elaboration based on survey data.

Table A2. Inverse probability weighted regression adjustment (IPWRA) estimation.

Variables	OME0	OME1	TME1
Region (Centre)	0.028 (0.17)	−0.173 (0.81)	0.681 (2.61) ***
Place of residence (Rural)	−0.161 (0.87)	−0.200 (0.70)	−1.585 (4.09) ***
Household size	0.066 (3.06) ***	0.055 (1.61)	0.076 (1.77) *
Age of HH	0.051 (1.41)	0.092 (1.43)	0.138 (2.05) **
Age of HH squared	−0.039 (1.06)	−0.091 (1.46)	−0.115 (1.67) *
Gender of HH (Female)	−0.004 (0.02)	−0.083 (0.33)	0.146 (0.42)
Educational level			
Primary	−0.162 (0.36)	0.707 (1.78) *	1.459 (1.37)
Secondary	0.173 (0.42)	1.127 (3.13) ***	1.706 (1.64)
Higher	0.613 (1.34)	1.846 (4.86) ***	1.463 (1.33)
Marital status (In couple)	0.267 (1.36)	0.265 (1.03)	0.022 (0.06)
Religion (Catholic)	−0.149 (0.89)	0.202 (1.05)	−0.179 (0.71)
Sector of activity			
Public/Association	−0.011 (0.05)	−0.782 (2.45) **	0.553 (1.25)
Formal Private	0.070 (0.27)	−0.390 (1.24)	0.057 (0.16)
Informal private	−0.248 (1.26)	−0.572 (2.34) **	−0.135 (0.43)
Test COVID-19	0.216 (1.03)	0.289 (1.37)	−0.326 (1.02)
Using social networks			0.549 (1.85) *
Knowledge of barrier measures			−0.123 (2.33) **
Constant	7.389 (7.68) ***	6.073 (3.56) ***	−6.462 (3.62) ***
Observations		422	

Notes: Author's calculation based on survey data. Robust standard errors in parentheses. *** significant at 1%, ** significant at 5%, * significant at 10%.

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