RESEARCH ARTICLE

Gender, digital financial services and vulnerability in the era of pandemics: A cross-sectional analysis [version 1; peer review: awaiting peer review]

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Abstract

Background: The COVID-19 pandemic has rapidly spread across the world, infecting millions and causing economic disruption on an unprecedented scale. While everyone is affected by the COVID-19 pandemic, vulnerable communities are at the greatest risk. The objective of this study is to examine the relationship between digital financial services (DFS), gender, and the vulnerability of informal settlement dwellers to COVID-19.

Methods: We sampled a total of 2,697 households from 101 informal settlements across eleven out of sixteen administrative regions of Ghana. The regions were selected based on the relative severity of the pandemic, and the associated national lockdown regulations.

Results: Adopting the multiple regression analytical technique, the results reveal three main findings: First, we observe that males in informal settlements are more likely to be exposed to infected people or a person who died from COVID-19 than females. However, women are more likely to be vulnerable to the pandemic than men as vulnerable populations have a higher susceptibility to pandemics due to less capacity to implement preparedness and response strategies due to disparities in their societal status. Finally, we find that the vulnerability of informal dwellers is moderated by the use of digital financial services.

Conclusions: Our results provide policy implications for authorities designing policies to address vulnerability to pandemics in poor informal settlements in Africa.

Keywords
Digital financial services, Gender, Vulnerability, Pandemics, COVID-19, Ghana
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Introduction
The outbreak of the COVID-19 pandemic has spread worldwide, affecting every aspect of life. Millions of people have been affected by COVID-19 and many more have lost their lives. To minimise the impact of COVID-19, governments all over the world instituted measures such as lockdowns, increased handwashing, social distancing, and travel bans. While these measures have helped in containing the spread of COVID-19, they have also led to some unintended consequences (Sumalatha et al., 2021). Indeed, the economy has suffered, jobs have been lost, debts are mounting, people are quarantined in their homes and most vulnerable people are likely to go below the poverty line. While COVID-19 poses a severe threat to all, vulnerable populations are severely affected and face even greater challenges. Indeed, many vulnerable populations are experiencing adverse consequences such as job loss, food insecurity, and the inability to manage existing medical conditions and maintain preventive measures such as social distancing and personal protective gear.

Previous research has found that vulnerable populations are at greater risk during pandemics because they usually don’t have the capability to implement preparedness and response plans or withstand its consequences due to the disparities in their economic status and other social factors including cultural, settlement, educational and linguistic barriers as well as the inability to access and use health facilities (Debruin et al., 2012 and Hutchins et al., 2009).

The COVID-19 pandemic and the requirement for social distancing have put a spotlight on digital financial services. Digital financial services are broadly defined as financial services offered through digital platforms such as mobile phones, internet, cards, point of sale (POS), among others (Alexander, 2017). In the case of this study, digital financial services refer to financial services offered/performed through the mobile phone because this was the most common form of technology available to the respondents of the study. Digital financial services (DFS) do not only allow for social distancing but also allow governments to disburse funds to those in need quickly and effectively. More importantly, digital financial services allow many households and firms to rapidly access online payments and financing (Agur et al., 2020). As noted by Arner et al. (2020), whereas digital financial services can be harnessed to respond to the COVID-19 pandemic, the pandemic also has the potential to accelerate their development and use. The point is that, for digital financial services, all transactions continue, and more importantly financial support reaches the vulnerable irrespective of COVID-19 restrictions and health guidelines (Auer et al., 2020).

The COVID-19 pandemic also poses questions about its effects on men and women. Indeed, the pandemic has affected women and men differently due to their distinct roles in society and national economies. According to the International Labour Organisation [ILO] (2021), while the COVID-19 pandemic led to unprecedented job losses, women have been disproportionately hit (4.2%) compared to men (3%). Research has also shown differences in COVID-19–related beliefs and behaviours. Thus, in their study, Galasso et al. (2020) found that women are more likely to perceive the pandemic as a very serious health problem and to agree and comply with restraining measures. This is partially the reason why more men than women are dying of COVID-19 (Grasselli et al., 2020). Aside from the evidence on perceived impacts, very little is known regarding the impact of the pandemic on various indicators of vulnerability.

Despite the plethora of scholarly research on COVID-19, there appears to be a paucity of research examining how digital financial services have been harnessed as a pro-poor tool to minimise the impact of COVID-19 on vulnerability in the context of developing countries. Some studies have concentrated on the utilisation of digital financial services during the COVID-19 pandemic (Auer et al., 2020; Ting et al., 2020), the impact of the COVID-19 pandemic on vulnerable populations such as women (Nyashanu et al., 2020) as well as adoption and implementation of COVID-19 pandemic measures (Prempoh, 2021). This study differs from previous research to the extent that the focus is on the use of digital financial services to support vulnerable populations in a developing country during the COVID-19 pandemic whereas previous studies focused on the impact of COVID-19 on the vulnerable or the use of digital financial services during COVID-19. The issue of how digital financial services can serve as a catalyst to ameliorate the plight of the vulnerable especially women in developing contexts is worth pursuing as this has implications for the achievement of several of the sustainable development goals [SDGs] (Bhatia and Singh, 2019).

The objective of this paper is to examine the relationship between gender, digital financial services, and vulnerability during COVID-19 in Ghana. This is important to the extent that most of the government policy measures announced in developing countries during the COVID-19 pandemic are in the form of cash assistance (Davidovic et al., 2020). The use of digital means helped in achieving the purpose of government policy by reaching the vulnerable while reducing contact and spread of the virus. This is significant because digital financial services allow for the disbursement of financial support to those in need quickly, effectively, and safely while preventing direct contact among individuals (Auer et al., 2020). Analysing the pandemic from a gender and digital financial inclusion perspective is significant as gender is a social category that shapes the pattern of the outbreak itself and people’s access to resources (Kim et al., 2020).
The results of the study revealed three main findings: First, we observe that men are more likely to be exposed to the COVID-19 pandemic than women living in slum populations. During pandemics, women are usually restricted to traditional roles including caregiving in their homes (Power, 2020). This acts as a movement restriction on the part of women which reduces their exposure to pandemics. Men, often charged with the responsibility of providing for their household are put in a very precarious position to go all out to work to fend for their families, hence increasing their exposure. Secondly, this study finds that women are more likely to be vulnerable than men during pandemics which confirms our hypothesis. The vulnerability to health for women during pandemics can be linked to contact between them and others who disregard preventive measures. Thirdly, vulnerable populations can insulate themselves from the harsh effects of pandemics when they make use of digital financial services. The use of digital financial services such as mobile money and M-Pesa helps to reduce disease transmission through human contact. Once the exposure levels of men are reduced, the vulnerability suffered by women is also reduced if not eliminated.

The next section provides a theoretical and empirical review of the literature. This is followed by the methodology employed in the study. The fourth section discusses the results of the study while the last section provides concluding remarks and practical implications of the paper.

**Literature review**

**Theoretical review**

Digital financial services are part of the financial inclusion movement that emphasises the provision of, and access to, financial services to all members of the population particularly the poor, vulnerable and several excluded members of the population (Ozili, 2018). Due to the importance of financial inclusion and its great promise, many governments especially in the emerging and developing economies have initiated policies and strategies to ensure financial inclusion (Allen et al., 2016). The literature on financial inclusion is replete with many theories of the concept – including public good theory, dissatisfaction theory, vulnerable group theory, systems theory, among others. In this paper, vulnerable group theory will be adopted to anchor this study. This theory suggests that financial inclusion initiatives should target the vulnerable in society as they are mostly at a disadvantage during economic hardships and crises. Thus, during pandemics and crises, the vulnerable are the most affected, and as such, it makes a lot of sense to bring these vulnerable people into the formal financial sector (Ozili, 2020). One way to achieve this is through the digital financial system. This includes the use of technology to deliver financial services to members of the society including the vulnerable such as poor people, young people, women, and elderly people. The crux of the vulnerable group theory is that financial inclusion efforts through means such as digital financial services should be targeted to vulnerable people in society (Ozili, 2020). During crises such as the COVID-19 pandemic, the use of digital financial services helps to provide support quickly and conveniently to the vulnerable population who need urgent support.

**Empirical review**

The COVID-19 pandemic started in 2019 in Wuhan China and resulted in immediate, serious human health issues around the world. The pandemic brought dire consequences to lives and livelihoods (Asante et al., 2021). The rapid spread of the pandemic across the world has continued to produce fear, panic and anxiety in people (Ahorsu et al., 2020). Thus, the alarming speed of the pandemic has overwhelmed even the most resilient health and social care systems (Guzman and Malik, 2020).

In such a situation, governments need to ensure public safety by prioritising the management of health crises. Also, a number of economic recovery strategies have been deliberately introduced across countries to support suffering economies affected by COVID-19. Key to these strategies is the need to protect the public health system as well as ameliorate the harmful impact of COVID-19 on the economy (Deloitte, 2020). The key COVID-19 control measures include border closures, lockdowns, social distancing, contact tracing, quarantine, and isolation (Asante et al., 2021).

According to the Lancet (2020), the vulnerable are those that are disproportionally exposed to risk, but vulnerability can change dynamically. In this case, it is added that a person not considered vulnerable at the outset of a pandemic can become vulnerable depending on the policy response. The Lancet (2020) therefore expanded the definition of vulnerability in the context of COVID-19 beyond individuals with comorbidities and ill health, elderly persons, and homeless people to incorporate people from a range of economic backgrounds who may struggle to cope either physically, psychologically, or financially as a result of the COVID-19 crisis.

The current COVID-19 crisis has further exacerbated the gender gap in terms of quality of employment particularly for those women working in the informal sector and feminised occupations (ILO, 2021). As noted by Sen and Östlin (2008), gender is a crucial social element of health which intersects with several dimensions of society. Gender has implications for how different people cope with vulnerability, and their capacity and responsibilities during unexpected public health
The issue of financial inclusion has received a lot of scholarly and practitioner attention because of its potential to contribute to inclusive economic and financial development as well as improve income equality (Bhatia and Singh, 2019). However, the use of traditional financial products and services for financial inclusion does not seem to reach the vulnerable including women. Indeed, the 2014 Global Findex data, showed that 47 per cent of women around the world have a financial account, compared to 53 per cent of men (Demirgüç-Kunt et al., 2015). In the current dispensation, technology can serve as a tool to pursue aggressive financial inclusion. According to Gammage et al. (2017), digital finance seems to offer innovative platforms for financial inclusion. This is because digital financial services have the potential to overcome restrictions brought on by geography, reduce the transaction costs of using financial services, and enhance transparency and therefore increase trust in financial systems (Gammage et al., 2017). Digital financial services have the potential to slow the spread of the COVID-19 pandemic as it allows for social distancing, quick and effective disbursement of financial services online (Agur et al., 2020). Indeed, Auer, Cornelli and Frost (2020) argued that digital financial resources support social distancing measures that were imposed in many countries to minimise the spread of the COVID-19 pandemic. So crucial is the fact that during lockdowns, digital financial services could still be used to deliver financial services to the vulnerable, and informal settlement dwellers when other forms become difficult (Auer, Cornelli, and Frost, 2020). Using digital financial technology like mobile money, people without bank accounts, especially women, vulnerable groups and informal sector workers can now have access to financial services which will help improve their economic situation during the pandemic (Agur et al., 2020). During pandemics, speed in the delivery of support is of the essence and digital financial technologies are obviously the game changer when it comes to speed and volumes of financial services (Auer et al., 2020).

**Methods**

**Study design**
A cross-sectional survey was conducted among residents of informal settlements in Ghana after obtaining ethical approval from the University of Ghana Ethics Committee for the Humanities (ECH). Data collection took place from August 2021 to November 2021 across informal settlements in Ghana.

**Research setting**
Ghana was the area of study. The country has 16 administrative regions with each region containing several districts. There are currently 261 districts. Projections from the Ghana Statistical Service put the current population of Ghana at 30.07 million (Alhassan et al., 2021). This study was conducted in informal settlements in eleven of the sixteen regions in Ghana (Greater Accra, Central, Volta, Ashanti, Western, Northern, Savanna, Northeast, Bono East, Bono, and Ahafo). Peoples Dialogue, a Non-Governmental Organisation that focuses on informal settlements in Ghana provided the list of informal settlements for this study. Peoples Dialogue has enumerated informal settlements in Accra and throughout Ghana (Farouk and Owusu, 2012). As part of the Shack/Slum Dwellers International (SDI) network, Peoples Dialogue has become the most reliable organisation to obtain data on informal settlements in Ghana. Based on the data from Peoples Dialogue, the informal settlements were zoned to thirteen (13).

**Participants**
Data for this study was collected from 101 informal settlements in 11 of 16 regions in Ghana. Households were eligible if they were within informal settlements.

**Sampling strategy**
The study adopted the 2014 Ghana Demographic and Health Survey sampling frame. The frame is a complete list of all the census Enumeration Areas (EAs) created for the 2010 Population and Housing Census (PHC). An EA is a geographic area covering an average of 145 households. A three-stage sampling procedure was adopted. In the first stage, a total of 261 districts were selected from all 16 regions. In the second stage, EAs were selected across all the districts. The total number of EAs across the country is 37,641. We took a cue from the GDHS 2014 and selected a total of 854 EAs by implementing a simple random sampling technique across all 261 districts. After the selection of EAs and before the main survey, a household listing operation was carried out in all the selected EAs. The household listing operation consists of visiting each of the 780 selected EAs and compiling a list of members of the household. In the third and final stage, 8 households were selected from the list of households compiled in the EAs using the systematic sampling procedure to obtain a total of 2,697 households. We administered structured questionnaires to each of the selected households. This sampling strategy ensured that we captured indicators across the national level and as well as districts across the country. A copy of the questionnaire used can be found under *Extended data* (Amidu, 2022).
A total of 2,697 households in informal settlements across Ghana were involved in this study through the use of a three-sampling procedure as described. This sample size is considered adequate and representative of informal settlements in the country.

**Data collection**

We acquired tablets for the 23 enumerators and engaged the services of a Data Manager to coordinate the transmission of interviewee responses from various sites to a station at Accra, the national capital. The use of tablets to collect the data enhanced the quality of the data collected by prompting and disallowing some responses which were not consistent per checks in the survey instrument. The instant synchronization of the data at the end of the interview helped the survey management team to follow what was happening at all survey sites with ease. However, interviews conducted in areas where internet connection was poor could only be synchronized in the evening when the team returned to the district capitals where they lodged. The data manager run the field check tables to assess the quality of data received through Dropbox on a daily basis, whilst the fieldwork was ongoing. Observations from the field check tables were then shared with the enumerators and the team members through a WhatsApp group. Meetings were then held regularly with the field enumerators to ensure that all queries raised were addressed and if clarification was required, the project team responded before the teams proceeded to the next survey areas. These protocols were put in place to provide assurance of data quality.

**Survey instruments**

There are four main variables under investigation in this study: vulnerable populations, digital financial services, gender, and COVID-19 exposure. These variables are discussed below with their measures.

**Sex/Gender:** We limit the measurement of sex and gender to binary measurement. Participants could indicate whether they were male or female using a tick box.

**COVID-19 exposure:** exposure to COVID-19 is defined as the state of being exposed to someone with COVID-19 (Kazak et al., 2021). Three questions namely personal knowledge of COVID-19 infected persons, having heard or associated with a known COVID-19 infected person, and being exposed to a COVID-19 related deceased person were used to measure exposure to COVID-19 in this study. The use of these measures led to the creation of the COVID-19 exposure index, with one being the lowest and three the highest.

**Vulnerable population:** the vulnerability index questionnaire by Acharya and Porwal (2020) was adopted in this study. This index was built on the social vulnerability index by Flanagan et al. (2011) with the addition of the COVID-19 pandemic. The questionnaire consists of five dimensions - (1) socio-economic condition; (2) demographic composition; (3) housing and hygiene condition; (4) availability of health-care facilities, and (5) COVID-19-related epidemiological factors. First, the socio-economic vulnerability of populations was measured with four indicator variables as follows: (1) attaining some level of education with primary level being the least, (2) employment status of respondents, (3) monthly household income and (4) as a proxy for poverty is the proportion of the population who did not have any household assets. These assets include but are not limited to television, radio, bicycle, phone, and refrigerator. Similarly, demographic vulnerability was measured by the use of the elderly population (this includes persons aged 60 years and above), place of residence (be it urban or rural), and how well homes are suited. Concerning housing and hygiene conditions, the paper utilises four variables: number of people per room, availability of toilet facilities within a household, availability of hand hygiene facilities and household access to water. With regards to the availability of healthcare, the study uses four indicators - possessing of health insurance, access to health care, willingness to visit and access health facilities, and the number of health care facilities in a community. For epidemiological factors, the study took into consideration three main indicators as proxies. They include a person’s current health condition, a person with any current chronic morbidity, a person undergoing any long-term medical treatment. A respondent scores 1 when he demonstrates or finds himself in a vulnerable situation and scores 0 when otherwise is observed. A total score of 18 denotes high vulnerability.

**Digital financial services:** In this paper, digital financial services inclusion was defined as the provision of financial services accessed and delivered through a mobile device. Therefore, mobile money was used as a proxy to measure digital financial inclusion. This study limits digital financial services to mobile money because this was the most common form of technology available to informal settlement dwellers. Indeed, in the advent of COVID-19, the government of Ghana increased the amount that could be transferred while lowering the charges on the mobile financial system. This served as an incentive for a lot of people to use the mobile financial system as a form of digital financial service. We construct an index of 1 to 9, with 9 being a person with more usage of financial technology and inclusion.
We employ a number of control variables that affect the relationship of interest. These include age, religion, marital status and region. The main and other control variables are presented in Table 1.

**Ethical statement**

This study was approved by the University of Ghana Ethics Committee for The Humanities (ECH) (approval number: ech 342/21-22). In addition, we clearly indicated the purpose of the study to the respondents and participation in the study was voluntary. Participants were also debriefed, their consent sought and made aware the data was for academic publication purposes.

**Analysis and estimation strategy**

In this section, firstly, we estimate the effect of gender on COVID-19 exposure, controlling for a wide range of potential drivers of exposure and dummies for individual participant household characteristics. We specify the model below to estimate the impact gender has on COVID-19 exposure.

$$Y_{1j} = X_j'\alpha + R_j'\beta + \epsilon_{1j}$$  \hspace{1cm} (1)

In the model above, COVID-19 exposure which is denoted as $Y_{1j}$, is the dependent variable. COVID-19 exposure is measured using three indicator variables namely: personal exposure, exposure to an infected person, and contact with a COVID-19 related deceased person. Each indicator is scored one when a respondent answers in the affirmative with regards to exposure-related questions. The subscript $j$ refers to the individual. $X_j'$ is a vector of individual household level characteristics such as age, marital status, geographical location, etc. $R_j'\beta$ is the gender. It consists of two mutually exclusive and exhaustive categories that are men or women. It takes the value 1 when the respondent is a man and 0 when the respondent is a woman. $\epsilon_{1j}$ is a normally distributed random error term with zero mean and constant variance.

Next, we explore how gender influences the vulnerability of marginalised populations. In line with the vulnerability literature, we forecast that women are more likely to be vulnerable than men during the pandemic outbreaks. This can be attributed to the poor socio-economic status most women have which makes it difficult for them to adopt measures that will help insulate them from the risks of pandemics thus increasing their vulnerability. To help us examine the relationship between gender and vulnerability, we model the equation below:

$$Y_{2j} = X_j'\alpha + R_j'\beta + \epsilon_{2j}$$  \hspace{1cm} (2)

Here, $Y_{2j}$ is the index score of vulnerability. Vulnerability in this study is constructed as an index comprising five main constructs: socioeconomic, demographic, housing and hygiene condition, availability of health care and epidemiological factors. A respondent scores 1 when they demonstrate or finds themself in a vulnerable situation on a dimension and scores 0 when otherwise is observed. A total score of 18 denotes high vulnerability. The subscript $j$ refers to the individual. $X_j'$ is a vector of individual household level characteristics such as age, marital status, geographical location, etc. $R_j'\beta$ is the gender. It consists of two mutually exclusive and exhaustive categories, that is men or women. It takes the value 1 when the respondent is a man and 0 when the respondent is a woman. $\epsilon_{2j}$ is a normally distributed random error term with zero mean and constant variance.

Having estimated the relationship between gender and COVID-19 exposure on one hand and the vulnerability on the other hand, the next step is to evaluate the impact of digital financial services on vulnerable populations in the era of COVID-19. The rationale is that even in the face of expected support, when the right financial technology is not employed, the support may not achieve the intended outcomes.

$$Y_{3j} = X_j'\alpha + P_j'\beta + \epsilon_{3j}$$  \hspace{1cm} (3)

Where, $Y_{3j}$, is the dependent variable, vulnerability. Vulnerability in this study is constructed as an index comprising five main constructs: socioeconomic, demographic, housing and hygiene conditions, availability of health care and epidemiological factors. A respondent scores 1 when they demonstrate or finds themself in a vulnerable situation on a dimension and scores 0 when otherwise is observed. A total score of 18 denotes high vulnerability. The subscript $j$ refers to the individual. $X_j'$ is a vector of individual household level characteristics such as age, marital status, geographical location etc. $P_j'\beta$ represents the digital financial services with an index, 1-9 with 9 being a person with more usage of financial technology and inclusion. $\epsilon_{3j}$ is a normally distributed random error term with zero mean and constant variance.

Furthermore, we estimate the joint effect of gender, vulnerability and digital financial services has on COVID-19 exposure. Here, further analysis is conducted to examine the channel through which gender is exposed to the COVID-19
Table 1. Variables and their definitions.

| Variable                              | Definition                                           | Measurement                              |
|---------------------------------------|------------------------------------------------------|-----------------------------------------|
| Gender                                | Gender of respondent                                 | 1 = if male; 0 = otherwise              |
| **Personal/Household characteristics**|                                                      |                                         |
| Age                                   | Age range of respondent                              | Years                                   |
| Marriage status                       | Marital Status of respondents                        | 1 = if married; 0 = otherwise           |
| Region                                | Residence in a particular region                     | 1 = if yes; 0 = otherwise               |
| Religion                              | Religion of respondent                               | 1 = if Christian; 0 = otherwise         |
| **Vulnerability (index score of how vulnerable a respondent is)**|                                                      |                                         |
| **Socioeconomic**                     |                                                      |                                         |
| Level of education                    | Education attainment of the person                   | 1 = if primary or lower, 0 otherwise    |
| Employment status                     | Employment status of respondent                      | 1 = if unemployment, 0 otherwise        |
| Poor household                        | Household with assets                                | 1 = if no assets, 0 otherwise           |
| Household income                      | Monthly household income                             | 1 = if income less than 313, 0 otherwise|
| **Demographic condition**             |                                                      |                                         |
| Elderly population                    | Person aged 60 and above                             | 1 = if age is less than 60, 0 otherwise  |
| Urbanisation                          | Place of residence (Urban or Rural)                  | 1 = if urban; 0=otherwise               |
| Poorly suited home                    | Poorly suited accommodation                         | 1 = if yes; 0=otherwise                 |
| **Housing and hygiene condition**     |                                                      |                                         |
| People per room/over crowding         | Proportion of Number of people in the room           | 1 = if average more than 3 in the room, 0 otherwise |
| Household with toilet                 | Availability of toilet facility                      | 1 = no toilet facility in the house, 0 otherwise |
| Household with hand hygiene facility  | Household without hand hygiene facility             | 1 = household without hand hygiene facility, 0 otherwise |
| Household with water                  | Household with reliable water supply                 | 1 = house without water supply, 0 otherwise |
| **Availability of health care**       |                                                      |                                         |
| Health insurance                      | Possession of health insurance                       | 1= if no health insurance, 0 otherwise   |
| Access to health care                 | Availability of health care                          | 1 = if no health care, 0 otherwise      |
| Visit to health facility              | Visiting of health care                              | 1 = if no visit has been made, 0 otherwise |
| The number of health care facility    | The number of health care facility in the neighbourhood | 1 = if no health care facility, 0 otherwise |
| **Epidemiological factors**           |                                                      |                                         |
| Person current health condition       | Person current health condition                      | 1 = if the person is experiencing any illness, 0 otherwise |
| Person with any chronic morbidity     | Person with any chronic morbidity                   | 1 = if the person has any chronic illness, 0 otherwise |
| Person undergoing long-term medical treatment | Person undergoing long-term medical treatment      | 1 = if the person undergoing a long-term medical treatment, 0 otherwise |
| Vulnerability index                   | Vulnerability index                                  | **Total score = 18 being the most vulnerable** |
pandemic. That is, we analyse whether the amelioration of gender to COVID-19 is dependent on vulnerability or the adoption and use of financial technology. We use the model below:

$$Y_{ij} = X_{ij}^{\prime} \alpha + R_{ij}^{\beta} + Q_{ij}^{\gamma} \beta + P_{ij}^{\delta} \beta + \left( R_{ij}^{\beta} + P_{ij}^{\delta} \beta \right) + \left( Q_{ij}^{\gamma} \beta + R_{ij}^{\beta} \right) + \epsilon_{ij} \quad (4)$$

Here again, $Y_{ij}$, the dependent variable is COVID-19 exposure. The subscript $j$ refers to the individual. $X_{ij}$ is a vector of individual household level characteristics such as age, marital status, geographical location etc. $R_{ij}^{\beta}$ is the gender. $Q_{ij}^{\gamma} \beta$ is the vulnerability and is constructed as an index comprising five main constructs: socioeconomic, demographic, housing and hygiene condition, availability of health care and epidemiological factors. A respondent scores 1 when they demonstrate or find themselves in a vulnerable situation and scores 0 when otherwise is observed. A total score of 18 denotes high vulnerability. $P_{ij}^{\delta} \beta$ represents the digital financial services with an index, 1-9 with 9 being a person with more usage of financial services and inclusion. In the equation (4) above, $\left( R_{ij}^{\beta} + P_{ij}^{\delta} \beta \right)$ represents the interaction between gender and digital financial service, and $\left( Q_{ij}^{\gamma} \beta + R_{ij}^{\beta} \right)$ represents the interaction between vulnerability and gender. $\epsilon_{ij}$ is a normally distributed random error term with zero mean and constant variance. All variables used in the models, their definitions, and measurements are shown in Table 1.

### Results

#### Descriptive statistics

In this section, we provide the summary and descriptive statistics of our key variables of interest employed in the study. Given the gendered perspective of this study, we first present in Table 2a the data gathered on gender under two broad classifications. We collected data from men and women over the age of 18 who consented to be a part of the study. Men constitute 1,070 (40%) out of the 2,697 individuals sampled and women make up the remaining 1,627 (60%). The raw data can be found under Underlying data (Amidu, 2022).

Another characteristic feature of our sampled respondents is their marital status. We classified respondents into the various categories as single/never married, co-habiting, married, separated/divorced, and widowed. We find the majority...
of them were married. The second-largest cohort in terms of marital status classification is the single/never married. They make up approximately 33% of the study’s sample population. Those co-habiting, separated/divorced, and widowed made up approximately 17% of the sample.

Furthermore, respondents were sampled across 11 out of the 16 regions of Ghana. The regional distribution of our sample reveals that persons from the Greater Accra region constituted about 38.75% of the sample thus ranking as the region with the highest representation in this study. The other regions included in this study were fairly represented with their sample size hovering above 1% but not more than 10%. Table 1a acts as a reference for the aforementioned statistics.

In order to explore the gender and vulnerability nexus, we again collected data across the five domain vulnerabilities and computed indices accordingly. The vulnerability scores of the regional slums under consideration are presented in Table 2b and each column denotes a specified vulnerability under the five domains. In the last column of the table, we find total vulnerability which happens to be the composite score of all five domain vulnerabilities per region. We observe from Table 2b that the total vulnerability score ranges between 4 and 6. Amongst the regions, we find the Western region recording the highest total vulnerability with a score of 5.439 whereas the Bono region scored the least with an index of 4.096. Again, the Western region suffers the highest socio-economic and demographic compared to the regional slums sampled by this study. In terms of housing and hygiene, health care and epidemiological vulnerability, we observe slums in the North-East, Central, and Volta regions suffering the most with vulnerability indices of 1.966, 2.151, and 0.961 respectively. On average, the domain vulnerability score for socioeconomic, demographic, housing and hygiene, health care vulnerability and epidemiological vulnerability are 0.856, 0.510, 1.342, 1.371, and 0.310 respectively.

We also collected data on the ownership of mobile accounts and usage of mobile-enabled digital financial services by our respondents as it forms part of our objective to examine the effect digital financial services have on the vulnerability of slum populations. In Table 2c, we present data on the usage of digital financial services as enabled by possessing a mobile account on a mobile device. We arrived at this by soliciting a Yes or No response from respondents. It comes to bare that the majority of respondents (95.81%) possess a mobile device whereas 86.87% of sampled respondents responded in the

| Table 2a. Frequency distribution of demographics. |
|---------------------------------|--------|--------|--------|
| **Gender**                     | Freq   | Percent| Cum    |
| Female                         | 1627   | 60.33  | 60.33  |
| Male                           | 1070   | 39.67  | 100    |
| **Marital status**             |        |        |        |
| Single/never married           | 883    | 32.74  | 32.74  |
| Co-habiting                    | 126    | 4.67   | 37.41  |
| Married                        | 1348   | 49.98  | 87.39  |
| Separated/Divorced             | 184    | 6.82   | 94.22  |
| Widow                          | 156    | 5.78   | 100    |
| **Region**                     |        |        |        |
| Western                        | 262    | 9.71   | 9.71   |
| Central                        | 104    | 3.86   | 13.57  |
| Greater Accra                  | 1045   | 38.75  | 52.32  |
| Volta                          | 129    | 4.78   | 57.1   |
| Ashanti                        | 512    | 18.98  | 76.2   |
| Ahafo                          | 62     | 2.3    | 78.49  |
| Bono                           | 227    | 8.42   | 86.91  |
| Bono East                      | 96     | 3.56   | 90.47  |
| Northern                       | 170    | 6.3    | 96.77  |
| Savanna                        | 59     | 2.19   | 98.96  |
| North-East                     | 28     | 1.04   | 100    |
Table 2b. COVID-19 vulnerability by regional slum.

| Regions   | Socio economic Vulnerability | Demographic vulnerability | Housing & hygiene vulnerability | Health care vulnerability | Epidemiological vulnerability | Total vulnerability Score |
|-----------|------------------------------|----------------------------|---------------------------------|----------------------------|------------------------------|---------------------------|
| Bono      | 0.855                        | 0.184                      | 1.101                           | 1.654                      | 0.303                        | 4.096                     |
| North East| 0.966                        | 0.172                      | 1.966                           | 0.793                      | 0.207                        | 4.103                     |
| Ahafo     | 0.887                        | 0.161                      | 1.226                           | 1.710                      | 0.258                        | 4.242                     |
| Savanna   | 0.879                        | 0.052                      | 1.879                           | 1.500                      | 0.172                        | 4.483                     |
| Northern  | 0.859                        | 0.065                      | 1.853                           | 1.729                      | 0.176                        | 4.682                     |
| G. Accra  | 0.809                        | 0.815                      | 0.978                           | 2.035                      | 0.189                        | 4.826                     |
| Ashanti   | 0.533                        | 1.105                      | 1.346                           | 1.744                      | 0.152                        | 4.881                     |
| Volta     | 0.938                        | 0.422                      | 0.852                           | 1.711                      | 0.961                        | 4.883                     |
| Bono East | 0.875                        | 0.563                      | 1.333                           | 1.698                      | 0.469                        | 4.938                     |
| Central   | 0.792                        | 0.953                      | 0.943                           | 2.151                      | 0.142                        | 4.981                     |
| Western   | 1.027                        | 1.115                      | 1.290                           | 1.656                      | 0.351                        | 5.439                     |

Table 2c. Digital financial services.

| Digital financial services          | Frequency | Percentage |
|-------------------------------------|-----------|------------|
|                                     | No   | Yes   | No   | Yes   |
| Possession of mobile device         | 113  | 2584  | 4.19 | 95.81 |
| Mobile account ownership            | 354  | 2343  | 13.13| 86.87 |
| Savings                             | 842  | 1855  | 31.22| 68.78 |
| Frequent withdraw                   | 535  | 2162  | 19.84| 80.16 |
| Payments                            | 2225 | 472   | 82.50| 17.50 |
| Tax obligation                      | 2693 | 4     | 99.85| 0.15  |
| Receiving money                     | 2630 | 67    | 97.52| 2.48  |
| Lending money                       | 2694 | 3     | 99.89| 0.11  |
| Borrowing                           | 2419 | 278   | 89.69| 10.31 |
| Investments                         | 2650 | 47    | 98.26| 1.74  |
| Insurance                           | 2673 | 24    | 99.11| 0.89  |

Table 2d. COVID-19 exposure.

| COVID-19 exposure index | Freq | Percent | Cum  |
|------------------------|------|---------|------|
| 0                      | 501  | 18.58   | 18.58|
| 1                      | 1963 | 72.78   | 91.36|
| 2                      | 173  | 6.41    | 97.78|
| 3                      | 60   | 2.22    | 100  |

The highest score of 3 indicating more exposure.

affirmative that they own an account on their mobile device. On the usage variables, withdrawal and savings were the most patronised mobile-enabled digital financial services. Payment using a mobile account ranked third with 17.50%. The least used service was lending the money using money account. The statistics show untapped mobile account usage gaps and also reflect to some extent the financial behaviour of Ghanaians.
This section of the study closes with data collected on the COVID-19 exposure status of respondents as shown in Table 2d. The exposure of respondents is scored as an index ranging from 0 to 3. We observe that the majority of respondents (constituting 91.36%) score 0 and 1 suggesting no to very low level of exposure. Respondents who scored 2 to 3 make up the remaining 8.64%. We can therefore infer from the exposure distribution of our sampled respondents that living in slums does not necessarily imply high exposure to COVID-19 despite overcrowding and insanitary conditions prevailing in such communities.

1. The influence of gender on COVID-19 exposure

In Table 3, we present the results of the influence of gender on COVID-19 exposure. We arrive at this by regressing gender against COVID-19 exposure whilst controlling for possible drivers of exposure. The results suggest that men are more likely to be exposed to the COVID-19 pandemic than women. We observe a positive and a highly significant relationship between men and COVID-19 exposure. This occurrence can be attributed to ignorance of preventive measures by this gender group. More so, men have a perception of having a stronger immune system that will enable them to fight the virus more than women (Bwire, 2020). Galasso et al. (2020) found that women are more likely to perceive the pandemic as a very serious health problem and therefore are more likely to agree and comply with restraining measures. Grasselli et al. (2020) put forward similar sentiments. They opine that the disregard for restrictive measures is partially the reason why more men than women are dying from COVID-19.

Individuals’ age serves as a significant determinant in exploring COVID-19 exposure. The outbreak of the COVID-19 pandemic resulted in the death of the elderly population around the world. This is attributed to weak immune systems and various underlying health conditions suffered by this age class. However, in this study, we find a negative and highly significant relationship between age and exposure for persons living in slums. We also find that the marital status and religious affiliation of an individual have no significant bearing when it comes to exposure to pandemics like COVID-19. Although the co-efficient of these variables are positive, they do not show any statistical significance. We can therefore suggest that marital status and religion are not significant determinants of one’s exposure status.

Regional slums including Central, Greater Accra, Ashanti, Bono and North-East regions showed statistical significance with exposure with variations in terms of direction and magnitude. The results suggest that among the above-mentioned regions, the North-East region is more likely to be exposed to COVID-19. We find a positive and a highly significant association between the region and exposure.

2. The influence of gender on vulnerability

In this section, we explore the influence of gender on vulnerability. The results of this are displayed in Table 4. The results suggest that men are less likely to be vulnerable compared to women. This observation is true and falls in tandem with the vulnerability literature. Women around the world suffer an array of vulnerabilities not limited to social, economic and health vulnerabilities. From Table 3, we observe a negative and a highly significant relationship between men and four domain vulnerability measures together with their composite. Although men may suffer epidemiological vulnerability more than women, the magnitude of the other four vulnerabilities far outweighs the effect of their epidemiological vulnerabilities thus explaining the negative total vulnerability observed. The epidemiological vulnerability men may suffer can be associated with the neglect of preventive measures.

Also, we find the following controlling variables to be significant determinants of vulnerability: age, marital status, and one’s region of residence. For age, we observe a positive and highly significant total vulnerability relationship. This suggests that an individual’s age can increase their overall vulnerability whereas marriage status goes a long way to reduce vulnerability. We find the coefficient of the total vulnerability of the married to be negative. Marriage provides some form of synergy which makes it possible for couples to reduce their vulnerability. The total vulnerability across the sampled regions appears to be negative and highly significant despite some of its domain vulnerabilities being positive.

3. The influence of digital financial service usage on the vulnerability of slum populations

Table 5 shows how the usage of digital financial services influences vulnerable populations in the era of COVID-19. In this section we regress digital financial services usage index against individual domain vulnerabilities (socioeconomic, demographic, housing and hygiene condition, availability of health care and epidemiological factors) and their composite. In this instance, we control for the age, marital status, region of residence and religion of respondents. We observe from the table in reference, a negative and highly significant relationship between usage of digital financial services during the COVID-19 pandemic and vulnerability (domain and composite). This suggests that the usage of
The table presents the results on the influence of gender on COVID-19 exposure. In this table, gender of respondents is regressed against COVID-19 exposure. Gender is measured as a dichotomous variable that takes the value of one if the respondent is a male and zero otherwise. Marital status is a dummy variable, taking the value of one if the respondent is a married person and zero otherwise. The religion is a dichotomous variable taking the value of one if the respondent is a Christian and zero otherwise The parameters are estimated with the small sample adjusted standard errors in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level respectively.

digital financial services reduces vulnerability thus confirming the importance of using digital financial services during and even beyond pandemics. Digital financial services reduce human contact hence reducing the risk of transmission of contagious diseases like COVID-19. The specific vulnerabilities are socio-economic, housing and hygiene, and health

|                | (1)                  | (2)                  | (3)                  | (4)                  |
|----------------|----------------------|----------------------|----------------------|----------------------|
|                | Covid exposure       | Covid exposure       | Covid exposure       | Covid exposure       |
| Gender         | 0.0677***            | 0.0707***            | 0.0707***            | 0.0731***            |
|                | (0.0229)             | (0.0228)             | (0.0228)             | (0.0228)             |
| Age            | -0.00410***          | -0.00431***          | -0.00438***          | -0.00438***          |
|                | (0.000896)           | (0.000922)           | (0.000922)           | (0.000922)           |
| Marital status |                      | 0.0196               | 0.0213               |                      |
|                | (0.0228)             | (0.0229)             |                      |                      |
| Religion       |                      |                      | 0.0252               |                      |
|                | (0.0260)             |                      |                      |                      |
| Central        | -0.533***            | -0.570***            | -0.569***            | -0.571***            |
|                | (0.0703)             | (0.0700)             | (0.0700)             | (0.0698)             |
| G. Accra       | -0.169***            | -0.198***            | -0.197***            | -0.198***            |
|                | (0.0425)             | (0.0428)             | (0.0428)             | (0.0428)             |
| Volta          | -0.0907              | -0.0990              | -0.0972              | -0.0990              |
|                | (0.0731)             | (0.0733)             | (0.0733)             | (0.0733)             |
| Ashanti        | -0.230***            | -0.266***            | -0.265***            | -0.258***            |
|                | (0.0431)             | (0.0438)             | (0.0438)             | (0.0444)             |
| Ahafo          | 0.0488               | 0.0245               | 0.0255               | 0.0279               |
|                | (0.0511)             | (0.0548)             | (0.0548)             | (0.0547)             |
| Bono           | -0.0901*             | -0.116**             | -0.114**             | -0.107**             |
|                | (0.0474)             | (0.0477)             | (0.0476)             | (0.0483)             |
| Bono East      | -0.0395              | -0.0596              | -0.0604              | -0.0484              |
|                | (0.0522)             | (0.0523)             | (0.0524)             | (0.0538)             |
| Northern       | 0.0201               | -0.00483             | -0.00941             | 0.00963              |
|                | (0.0455)             | (0.0453)             | (0.0460)             | (0.0504)             |
| Savanna        | 0.00275              | -0.00513             | -0.0106              | 0.00830              |
|                | (0.0553)             | (0.0551)             | (0.0554)             | (0.0586)             |
| North East     | 0.341**              | 0.322**              | 0.319**              | 0.337**              |
|                | (0.152)              | (0.152)              | (0.152)              | (0.153)              |
| Constant       | 1.034***             | 1.209***             | 1.207***             | 1.188***             |
|                | (0.0378)             | (0.0531)             | (0.0531)             | (0.0564)             |
| Observation    | 2697                 | 2697                 | 2697                 | 2697                 |
| R square       | 0.0514               | 0.0596               | 0.0598               | 0.0601               |
| Adjusted R square | 0.0475             | 0.0553               | 0.0553               | 0.0552               |
| P-values       | 0.000                | 0.000                | 0.000                | 0.000                |

The table presents the results on the influence of gender on COVID-19 exposure. In this table, gender of respondents is regressed against COVID-19 exposure. Gender is measured as a dichotomous variable that takes the value of one if the respondent is a male and zero otherwise. Marital status is a dummy variable, taking the value of one if the respondent is a married person and zero otherwise. The religion is a dichotomous variable taking the value of one if the respondent is a Christian and zero otherwise The parameters are estimated with the small sample adjusted standard errors in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level respectively.
### Table 4. The influence of gender on vulnerability of slum populations.

|       | (1) Socioeconomic Vulnerability | (2) Demographic Vulnerability | (3) Housing & Hygiene Vulnerability | (4) Health Care Vulnerability | (5) Epidemiological Vulnerability | (6) Total Vulnerability Score |
|-------|---------------------------------|-------------------------------|------------------------------------|-------------------------------|----------------------------------|-----------------------------|
| Gender | -0.0676***                      | -0.00611                      | -0.0642***                         | -0.0352***                    | 0.0958***                       | -0.0149***                  |
| Age    | 0.00363***                      | 0.00379***                    | -0.000117                          | 0.00592***                    | -0.00147***                    | 0.00207***                  |
| Married| -0.0541***                      | -0.0380***                    | 0.00733                            | -0.0384***                    | -0.0345***                     | -0.0308***                  |
| Religion| -0.0300***                      | -0.0114                       | -0.0288***                         | -0.00650                      | 0.0183**                        | -0.0120**                   |
| Central| -0.0247                         | -0.0237                       | -0.0790***                         | -0.0174                       | 0.0947***                       | -0.00885                   |
| G. Accra | -0.0292**                      | -0.0779***                    | -0.0713***                         | -0.0141                       | 0.0703***                       | -0.0221**                   |
| Volta  | -0.0134                         | -0.227***                     | -0.101***                          | 0.214***                      | -0.00298                       | -0.0283**                   |
| Ashanti| -0.102***                       | 0.0215*                       | 0.0113                             | -0.0188                       | 0.000170                       | -0.0197**                   |
| Ahafo  | -0.0129                         | -0.300***                     | -0.0911                            | 0.00373                       | -0.0123                        | -0.0571***                  |
| Bono   | -0.0301*                        | -0.294***                     | -0.0560**                          | 0.0167                        | -0.0171                        | -0.0679***                  |
| Bono East | -0.0290                      | -0.171***                     | 0.00255                            | 0.0677**                      | 0.00221                        | -0.0226*                    |
| Northern| -0.0207                        | -0.329***                     | 0.130***                           | -0.0143                       | 0.00919                        | -0.0310***                  |
| Savannah| -0.0272                        | -0.345***                     | 0.134***                           | -0.0375                       | -0.0363                        | -0.0481***                  |
| North East| 0.00270                      | -0.301***                     | 0.164***                           | -0.0131                       | -0.232***                      | -0.0669***                  |
| Constant| 0.176***                       | 0.242***                      | 0.365***                           | -0.0998**                     | 0.455***                       | 0.245***                    |
| Observation| 2697                           | 2697                           | 2697                               | 2697                          | 2697                           | 2697                        |
| R square| 0.115                          | 0.387                          | 0.0851                             | 0.180                         | 0.144                          | 0.0901                      |
| Adjusted R square| 0.110                        | 0.384                          | 0.0803                             | 0.175                         | 0.140                          | 0.0854                      |
| P-values| 0.000                          | 0.000                          | 0.000                               | 0.000                         | 0.000                          | 0.000                       |

The table presents the results on the influence of gender on vulnerability of slum populations. In this table, gender of respondents is regressed against the individual indicators of vulnerability (which has five domains: (1) socioeconomic condition; (2) demographic composition; (3) housing and hygiene condition; (4) availability of health-care facilities, and (5) COVID-19-related epidemiological factors and their total. Gender is measured as a dichotomous variable that takes the value of one if the respondent is a male and zero otherwise. Marital status is a dummy variable, taking the value of one if the respondent is a married person and zero otherwise. The religion is a dichotomous variable taking the value of one if the respondent is a Christian and zero otherwise. The parameters are estimated with the small sample adjusted standard errors in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level respectively.
Table 5. The effect of digital financial services on vulnerability.

| (1) Socioeconomic Vulnerability | (2) Demographic Vulnerability | (3) Housing & Hygiene Vulnerability | (4) Health care Vulnerability | (5) Epidemiological Vulnerability | (6) Total Vulnerability Score |
|--------------------------------|-------------------------------|-----------------------------------|-------------------------------|---------------------------------|-----------------------------|
| DFS Usage index               | -0.0438***                   | -0.0313***                      | -0.0341***                    | -0.00782**                     | -0.00951***                  |
|                                | (0.00317)                    | (0.00285)                       | (0.00447)                     | (0.00354)                      | (0.00337)                    |
| Age                           | 0.00321***                   | 0.00368***                     | -0.000462                    | 0.00581***                     | -0.00141***                  |
|                                | (0.000305)                   | (0.000304)                      | (0.000397)                    | (0.000427)                     | (0.000299)                   |
| Marital status                | -0.0478***                   | -0.0362***                     | 0.0124                       | -0.0370***                     | -0.0341***                   |
|                                | (0.00743)                    | (0.00689)                       | (0.0104)                      | (0.00881)                      | (0.00780)                    |
| Religion                       | -0.0177***                   | -0.00953                       | -0.0178                      | -0.00128                       | 0.00650                      |
|                                | (0.00853)                    | (0.00765)                       | (0.0116)                      | (0.00926)                      | (0.00895)                    |
| Central                        | -0.0279                      | -0.0229                        | -0.0829***                   | -0.0209                        | 0.108***                     |
|                                | (0.0228)                     | (0.0164)                       | (0.0301)                      | (0.0231)                       | (0.0222)                     |
| G. Accra                       | -0.0338**                    | -0.0777***                     | -0.0762***                   | -0.0175                        | 0.0815***                    |
|                                | (0.0132)                     | (0.0118)                       | (0.0190)                      | (0.0155)                       | (0.0129)                     |
| Volta                          | -0.0145                      | -0.225***                      | -0.103***                    | 0.212***                       | 0.00776                      |
|                                | (0.0215)                     | (0.0185)                       | (0.0267)                      | (0.0327)                       | (0.0204)                     |
| Ashanti                        | -0.104***                    | 0.0221*                        | 0.00954                      | -0.0206                        | 0.00765                      |
|                                | (0.0138)                     | (0.0126)                       | (0.0205)                      | (0.0167)                       | (0.0142)                     |
| Ahafo                          | 0.00436                      | -0.293***                      | 0.00260                      | 0.00335                        | 0.00801                      |
|                                | (0.0202)                     | (0.0193)                       | (0.0371)                      | (0.0286)                       | (0.0266)                     |
| Bono                           | -0.0157                      | -0.289***                      | -0.0394                      | 0.0118                         | -0.00768                     |
|                                | (0.0170)                     | (0.0135)                       | (0.0240)                      | (0.0208)                       | (0.0169)                     |
| Bono East                      | -0.0271                      | -0.170***                      | 0.00356                      | 0.0670**                       | 0.00743                      |
|                                | (0.0191)                     | (0.0246)                       | (0.0317)                      | (0.0323)                       | (0.0232)                     |
| Northern                       | -0.0294                      | -0.330***                      | 0.121***                     | -0.0187                        | 0.0208                       |
|                                | (0.0185)                     | (0.0130)                       | (0.0283)                      | (0.0221)                       | (0.0187)                     |
| Savanna                        | -0.0337                      | -0.346***                      | 0.128***                     | -0.0407                        | -0.0278                      |
|                                | (0.0240)                     | (0.0144)                       | (0.0378)                      | (0.0275)                       | (0.0245)                     |
| North East                     | -0.00423                     | -0.300***                      | 0.156***                     | -0.0189                        | -0.212***                    |
|                                | (0.0332)                     | (0.0220)                       | (0.0450)                      | (0.0444)                       | (0.0312)                     |
| Constant                       | 0.235***                     | 0.264***                       | 0.407***                     | -0.0973***                     | 0.506***                     |
|                                | (0.0194)                     | (0.0172)                       | (0.0269)                      | (0.0218)                       | (0.0187)                     |
| Observation                    | 2697                         | 2697                            | 2697                         | 2697                            | 2697                         |
| R square                       | 0.146                         | 0.392                          | 0.0908                       | 0.175                           | 0.0920                       |
| Adjusted R square              | 0.141                         | 0.388                          | 0.0861                       | 0.171                           | 0.0873                       |
| P-values                       | 0.000                         | 0.000                          | 0.000                        | 0.000                           | 0.000                        |

The table presents the results on the influence of digital financial services on vulnerable populations. In this table, the usage of digital financial services among respondents is regressed against the individual indicators of vulnerability (which has five domains: (1) socioeconomic condition; (2) demographic composition; (3) housing and hygiene condition; (4) availability of health-care facilities, and (5) COVID-19-related epidemiological factors) and their total. Age is a continuous variable. Marital status is a dummy variable, taking the value of one if the respondent is a married person and zero otherwise. The religion is a dichotomous variable taking the value of one if the respondent is a Christian and zero otherwise. The parameters are estimated with the small sample adjusted standard errors in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level respectively.
care. In terms of marital status, a negative and highly significant relationship is observed for all vulnerability measures except for housing and hygiene. This may be a result of the married sharing limited space with their spouse and children thus increasing their vulnerability along with that domain. Although age appears to be positive and highly significant, in terms of epidemiological vulnerability it shows a negative effect. This suggests that the age of a respondent can reduce this epidemiological vulnerability.

On the regional influence, we observe a negative and highly significant relationship for the total vulnerability of sampled regions given usage of digital financial services. A closer look at results on the Greater Accra Region suggests the high potency of digital financial services to reduce vulnerability in its slums given its status as the epicentre of the COVID-19 outbreak in the country. This can be attributed to the greater concentration of digital infrastructure in the region which promotes the usage of digital financial services. We observe that, given the usage of digital financial services, both domain vulnerabilities and their total are negative and highly significant except for epidemiological vulnerability which shows a positive and highly significant association. Generally, all the regions show at least a negative significant relationship with a domain vulnerability. The results also suggest that regional differences and dynamics should be factored in when policies are being formulated towards improving the living conditions of persons living in slums and considered vulnerable. This is at the backdrop of COVID-19 disproportionately affecting regions. For religion, we observe that, among the five domain vulnerabilities, only socio-economic vulnerability shows some statistical significance.

4. The sensitivity of gender, vulnerability and digital financial services to COVID-19 exposure

Finally, the study explores the sensitivities of gender, vulnerability and usage of digital financial services of respondents on their exposure to the COVID-19 pandemic. We observe from Table 6 that COVID-19 exposure is highly sensitive to the interaction among gender, vulnerability and usage of financial service. The results show a negative and highly significant relation. The results suggest that given the seemingly high exposure of men to the pandemic, men can take advantage of the opportunities offered by the usage of digital financial services to reduce their exposure to the COVID-19 pandemic.

|          | (1)   | (2)   | (3)   |
|----------|-------|-------|-------|
|          | covid_exposure | covid_exposure | covid_exposure |
| Gender   | 0.115*** |       |       |
|          | (0.0375) |       |       |
| Total vulnerability score | -0.712*** | -0.859*** |       |
|          | (0.116)  | (0.108) |       |
| DFS index | 0.0376*** |       | 0.0469*** |
|          | (0.0128) |       | (0.0102) |
| Gender* DFS index |       | 0.0214** |       |
|          |         | (0.00906) |       |
| Gender* Vulnerability |       |       | -0.0284 |
|          |         |         | (0.0764) |
| Gender* vulnerability * DFS | -0.132** |       |       |
|          | (0.0634) |       |       |
| Age      | -0.00259*** | -0.00251*** | -0.00390*** |
|          | (0.000938) | (0.000945) | (0.000924) |
| married  | -0.00333 | -0.00714 | 0.0144 |
|          | (0.0227) | (0.0226) | (0.0229) |
| Religion | 0.0109 | 0.0130 | 0.0109 |
|          | (0.0256) | (0.0257) | (0.0258) |
Conclusion and policy implications

In this study, we examined the usage of digital financial services, vulnerability, and exposure of slum populations in the COVID-19 pandemic. We employed data from 101 informal settlements across 11 out of the 16 administrative regions of Ghana. By exploring these variables from a gendered perspective, our study makes the following contribution to literature: firstly, men are more likely to be exposed to the COVID-19 pandemic. Secondly, similarly to other findings, this study finds that women are more likely to be vulnerable than men even during pandemics. Thirdly, by making use of digital financial services vulnerable groups can reduce their exposure to the pandemic.

We therefore conclude that there exist gender disparities with regards to COVID-19 exposure and vulnerability. Also, there is a ripple effect of men’s exposure to COVID-19 on the vulnerability of women at large. Given that men are more likely to be exposed to the pandemic than women, there is a need to educate men more on the need to take preventive measures seriously since their negligence would affect women negatively thus increasing their vulnerability. Given that women perform more traditional homemaking roles during pandemics (Power, 2020), support should be given to women to ensure they do not lose their source of livelihood to be able to adequately provide for their needs and that of their

Table 6. Continued

| Region       | Column 1 | Column 2 | Column 3 |
|--------------|----------|----------|----------|
|              | covid_exposure | covid_exposure | covid_exposure |
| Central      | -0.583*** | -0.574*** | -0.566*** |
|              | (0.0699)  | (0.0700)  | (0.0706)  |
| G. Accra     | -0.215*** | -0.213*** | -0.192*** |
|              | (0.0431)  | (0.0432)  | (0.0425)  |
| Volta        | -0.126*   | -0.120*   | -0.0972   |
|              | (0.0722)  | (0.0723)  | (0.0723)  |
| Ashanti      | -0.276*** | -0.271*** | -0.256*** |
|              | (0.0447)  | (0.0448)  | (0.0442)  |
| Ahafo        | -0.0319   | -0.0220   | 0.0102    |
|              | (0.0561)  | (0.0564)  | (0.0551)  |
| Bono         | -0.170*** | -0.168*** | -0.123**  |
|              | (0.0504)  | (0.0505)  | (0.0480)  |
| Bono East    | -0.0694   | -0.0670   | -0.0503   |
|              | (0.0551)  | (0.0555)  | (0.0535)  |
| Northern     | -0.0160   | -0.0110   | 0.0198    |
|              | (0.0512)  | (0.0511)  | (0.0497)  |
| Savanna      | -0.0341   | -0.0271   | 0.0153    |
|              | (0.0605)  | (0.0604)  | (0.0590)  |
| North East   | 0.281*    | 0.284*    | 0.346**   |
|              | (0.150)   | (0.151)   | (0.154)   |
| Constant     | 1.297***  | 1.401***  | 1.127***  |
|              | (0.0729)  | (0.0661)  | (0.0584)  |
| Observation  | 2697      | 2697      | 2697      |
| R square     | 0.0872    | 0.0834    | 0.0640    |
| Adjusted R square | 0.0814 | 0.0783 | 0.0588 |
| P-values     | 0.000     | 0.000     | 0.000     |

The table presents the results on the sensitivity of COVID-19 exposure to gender, digital financial services and vulnerability of slum populations. In this table, the usage of digital financial services among respondents is interacted with gender and their total vulnerability score. Age is a continuous variable. Marital status is a dummy variable, taking the value of one if the respondent is a married person and zero otherwise. The religion is a dichotomous variable taking the value of one if the respondent is a Christian and zero otherwise. The parameters are estimated with the small sample adjusted standard errors in parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level respectively.
families. Again, the labour department of organisations should not be quick in making women redundant during pandemics but should rather find innovative means by which women can contribute towards growth.

Like several other studies, this paper has some limitations. First, the cross-sectional nature of the data means that we cannot assume causality in the findings, rather they should be interpreted as associations. Again, the data was limited to Ghana and residents of informal settlements. However, these limitations do not affect the validity of the findings which can be used in similar contexts especially for vulnerable populations across the world.

**Data availability**

**Underlying data**
OSF: Gender, digital financial services and vulnerability in the era of pandemics. https://doi.org/10.17605/OSF.IO/US6AV (Amidu, 2022).

This project contains the following underlying data:

- Gender DFS and Vulnerability CLEAN.xlsx [This file contains data collected from informal settlement dwellers in Ghana]

**Extended data**
OSF: Gender, digital financial services and vulnerability in the era of pandemics. https://doi.org/10.17605/OSF.IO/US6AV (Amidu, 2022).

This project contains the following extended data:

- Questionnaire.pdf

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

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