Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Journal of Rural Studies 95 (2022) 373–381

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud

Knowledge acquisition and precautionary behaviors for individual resilience to the COVID-19 pandemic: A study of rural Latin America

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ARTICLE INFO

Keywords:
Individual resilience
Precautionary behaviors
COVID-19 pandemic
Latin America

ABSTRACT

The concept of resilience gains prominence as human society faces more frequent and impactful shocks and disturbances. This study seeks to investigate how rural populations build resilience amid the COVID-19 pandemic. A simple theoretical model is presented to illustrate the determinants of knowledge acquisition and precautionary behaviors among rural residents. Based on a High Frequency Phone Survey of 10,583 Latin American adults, this study found that rural residents were less capable of using informal channels (e.g., the internet) to collect COVID-19 information. Younger generations were generally less likely to adopt precautionary behaviors than the elderly. The age disparity, however, was relatively minor for rural populations. Costly preventive measures such as staying at home are less affordable for rural residents. Meanwhile, confidence in government ensures better compliance to ensure public health guidelines. We argue that internet skills, prosociality, and political confidence are necessary to build rural residents' resilience during the pandemic.

1. Introduction

The coronavirus (COVID-19) outbreak caused over 850,000 deaths globally at the time of this writing (Feb-2022). This was not the first global pandemic; however, one very significant problem people encountered was illness uncertainty (Gabarron et al., 2021). The lack of sufficient and consistent information about the disease caused anxiety and affected individual preventative measures (Lee and Basnyat, 2013; Kuang and Wilson, 2017). In this sense, resilience plays an important role in helping individuals to survive disasters and overcome hardship. It depicts the capacity human beings possess to interact with stresses or disturbances through institutions, a sense of community, and cooperation (Eachus, 2014; Barret et al., 2021). The traditional theory assumes that personal attributes play a vital role in building individual resilience in the face of health stresses, including age, gender, and educational level (Crowley et al., 2021; Frías-Armenta et al., 2021).

At the early days of the COVID-19 pandemic, rural areas seemed relatively safe. Majority of cases were concentrated in urban cities. However, the pandemic soon began to spread at a fast speed in rural communities. According to statistics from USA facts, rural communities in United State experienced 175 deaths per 100,000 residents through Feb 2021. The ratio is only 151 for urban communities.[1] The urban and rural divide may be more evident in developing countries. Due to the urban lockdown, migrant workers were forced to travelled back to their rural hometown. A research in India found that in the month of April 2020, rural communities reported only 23% of newly confirmed cases. However in the month of August 2020, the ratio increased to 54% (CSD, 2020).

Several reasons may account for why rural communities are particularly vulnerable to the COVID-19 pandemic. On the one hand, a large percentage of rural residents suffer from chronic diseases. For instance, the number of diabetes patients in rural areas of the U.S. is 17% higher than in urban areas (Coughlin et al., 2019). For those with underlying health problems, the impact of COVID-19 will be more profound. On the other hand, health facilities in rural regions are not well equipped to deal with the pandemic due to the lack of ICUs and medical staff with

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[1] https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/covid-19-and-rural-communities-protecting-rural-lives-and-health.

https://doi.org/10.1016/j.jrurstud.2022.09.015
Received 26 March 2022; Received in revised form 20 August 2022; Accepted 12 September 2022
Available online 27 September 2022

specialized skills (OECDa, 2020). Moreover, rural residents generally have jobs that are not remote, making flexible working arrangement and social distancing much harder to be implemented. Recent studies found that urban residents have better preventive practices and are more resilient to health crises than rural residents during the pandemic (Sun and Monnat, 2021). Therefore, studies on how rural dwellers respond to COVID-19 have significant theoretical and practical implications.

There are three factors to consider when assessing individual resilience in the face of the pandemic. First, individuals can obtain COVID-19 knowledge from two major sources. Those sources are more formal, such as newspapers and network news on television, as well as informal channels such as online media and personal networks. Residents in different social and economic strata rely on a variety of channels, shaping divergent precautionary behaviors (Almutairi et al., 2020). Second, compliance with some precautionary behaviors such as hand washing or masks is more likely. Other behaviors such as quarantines may impose heavy individual burdens, especially in less developed regions (Schraff, 2021). The determinants of regular and costly precautionary behaviors will be quite different. Finally, COVID-19 spreads via face-to-face contact. Adopting precautionary behaviors are thought of as responsible actions to protect others (Tapia-Fonllem et al., 2013; Vijaykumar et al., 2021). We could observe better policy compliance in regions where peer pressure plays a significant role in decision-making (Albert et al., 2013).

In sum, this paper investigates the behavior patterns of rural populations during the pandemic to understand how to build individual resilience. Specifically, it seeks to find out motives behind different channel of knowledge acquisition and different types of precautionary behaviors. Despite studies on personal risk management during COVID-19, those reports did not examine rural populations in detail. As mentioned above, as compared to urban areas, rural communities face inadequate healthcare services, limited medical resources, and the populace tends to suffer from chronic diseases (Viscomi et al., 2013). In the meantime, there are enormous digital inequalities between urban and rural areas. Globally, people in urban areas use the internet more frequently than those in rural areas (76% versus 39% by 2020).[2] Digital infrastructure access barriers contribute to health disparities between rural and urban populations (O'Sullivan et al., 2020).

The remainder of this paper is structured as follows: Section 2 reviews the literature on antecedents of precautionary behaviors and introduces our theoretical hypotheses. Section 3 reports explanations on data sources, variables, and regression models. Sections 4 and 5 present empirical results and a robustness check. Finally, Section 5 summarizes the conclusions.

2. Literature review and hypothesis

2.1. Resilience, health, and theoretical framework

Human beings are exposed to various risks and uncertainties every day. One of the more puzzling questions that challenge scholars is why some people overcome hardships when faced with the difficulties of life, while others do not (Eachus, 2014). The concept of resilience was introduced to explain the capacity human beings have to thrive and grow against adversities and life risks (See a summary of Barrett et al., 2021). The recent COVID-19 pandemic has led to a dramatic loss of lives worldwide and presents an unprecedented challenge to public health. It also provides an opportunity to study individual resilience amid health crises. Scholars across various disciplines wish to determine what shapes precautionary behaviors and builds individual resilience (Guidry et al., 2021; Wang et al., 2021; Clark et al., 2022). According to their findings, social-demographic features are critical in determining resilience amid a health crisis. Variables such as gender, education, and age require inclusion when predicting resilience (Kaye-Kauderer et al., 2021). However, resilience is more than a personality trait, it also progresses as a result of a complex process of human interaction with the environment. The capacity of individuals to cope with and recover from adversities also resides on context factors such as available resources, social support from other people, specific cultures, and religion (Silva-Villanueva, 2019).

Individuals' decision to engage in any specific behavior such as smoking, gambling, or precautions against diseases can be explained by the theory of planned behavior (TPB). According to this model, personal attitudes, subjective norms and perceived behavioral control jointly determine how hard people are willing to try to perform a specific behavior (ArmitageConner, 2001). Personal attitudes refer to positive and negative view that we think of a behavior. For instance, some people may think that smoking is relaxing, whereas others may realize that smoking is harmful to health (Brookes, 2021). Subjective norms refer to our perception of others' attitude toward a specific behavior. Subjective norms can be interpreted as informal rules that define acceptable and appropriate actions within a given group or community. Perceived behavior control describes the extent to which people believe that they can control their behavior. It refers to the resources and opportunities available to a person to dictate the likelihood of behavioral achievement (Ajzen, 1991).

Based on the theory of planned behavior, we present a simple framework in Fig. 1 to illustrate individual resilience to the COVID-19 pandemic. One of the central premises of this theory is that people make decisions rationally by systematically using accessible information. Given that COVID-19 is a newly emerged disease, people may rely on two distinct but compatible sources to acquire necessary knowledge: formal and informal channels. The former refers to information acquisition via sources such as newspapers, television, and other traditional media; the latter refers to information sources such as websites, social networks, or digital media.

Knowledge to COVID-19 is critical in attitude formation. It helps us to judge the expected severity and susceptibility to illness and then leads to precautionary measures. Symptoms of COVID-19 include fever, cough, and shortness of breath. Recommended precautionary measures include hand-washing, social distancing, and wearing face masks. The elderly with lung problems and heart disease are more vulnerable to

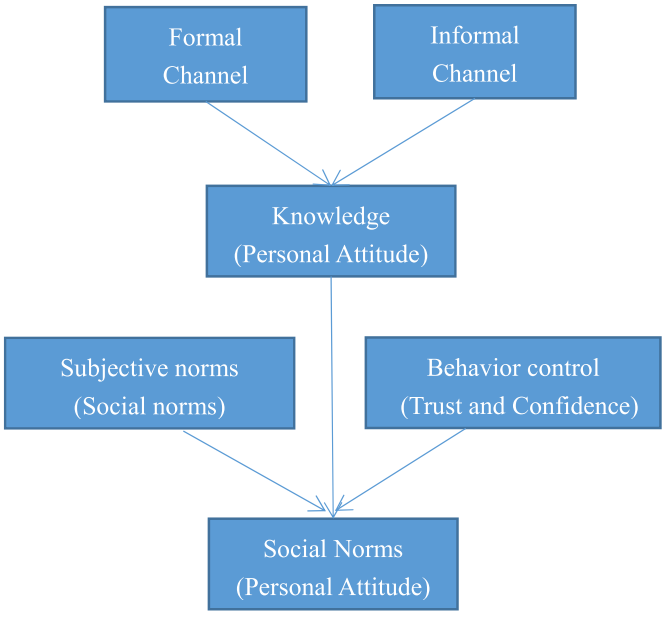

Fig. 1. Individual knowledge acquisitions and precautionary behaviors to the pandemic.

[2] See the link for the complete report: https://www.itu.int/itu-d/reports/statistics/2021/11/15/internet-use-in-urban-and-rural-areas/.

COVID-19 (World Health Organization, 2020). Infants can also become infected shortly after being born. Pregnant women thus should take extra precautions.[3] Although this information is well-known to the public now, few people knew the details initially. For instance, there once was a heated debate on the necessity of wearing face masks in public.[4] In sum, without the appropriate knowledge, it is difficult to differentiate between the signs of COVID-19 and seasonal flu. It also means that a lot of people have the coronavirus without realizing it and are continuing to spread the infection.

Perceived behavioral control indicates that behavior is also influenced by the perception of how successfully the behavior can achieve the expected result. For instance, although wearing a face mask can slow the spread of COVID-19, many individuals still choose not to do so in public. On the one hand, people may feel resentment and frustration if they are faithful mask wearers but others fail to comply with the health guideline. On the other hand, the belief in conspiracy theory also leads to avoidance of following safe measures (Banai et al., 2021). Therefore, people who show limited trust in government and social media are less likely to adhere to the official guideline. Finally, the subjective norms indicate that people are more likely to exercise precautionary behaviors if they believed that other people approve of these behaviors (Brookes, 2021). Therefore, to what extent individuals are willing to comply with health guidelines also depends on social determinants such as peer pressure. For instance, Pelletier et al. (2014) found that healthy eating behaviors of young adults reflect their perception of normative behaviors among friends. The social acceptance of smoking also has varied tremendously from decade to decade (Boardman et al., 2010).

To analyze how individuals build individual resilience amid a health crisis (i.e. COVID-19), this paper adopted a two-stage strategy. The first stage investigated what contributed to knowledge acquisition of COVID-19 (formal vs. informal channels). According to the information from WHO, COVID-19 is the disease caused by a new coronavirus called SARS-CoV-2. The knowledge acquisition process thus becomes rather important as people lack sufficient understanding of this new virus. The second stage focused on how knowledge and other factors contributed to precautionary behaviors amid the COVID-19 pandemic. Not all preventive measures were equivalently cost-effective for every resident. We divided these measures into two groups based on the underlying individual burdens imposed. This is because individuals avoid any action if the costs are too high (Kaye-Kauderer et al., 2021). Some residents are less likely to comply with health guidelines such as staying at home due to their economic situations. Thus, there is a need to classify precautionary behaviors into at least two groups (costly and regular) based on the financial burden imposed on individuals.

2.2. COVID-19 in Latin American

On Feb 25, 2020, Brazil reported the first COVID-19 case in Latin America. Although the country soon enforced lockdowns, the pandemic has not been controlled. The number of confirmed cases increased to 65,000 within only two months (Burki, 2020). By the end of OCT 2021, there were more than 45 million registered infections which caused nearly one-third of COVID-19 related deaths worldwide. Except for the health risks, the pandemic also posed a tremendous social and economic threat. According to the report from IMF, Latin America experienced a 7% of economic contraction in 2020. Furthermore, due to the crisis, there has been a sharp falling of Latin American currencies. The Economic recession further increases income inequality. Around 17 million people in this region moved into poverty gain (Sullivan and Meyer, 2022).

[3] https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/coronavirus-in-babies-and-children.

[4] https://www.acsh.org/news/2020/03/31/great-face-mask-debate-wear-or-not-wear-14675.

Several reasons may account for the failure in initial stage containment in Latin America. First, one of the primary policies in Latin America to halt the spread of COVID-19 at early stage is lockdowns. However, a large proportion of working forces here are informally employed. Many of them then had to violate lockdowns to work outdoors (Bakker and Goncalves, 2021). It is difficult for these low-income workers to reduce mobility. Second, people in Latin America have limited trust in government, which further lead them to violate public health guideline. Statistics show that the average trust level in Latin America is 33.9% which is far below the OECD average of 45%. In large countries such as Brazil, Argentina and Venezuela, only one-quarter of residents are willing to trust the government (OECDb, 2020b). Finally, many residents in Latin America suffered from chronic diseases. For instance, more than 75% of female in Mexico and Chile are overweight, which has been consistently associated with increased COVID-19 severity and mortality. As a major component of the “third world”, the study on Latin America allow us to figure out what may enhance or hamper resilience building in times of crisis in developing regions.

2.3. Research hypothesis

Studies indicate that news volume consumption positively correlates to active responses to epidemics such as SARS, H1N1, and COVID-19 (see a summary of Foster and Vendemia, 2021). It is difficult to claim whether informal or formal channels are more effective in fostering precautionary behaviors. Although some media are not politically neutral, information from formal channels is generally more authoritative and accurate (Ash et al., 2020). However, according to social network theory, information channeled through an informal channel (e.g., social networks) is more valuable and less redundant and this increases individuals’ overall knowledge of disease (Xiong et al., 2017; Perkins et al., 2015). As long as solid infrastructures and necessary internet skills remain in place, informal channels will become an essential source for users to personalize health care decisions (Scanfeld et al., 2010).

Whether informal channels provide timely and accurate information on COVID-19 depends on individual internet skills and ICT facilities. The digital divide between rural and urban areas exists and rural communities have been struggling to keep up with the development in digital connectivity (Risnen and Tuovinen, 2020). Studies indicated that rural residents tend to spend more time reading newspapers and watching TV news than their urban counterparts (Blekesaune and Elvestad og, 2012). On one hand, rural areas generally lack well-functioned infrastructures, while urban communities have much better internet connectivity. The gap in poorer areas (e.g., African countries) is even greater. Only 15% of the rural population has access to the internet as compared to over 50% of urban citizens (ITU, 2021). Therefore, rural dwellers do not rely on informal channels due to inadequate internet access.

Furthermore, rural communities also lack an adequate capacity and skill to embrace new technologies (Salemink et al., 2017). One of the major drawbacks of informal channels is the plethora of misinformation. Compared with true information, misinformation spreads spread faster online by exploiting strong emotions such as fear, surprise, and disgust . It influences beliefs and behaviors detrimental to solving the health crisis (Roozenbeek et al., 2020). Since the outbreak, governments worldwide have employed a range of methods to handle on line misinformation on COVID-19 (Pomeranz and Schwid, 2021). At the individual level, the impact of miss information is never shared equally. Better educated people with advanced internet skills are more likely to identify misinformation. Internet skills refer to what people can do online (Desursen and van Dijk, 2016). Browsing and searching content online is only a basic level. Many people cannot prevent themselves from getting lost and disoriented when surfing online (Desursen and van Dijk, 2011). The ability to assess and select online information determines whether individuals can achieve professional goals online (Mota and Cilento, 2020). Taking all these into consideration, we propose that

H1a. : Formal channels are significant in predicting COVID-19 knowledge for rural populations.

H1b:. Informal channels are insignificant in predicting COVID-19 knowledge for rural populations.

Many behaviors that help control COVID-19 involve a conflict of interest between what is best for individuals and what is best for society (Dong et al., 2020). Therefore, precautionary behaviors against COVID-19 should also be considered as a specific type of pro-social behavior. According to Campos-Mercade et al. (2021), pro-social individuals are more likely to wear face masks, follow social distancing guidelines, and stay at home. Not all people are willing to practice pro-social behaviors to benefit society as a whole. Free-ride is also a common phenomenon in social dilemmas (Jin et al., 2021). Based on a survey in Japan, Cato et al. (2021) found the free-rider problem is particularly severe for social distancing among all precautionary behaviors. Between 30 and 40% of respondents refused to follow social distancing rules. As suggested by Sawitri et al. (2015), the adoption of pro-social behaviors depends primarily on two factors: (1) the norms that individuals should be responsible for others; (2) actions taken by individuals effectively satisfy those norms. Therefore, the majority of people are "strategic cooperators". They are willing to contribute to the public good only when they believe others will do the same (Fischbacher et al., 2001). No one will follow public health guidelines if he/she anticipates that everyone will not. Reciprocity norms are necessary for individuals to make pro-social behaviors during the pandemic.

With the development of the market economy, individuals engage in economic activities more frequently than ever before. One of the fundamental principles of the market economy is maximizing self-interest. In the absence of appropriate regulation, market forces reduce altruistic behavior and inhibit social trust (Xin and Xin, 2017). Additionally, economic development normally comes with large-scale population mobility. A growing body of literature suggests that diversity tends to inhibit trust, at least in the short run (Laurence, 2011). Migrants and urban locals both view one another as out-group members due to the distinct characteristics between them. Disparities in languages, religions, norms, and values widen social distance (Nielsen et al., 2006). The COVID-19 pandemic posed a divergent impact on people of different ages. Scientific research indicated that the elderly were more susceptible to infection and suffer from severe disease symptoms (Liu et al., 2022). They were also associated with higher fatality rates (Wu and McGoogan, 2020). Therefore, younger generations are less likely to engage in precautionary behaviors (Nguyen and Xuan, 2021; Diclemente et al., 2021). However, we would expect the age disparity to be minor for rural communities because Nature Will explains in their social life. Higher levels of social trust facilitate the engagement of the rural population in more pro-social behaviors. Taking these factors into account, we propose that

H2a. : Younger generations are less likely to comply with precautionary behaviors

H2b. : The age disparity is relatively minor for rural communities than for urban communities

Our final concern was whether rural residents would comply with public guidance that may impose high personal costs. Scholars have pointed out the pandemic increased poverty and enlarged the gap between poor and rich (Bargain and Aminjonov, 2021; Gutierrez-Romero and Ahamed, 2020). The low-income family has limited economic resources required to support remote working. Therefore, precautionary measures like lockdown put them at high risk for hunger (Ravallion, 2020). Several empirical studies support these findings. For instance, Carlitz and Makhura (2021) found that poor communities are more likely to resist lockdown measures in South Africa. Based on a survey in Ghana, Günther (2021) indicated the significant resistance to lockdown policies stems from poverty and underdeveloped infrastructure.

Given huge economic pressures, we expect that rural residents are less likely to comply with lockdown measures than urban residents. However, we also believe the level of confidence in government mediates the above-mentioned regional gap. Public health measures are challenging to maintain as discontent spreads over time. Political confidence would convince people that governors act in the best interest of the governed (Schraff, 2021). Moreover, they are less likely to hold conspiracy beliefs and adhere to official recommendations (Karić and Međedović, 2021). At the early stage of the pandemic, conspiracy beliefs once served as the most significant predictor of precautionary behaviors. Some people even believed the virus was harmless or nonexistent (Imhoff and Lamberty, 2020). Given this, we propose that

H3a. : Rural residents are less likely to comply with costly measures due to economic pressures.

H3b. : Confidence in government promotes compliance with costly measures for rural residents.

3. Research methodology and data source

3.1. Data sources and variables

The data used in the paper came from a High Frequency Phone Survey on COVID-19 (HFPS), conducted by the World Bank to monitor the impacts of COVID-19 in thirteen Latin American countries[5] between March and July 2020. This timetable was at the beginning of the pandemic and a time when very little information about the pandemic was known with any certainty. It is a perfect data set to reveal how individual acquire COVID-19 knowledge and adopt precautionary behaviors. The HFPS collected information on residents' knowledge of the COVID-19, precautionary behaviors, changes in employment, education, income loss, and food insecurity. All eligible respondents were above 18 years old with 10,583 total valid samples. Approximately 47% of respondents were rural.

3.1.1. Knowledge of COVID-19

Hypothesis 1refers to determinants of COVID-19 knowledge. Respondents were asked to name as many symptoms related to COVID-19 as possible. Typical symptoms include fever, cough, headache, shortness of breath, muscle aches, or sore throat. We assume the number of symptoms each respondent cited measures the richness of knowledge of COVID-19. Respondents that named at least three symptoms were assigned a value of "1". Otherwise, they were assigned a value of "0". Details of descriptive statistics are given in Table 1. Of all respondents, 65.2% were classified as a "knowledge-rich group". Distinctions between urban and rural samples were insignificant, as 67.2% of urban respondents were knowledgeable (64.1% for rural respondents).

3.1.2. Precautionary behaviors

Hypothesis 2refers to determinants of precautionary behaviors. Respondents were also asked whether they adopted any precautionary measures (e.g., hand washing, face covering, social distancing, staying at home, avoiding social gatherings, canceling travel plans) to prevent COVID-19. We counted the total number of precautionary behaviors to see the extent to which respondents complied with public health guidance. On average, respondents adopted three different measures to stop the spread of COVID-19. Hypothesis 3 presumes that rural residents were less likely to comply with "costly measures" as they are not eligible for remote work. Therefore, those who engaged in preventive actions such as "staying at home", "avoiding social gatherings", and "canceling travel plans" were classified as one group and assigned a value of "1".

[5] The survey covers Argentina, Bolivia, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Paraguay, and Peru.

Table 1
Descriptive statistics.

	Explanation	Mean	S.D
Knowledge	Mentioned at least three symptoms of COVID-19 = 1 Mentioned less than three symptoms of COVID-19 = 0	65.2% 64.1%^{R} 67.2%^{U}	0.2322 0.1933^{R} 0.2291^{U}
Pre behaviors (number)	Total number of measures taken since the pandemic Min = 0, Max = 6 (hand washing, face covering, social distancing, stay at home, avoid social gathering, cancel traveling plan)	2.7822 2.9410^{U} 2.8207^{R}	1.3122 1.2207^{U} 1.4072^{R}
Pre behaviors (costly)	Take costly measures since the pandemic = 1 (Costly: stay at home, avoid social gathering, cancel traveling plan) Take regular measures or non-measures = 0 (Regular: hand washing, face covering, social distancing)	21.3% 26.2%^{U} 15.4%^{R}	0.1522 0.1623^{U} 0.2042^{R}
Informal channels	Receive COVID-19 information primarily from websites or social networks = 1 Otherwise = 0	22.1% 23.7%^{U} 19.4%^{R}	0.2372 0.2461^{U} 0.2288^{R}
Formal Channels	Receive COVID-19 information primarily from TVs, Newspapers and broadcasts = 1 Otherwise = 0	42.5% 43.7%^{U} 41.8%^{R}	0.1688 0.1715^{U} 0.1891^{R}
Political confidence	Satisfied with the government during the pandemic = 1 Not satiated during the pandemic = 0	70.2% 68.6%^{U} 71.9%^{R}	0.4574 0.4641^{U} 0.4492^{R}
Age	Elderly group (50 above) = 1 Younger group (below 50) = 0	30.27% 32.79%^{U} 27.45%^{R}	0.1577 0.1464^{U} 0.1695^{R}
Education	Educational attainments None = 1, …, College degree or above = 12	5.4712 6.3822^{U} 4.5516^{R}	2.8827 2.5133^{U} 2.8922^{R}
Region	Rural samples = 1 Urban samples = 0	47.52%	0.2212
Family members	Number of family members live with Min = 0, Max = 16	2.2773 2.1522^{U} 2.4159^{R}	1.8355 1.7835^{U} 1.8712^{R}
Employment	Employed before the pandemic Yes = 1, No = 0	0.7511 0.7672^{U} 07334^{R}	0.1323 0.1226^{U} 0.1421^{R}
daily medication	Daily Medication Yes = 1, No = 0	0.2793 0.2905^{U} 0.2672^{R}	0.1484 0.1425^{U} 0.1541^{R}
Rooms per capita	Average room per family member Min = 0.16, Max = 20	1.8281 1.8891^{U} 1.9962^{R}	1.1662 1.1557^{U} 1.1665^{R}
Gender	Gender of respondents Male = 1, Female = 0	52.12% 51.17%^{U} 52.29%^{R}	0.2301 0.2047^{U} 0.2133^{R}

Note: "R" refers to the value of rural samples and "U" refers to the value of urban samples.

The rest (those not involved in regular measures such as hand washing, face-covering, and social distancing) were assigned a value of "0". As Table 1 indicates, fewer rural samples adopted "costly measures" as compared to their urban counterparts.

3.1.3. Other key variables

As detailed above, sources of information play a central role in the diffusion of COVID-19 knowledge. Approximately 22.1% of respondents relied primarily on informal channels to obtain COVID-19 information and that percentage was slightly lower in rural communities. Informal and formal channels are not mutually exclusive. Around 30–40% of respondents claimed using both channels frequently to seek COVID-19 information.

Hypothesis 2 presumes a divergent effect of age on precautionary behaviors in rural and urban communities. As Jin et al. (2021) highlighted, age relates closely to variations in the perception of precautionary behavior costs and benefits of infectious diseases. Based on a meta-study of 6,111,583 subjects, Bonanad et al. (2020) found the mortality rate increased significantly after the age of 50. We thus set "50" as the age threshold and divided samples into two groups. If younger generations align with precautionary behaviors, we might conclude they are more concerned about the collective benefit. They are willing to sacrifice freedom despite lower infection rates. *Daily medication* may refer to a proxy of health awareness. Those who used to take pills may be more sensitive to health crises. *Rooms* per capita and *Family members* refer to family living conditions.

3.2. Model setup

To explore the association between rural-urban differences and COVID-19 precautionary behaviors, this study relied on the logit model often used when dependent variables are binary or categorical, such as "Yes or No", or "poor, fair, average, and good". The likelihood of observing outcome i corresponds to the probability that the estimated linear function and random errors:

The probability change learning of COVID-19 and engaging in precautionary behaviors depends on X, which refers to the independent variables listed in Table 1. β refers to the coefficients we seek to estimate.

4. Empirical results

4.1. Determinants of knowledge acquisition

For each regression step, we present full-sample, rural sample, and urban sample analyses. As indicated in Table 2, both formal and informal channels are significant in predicting COVID-19 knowledge ($b = 0.492/0.564$, $P < 0.001$). Unlike linear regressions, the coefficient of logit estimation is difficult to interpret. Therefore, we computed the variation on COVID knowledge when the value of informal/formal channels shifted from "0" to "1" (also known as the marginal effect). This was done using the "*PRVALUE*" command in *Stata*. The percentage of becoming the "knowledge-rich group" increased by 4.25% if all respondents accessed COVID-19 information through formal channels. Accordingly, the predicted percentage of the "knowledge-rich group" increased by 6.02% if all respondents accessed COVID-19 information through informal channels. In the full-sample studies, informal channels more effectively promoted pandemic-related knowledge. However, Columns 2 and 3 in Table 2 indicated that informal channels were less effective in rural communities but beneficial to urban populations. Overall, the data supported both H_{1a} and H_{1b} as rural populations rely

Table 2
Factors predicting COVID-19 knowledge.

	Full sample	Rural	Urban
Informal channels	0.564 (0.000)	0.244 (0.131)	0.782 (0.000)
Formal channels	0.492 (0.000)	0.633 (0.000)	0.433 (0.007)
Age	0.313 (0.000)	0.223 (0.228)	0.392 (0.037)
Education	0.174 (0.000)	0.216 (0.000)	0.132 (0.000)
Family members	−0.201 (0.000)	−0.037 (0.518)	−0.298 (0.001)
Employment	0.217 (0.000)	0.273 (0.001)	0.431 (0.009)
Daily medication	0.105 (0.379)	0.093 (0.599)	0.065 (0.692)
Rooms per capita	−0.113 (0.002)	−0.109 (0.034)	−0.113 (0.021)
Gender	0.309 (0.013)	0.404 (0.000)	0.331 (0.002)
No. obs.	105,083	49,936	58,447
Wald X^2	346.10	201.10	198.61
Pr (y = 0 | formal channels)	−4.25%	−6.77%	−3.42%
Pr (y = 1 | formal channels)	+4.25%	+6.77%	+3.42%
Pr (y = 0 | informal channels)	−6.02%	−1.02%	−7.31%
Pr (y = 1 | informal channels)	+6.02%	+1.02%	+7.31%

Note: Logit models are performed; P values are reported in parentheses.

primarily on formal channels.

Several control variables exhibited significant signs. For instance, education had a significant impact on COVID-19 knowledge and agreed with findings from west Asia (Imtiaz et al., 2021). Males possess better COVID-19 knowledge than females, partly due to gender differences in knowledge acquisition. As Evans and Schweingruber (2002) noticed, males prefer news on science, sports and politics. Females are more concerned about information about arts and music. Employment also exerts a positive impact on COVID-19 knowledge.

To better reveal what contribute knowledge acquisition in rural and urban regions, we plot the interaction effect in Fig. 2. The Y-axis depicts the probability of becoming a knowledge rich individual (Mentioned at least three symptoms of COVID-19). The X-axis denotes the use of informal channel. As reported in Fig. 2, plots of observations that relied on formal channels (dash curve) are located above the solid curve for rural samples, suggesting that formal channel is effective in predicting knowledge acquisition for rural residents. The distance between two curves is shorter for urban samples. This may imply that formal channel is not significant for urban citizens. For urban samples, both the dashed curve and solid curve show an upward trend. This may imply that the use of informal channel is effective for urban residents. For rural samples, the solid curve is relatively flat, suggesting that the effect of informal channel tend to be insignificant. The plot figure thus confirm the results in Table 1. For both urban and rural using both informal channel and formal channel have the highest probability of gaining better knowledge to COVID-19.

4.2. Determinants of precautionary behavior

Table 3 estimates the factors predicting precautionary behaviors. Consistent with previous studies (Hornik et al., 2021, Frías-Armenta et al., 2021), COVID-19 knowledge was incorporated as a key action determinant. Ordered logit models were performed as the outcome variables are ordinal. Those results suggested that knowledge facilitated precautionary behaviors in both rural and urban communities. Learning enough about COVID-19 helped residents better prevent its spread. Age had a negative sign across all regressions. Of all younger respondents (<50 years old), the percentage of those who adopted at least five types of precautionary measures decreased by 4.28% in rural communities and 13.31% in urban communities. The rural-urban difference for younger people in adopting precautionary behaviors exists.

H_{2a} predicted that younger generations in rural communities may not be as opposed to precautionary measures due to an altruistic culture and this hypothesis was supported in our research. Several control variables were also significant as we expected. *Daily medication* exhibits a positive sign. As the health belief model presumes, better health awareness stimulates effective responses against health threats. *Gender* negatively correlated to precautionary behaviors. One possible explanation is that men are generally more overconfident than women, which reduces their motives to follow public guidance (Barber and Terrance, 2001).

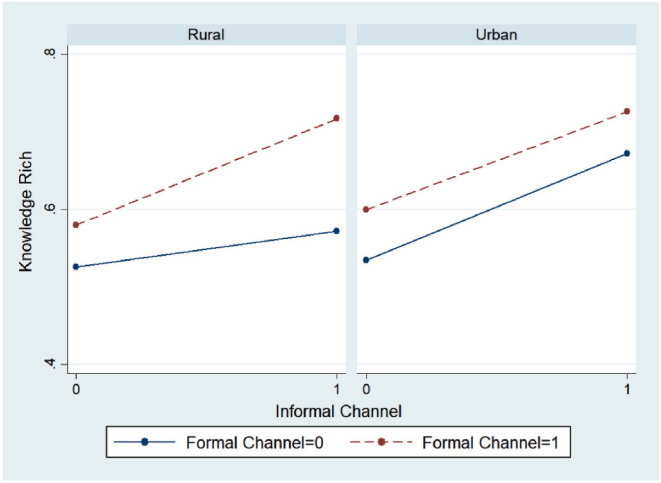

Fig. 2. Interaction effect of informal and formal channel.

Table 3
Factors predicting COVID-19 precautionary behaviors.

	Full sample	Rural	Urban
Knowledge	0.601 (0.018)	0.729 (0.003)	0.693 (0.007)
Age	−0.461 (0.000)	−0.177 (0.023)	−0.558 (0.000)
Education	0.187 (0.006)	0.023 (0.056)	0.008 (0.357)
Family members	−0.013 (0.527)	0.032 (0.435)	−0.055 (0.122)
Employment	0.029 (0.523)	0.028 (0.668)	0.031 (0.644)
Daily medication	0.334 (0.000)	0.435 (0.000)	0.242 (0.000)
Rooms per capita	−0.021 (0.253)	−0.003 (0.871)	−0.042 (0.192)
Gender	−0.216 (0.000)	−0.258 (0.000)	−0.196 (0.003)
No. obs.	10,583	5027	5556
Wald X^2	259.12	201.10	198.61
Pr (y = 1,2,3,4 | Age)	+11.28%	+4.28%	+13.31%
Pr (y = 5,6 | Age)	−11.28%	−4.28%	−13.31%

Note: Logit models are performed; *P* values are reported in parentheses.

Our final concern was whether rural communities were less likely to comply with costly precautionary measures such as staying at home, and whether political confidence reinforces their motives to comply with these measures. As Table 4 indicates, political confidence significantly shapes precautionary behaviors even though they may incur higher individual costs. If respondents were satisfied with the government, the percentage of those who adopt costly precautionary measures increased by 17.29%. *Region* exhibits a negative sign, suggesting that residents in rural communities were less likely to comply with costly measures; this data confirmed H_{3a}. We divided samples into high and low political confidence groups. This helped us to figure out whether political confidence had a divergent effect on rural and urban communities (to confirm hypothesis H_{3b}). Although *Region* seems significant in columns 2 and 3, the margin effect differs significantly (12.07% vs. 6.88%). Strengthening political confidence improves the effectiveness of public health guidance, and that effect is more robust in rural communities.

5. Robustness check

One of the major caveats of previous analysis is the problem of

Table 4
Factors predicting costly COVID-19 precautionary behaviors.

	Full sample	High Pol.con	Low Pol.con
Knowledge	0.109 (0.201)	0.088 (0.253)	0.122 (0.187)
Age	−0.589 (0.000)	−0.497 (0.000)	−0.622 (0.000)
Political confidence	0.672 (0.000)	-	
Education	0.233 (0.001)	0.212 (0.006)	0.302 (0.000)
Family members	0.053 (0.309)	0.042 (0.410)	0.055 (0.331)
Employment	0.274 (0.015)	0.309 (0.003)	0.242 (0.038)
Daily medication	0.409 (0.000)	0.502 (0.000)	0.387 (0.000)
Rooms per capita	−0.021 (0.253)	−0.003 (0.871)	−0.042 (0.192)
Gender	−0.327 (0.000)	−0.388 (0.000)	−0.266 (0.012)
Region	0.305 (0.000)	0.413 (0.000)	0.287 (0.023)
No. obs.	10,583	7429	3154
Wald X^2	341.12	302.08	278.55
Pr (y = 0 | Political confidence)	−17.29%	-	-
Pr (y = 1 | Political confidence)	+17.29%	-	-
Pr (y = 0 | Rural)	−8.78%	−12.07%	−6.88%
Pr (y = 1 | Rural)	+8.78%	+12.07%	+6.88%

Note: Logit models are performed, *P* values are reported in parentheses.

omitted variables. Some factors that are related to healthy perception or behaviors have not been included in the survey, which is a common issue for cross-sectional data analysis. Thus, we introduced bivariate-probit regressions that jointly model two binary (or ordinal) dependent variables as a function of some explanatory variables. As the equation below illustrates, estimations were divided into two stages. The first equation included the predictors of COVID-19 knowledge, which is also a significant determinant of the second equation

$$y_{ki}^{*} = x_{ki}\beta_k + \varepsilon_{ki} = \begin{cases} \text{Knowledge}^{*} = x_{1i}\beta_1 + \varepsilon_{1i} \\ \text{Behaviors}^{*} = x_{2i}\beta_2 + \gamma_i \text{Knowledge}^{*} + \varepsilon_{2i} \end{cases}, \; K = 1, 2 \tag{2}$$

The first part in Table 5 indicates that both informal and formal channels are conducive to COVID-19 knowledge. Consistent with previous sections, *Education*, *Employment* and *Gender* all exhibit positive signs. The second part in Table 5 proves that knowledge is critical in shaping behaviors (at 5% level). Younger generations are less likely to comply with public health guidance than the elder group in urban communities. Political confidence exerts a substantial impact on precautionary behaviors, and the promoting effect is stronger in rural communities. Prob > X^2 is less than 0.001 across all three regressions, suggesting that *biprobit* regressions and the regular logit model produce almost identical results. In other words, empirical findings from previous sections are reliable.

6. Conclusions and discussion

Although research on "Resilience" may date back to the 1950s, scholars have not reached a consensus on what makes resilient individuals and why some people are more resilient than others (Silva-Villanueva, 2019). Moreover, previous studies generally concentrated on a few African or south Asia countries after natural disasters (Barrett et al., 2021). Using data from the High Frequency Phone Survey, this study attempted to find out what contributes to behavior patterns of rural populations in Latin America amid the COVID-19 pandemic based on a two-stage strategy. The primary findings can be summarized as follows: (1) Rural populations lack the necessary skills to embrace new technologies. They rely primarily on formal channels to acquire COVID-19 knowledge. Informal channels such as online websites and digital media contribute to COVID-19 knowledge only for urban samples; (2)The engagement of precautionary behaviors increased with age. This was partly due to the added vulnerability of the elderly to COVID-19. The age disparity was less evident in rural regions, suggesting that rural residents are more concerned about collective benefits than individual interests; (3) Due to economic pressures, rural residents were less likely to comply with costly measures such as staying at home or reducing social gatherings. However, political confidence increases better policy compliance. This further confirms the significance of social determinants in shaping precautionary behaviors.

Table 5
Factors predicting costly COVID-19 precautionary behaviors.

Knowledge	Full	Rural	Urban
Informal channels	0.364 (0.000)	0.275 (0.001)	0.492 (0.000)
Formal channels	0.231 (0.000)	0.211 (0.011)	0.301 (0.007)
Age	0.178 (0.266)	0.203 (0.210)	0.292 (0.137)
Education	0.309 (0.000)	0.298 (0.000)	0.248 (0.000)
Family members	0.043 (0.178)	0.067 (0.123)	0.098 (0.92)
Employment	0.313 (0.000)	0.309 (0.001)	0.478 (0.001)
Daily medication	0.078 (0.390)	0.083 (0.322)	0.088 (0.309)
Rooms per ca-pita	−0.083 (0.062)	−0.094 (0.054)	−0.177 (0.121)
Gender	0.409 (0.000)	0.513 (0.000)	0.368 (0.000)
Behaviors	**Full**	**High Pol.con**	**Low Pol.con**
Knowledge	0.988 (0.044)	1.001 (0.026)	1.091 (0.011)
Age	−0.399 (0.006)	−0.133 (0.060)	−0.431 (0.000)
Political confidence	0.541 (0.000)	-	
Education	0.278 (0.000)	0.123 (0.026)	0.198 (0.017)
Family members	0.019 (0.321)	0.022 (0.381)	0.029 (0.201)
Employment	0.058 (0.318)	0.041 (0.522)	0.063 (0.309)
Daily medication	0.378 (0.000)	0.399 (0.000)	0.360 (0.000)
Rooms per ca-pita	−0.033 (0.292)	−0.018 (0.530)	−0.037 (0.245)
Gender	−0.351 (0.000)	−0.298 (0.000)	−0.224 (0.000)
Region	0.327 (0.000)	0.464 (0.000)	0.207 (0.033)
Wald X^2	341.12	302.08	278.55
Prob > X^2	0.0022	0.0017	0.0017

Note: Biprobit models are performed, *P* values are reported in parentheses.

Our study tend to contribute existing literature in the following ways: First, it brings the concept of resilience into the context of a health crisis. Previous studies generally treated resilience as a phenomenon of recovery, paying undue attention to development after disasters (e.g., Hua et al., 2018; Eshel and Kimhi, 2016). However, studies concerning resilience should also focus on psychological processes before or amid the crisis, as it impacts both preparedness and coping strategies. Second, we showed that resilience goes deeper than personality traits, and community differences should be involved in the future. The traditional health belief model highlights the benefits of and barriers to taking preventive actions act as the major component behind individual preventive behaviors. Actions are taken only if the anticipated benefits outweigh the anticipated costs (Sayegh and Knight, 2013). However, cultural and social factors affect how individuals perceive risks and benefits. This is why huge disparities between urban and rural regions were observed in this study. Future works may investigate other regional attributes of resilience by accounting for the effects of language, religion, norms, and values.

This study also provides several practical implications for building rural resilience. First, knowledge is critical in shaping protective measures against health threats. This research, along with several other studies, found that knowledge of COVID-19 positively correlated with precautionary behaviors (e.g., Zhong et al., 2020a, b; Sylvester, 2021; Nazrin et al., 2022). Therefore, it is necessary to provide rural residents with adequate access to informal channels to collect COVID-19 information. Second, peer pressure was also key to rural resilience during the pandemic (Wang et al., 2021). It appears that COVID-19 responses were shaped by both by self-interest and by collective interest (Miller, 2001). Community resilience involves many core elements that include networks, relationships, and communication. Among them, the intensity and the breadth of social connections are of the greatest significance (Bian et al., 2020). Therefore, promoting responsible behavior in the face of crises through social capital deserves more attention in the future. Finally, political confidence is critical in fostering compliance with public health guidelines. Our results suggest that rural residents are less likely to adopt costly preventive practices due to poor economic conditions. However, addressing this problem requires strengthening political confidence. It is more likely to convince citizens that what the government is doing is in their best interests in region with higher levels of public trust. Therefore, local government may consider promoting people's compliance with health guidelines in the face of crisis through public trust.

A large amount of literature has emerged around the concept of resilience over the last decade. Those studies generally concentrated on a few African or south Asia countries after natural disasters (Barrett et al., 2021). Due to limited geographic coverage, it remains unclear how individuals become more resilient to better cope with external shocks. Overall, we have shown how important it is to improve internet skills, prosociality, and political trust in building rural resilience to the health crisis. We believe this study applies to address rural health risks, building individual resilience in the countryside, and fostering urban-rural integration in the post-pandemic era.

Author contributions

Ailun Xiong: Writing – original draft; formulation or evolution of overarching research goals and aims Yuheng Li: Conceptualization;

Formal analysis; Writing – review & editing Shuang Liu: Provision of study materials Hongyi Li: Writing – review & editing.

Data availability

Data will be made available on request.

Acknowledgement

The written of the paper was supported by the National Natural Science Foundation of China (42171208; 71902014).

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