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Intersectional vulnerabilities and climate-related health risks among informal outdoor workers in urban Vietnam: Survey-based insights

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Contents

Abstract 5

1. Introduction 6

2. Conceptual Approach 9

3. Methods 10

3.1 Sample 10
3.2 Ethics 10
3.3 Analysis 10

4. Results 12

4.1 Descriptive Overview 12
4.2 Climate-related health risks: constrained physical and mental capabilities 12
4.3 Livelihood risks: economic impacts of capability deprivation 14
4.4 Determinants of adaptive capacities 16

5. Discussion 19

5.1 Intersecting constraints on health, livelihoods, and adaptation 19
5.2 Unequal resources and unequal resilience 19
5.3 From individual risks to structural capability deprivation 20
5.4 Implications for research 20
5.5 Policy implications 20
5.6 Limitations 21

6. Conclusions 22

Acknowledgements 23

Reference List 24

Appendix – Methods and Statistical Results 26

Methods 26
Descriptive statistics 26
Logistic regression results 28

Abstract

Informal outdoor workers in low- and middle-income countries are among the most exposed to climate-related health and livelihood risks yet remain structurally excluded from formal systems of protection and adaptation. This paper draws on Sen's capability approach and Venkatapuram's concept of health capability to examine how intersecting inequalities constrain workers' real freedoms to maintain well-being under climate stress. Based on survey data from 400 informal outdoor workers across four Vietnamese cities, we use logistic regression to analyse how economic, social, and human capital shape climate-related health impacts, income loss, and adaptive capacity. The findings reveal that chronic illness, low income, insecure housing, limited education, and digital exclusion are significantly associated with increased susceptibility to climate-related health risks and reduced ability to cope. Mental health conditions and lack of digital access further constrain perceived coping ability. These patterns reflect not only differential exposure but deeper structural constraints on the capabilities required to avoid harm and adapt. By moving beyond risk-factor models to center capability deprivation, this paper contributes a novel perspective to climate-health research and calls for adaptation policies that address the social conditions underlying vulnerability and expand the real freedoms of informal outdoor workers in climate-vulnerable urban contexts.

1. Introduction

What shapes the climate-related risks faced by informal outdoor workers in the Global South? While climate change increases exposure to extreme weather events such as heatwaves, heavy rainfall, and floods, these impacts are unevenly distributed. Informal outdoor workers – whose labour is physically intense, poorly regulated, and often lacks social protection – are especially vulnerable. In low- and middle-income countries, where informal employment accounts for a substantial share of the workforce, their risks are amplified by precarious working conditions and the absence of occupational safeguards (Masuda et al., 2024). Although they contribute little to climate change, these workers are among those most exposed to its impacts.

While existing literature has documented the environmental hazards faced by informal workers, far less attention has been paid to the social and structural mechanisms through which climate stress translates into unequal health and livelihood outcomes. This paper addresses this gap by shifting the analytical focus from exposure-based accounts alone to a capability-centered understanding of how structural conditions constrain individual's real freedoms to protect health and livelihoods under climate stress. Drawing on Amartya Sen's capability approach and Sridhar Venkatapuram's concept of health capability, we conceptualise vulnerability as arising not simply from climate hazards, but from constrained substantive freedoms, i.e. the real opportunities individuals have to achieve and maintain well-being under environmental stress. In this framing, the capacity to avoid harm, access care, and sustain livelihoods is shaped not only by environmental hazards, but by the social, economic, and institutional conditions that shape people's ability to convert resources into protective action.

To operationalise this approach, we examine how different forms of capital – economic, social, and human – act as proxies for the structural conditions that influence individuals' capabilities. Economic capital includes income, home ownership, occupation, and education; social capital includes residency status, marital status, and professional association membership; and human capital includes age, gender, and underlying health conditions. These capitals affect individuals' access to protective resources, shape their capacity to anticipate and respond to climate stressors, and mediate the extent to which climate risks result in health and livelihood outcomes. Our analysis focuses on three dimensions of vulnerability: (i) climate-related health risks, (ii) climate-related livelihood risks, and (iii) adaptive capacities.

We apply this framework to the case of Vietnam, a rapidly urbanising middle-income country with a tropical climate and a large informal workforce. Approximately 70% of Vietnam's labour force is employed informally (ILOSTAT, 2023), contributing an estimated 15% to 27% of national income (Nguyen, 2019). Informal outdoor workers in Vietnam, including street vendors, construction labourers, porters, and motorbike taxi drivers, are among the first to experience climate-related disruptions yet are among the least protected. They also face intersecting forms of disadvantage, including gender-based inequality, chronic illness, and limited access to health and digital infrastructure, all of which constrain their ability to cope with environmental risks.

This working paper presents preliminary quantitative findings from an ongoing Wellcome-funded mixed-methods research project[1]. It draws on a structured survey of 400 informal outdoor workers across four Vietnamese cities – Hanoi, Ho Chi Minh City, Da Nang, and Can Tho – to examine the social determinants of climate-related health

[1] https://climate-health-vietnam.org/

and livelihood risks, and the factors shaping adaptive capacity. Using logistic regression analysis, we identify how economic, social, and human capital predict key climate-related outcomes. In doing so, the paper advances a capabilities-based understanding of climate-health vulnerability and contributes to current debates on intersectionality, climate adaptation, and equity in the rapidly transforming urban landscapes of the Global South.



Image 1: Barefoot porters push a cart of gravel through a narrow construction site in Da Nang, May 2024. Photo by Anh Ngoc Vu.



Image 2: A scrap collector pushes a fully loaded cart through a busy street in Da Nang, May 2024. Photo by Anh Ngoc Vu.

2. Conceptual Approach

This paper draws on Amartya Sen's (1979) capability approach as a normative lens for understanding climate-related vulnerability. Rather than focusing on income or exposure alone, the capability approach emphasises individuals' real freedoms – their capabilities – to achieve valued functionings, or states of being and doing that people have reason to value, such as maintaining health, securing livelihoods, or avoiding preventable suffering. Climate change threatens these freedoms by constraining the social, economic, and institutional conditions that enable people to avoid harm and adapt effectively.

Sen (1999) argues that access to resources, such as income, education, or housing, is important but not sufficient to secure these freedoms. What matters is how individuals can convert these resources into actual capabilities, which is shaped by a range of conversion factors: personal (e.g., age, health status), social (e.g., gender norms, legal status), and environmental (e.g., infrastructure, climate conditions). Thus, two individuals with the same resource level may have vastly different capabilities depending on these contextual influences. While Sen does not offer a fixed typology of capabilities or conversion factors, this framework provides a means to interrogate how structural inequality limits adaptive capacity.

To translate this normative framework into empirical anlaysis, we draw on Bourdieu's (1986) typology of capital as a heuristic device for organising the structural conditions that shape individuals' capabilities. Specifically, we examine three dimensions – economic, social, and human capital – as empirically observable proxies for the structural conditions that shape individuals' capabilities. These forms of capital are not capabilities themselves, but they influence people's real freedoms to respond to climate risks by expanding or constraining the choices available to them. For instance, limited education, insecure housing, chronic illness, or lack of social support may restrict a person's ability to adapt to extreme heat or access healthcare. This approach aligns with the literature on social determinants of health and adaptive capacity in informal labour contexts (e.g., Masuda et al., 2024; WHO, n.d.). In our survey of informal outdoor workers in four Vietnamese cities, we group predictor variables under each of these capitals (see chapter 3 for more detail). A control variable – whether a worker continues working during extreme weather – was also included to account for direct exposure to climate hazards.

Before turning to the empirical strategy, it is important to clarify how the capability approach is applied in this quantitative analysis. Capabilities, in Sen's framework, are normative and relational constructs referring to individuals' real freedoms to achieve valued functionings; they are not directly observable or reducible to single indicators. Accordingly, the logistic regression models used in this paper do not measure capabilities themselves. Instead, they identify structural correlates of constrained capability by examining how different forms of capital are associated with climate-related health impacts, livelihood disruption, and adaptive outcomes. The analysis therefore uses statistical associations to illuminate the patterned social conditions under which capabilities are expanded or curtailed, and the quantitative findings are interpreted within, rather than as a substitute for, the normative capability framework.

Taken together, this integrated conceptual framework allows us to move beyond exposure-based models to examine how intersecting forms of disadvantage shape informal workers' capabilities to protect their health and secure livelihoods under climate stress. It supports a more holistic, justice-oriented understanding of climate-health vulnerability grounded in the capability approach and sensitive to lived realities of informality and precarity.

3. Methods

3.1 Sample

The survey was carried out between May and June 2024 by our local project partner, SocialLife Research Institute (hereafter SocialLife), based in Ho Chi Minh City. Grounded in a co-constructed research approach, the study prioritises trust-building and sustained engagement with informal outdoor workers – a population often structurally marginalised and underrepresented in research and policy. Participants were identified through multi-stage clustered and quota-based sampling strategies, reflecting both occupational and geographic diversity. The sample comprised 400 respondents: 100 each from the cities of Ho Chi Minh City, Da Nang, Ha Noi, and Can Tho, and equally distributed across four occupational groups (construction workers, porters, motorbike taxi riders, and street vendors) who characteristically work informally and outdoors. Four outliers were removed during analysis, leaving a sample of 396.

Given the precarious and unregistered nature of informal work in Vietnam, a non-probability sampling approach was necessary. While this limits the generalisability of the findings to the broader population, the sampling design enabled access to a hard-to-reach population and allowed for a contextually grounded exploration of climate-related risks among workers typically excluded from formal data collection and public policy processes.

3.2 Ethics

To ensure ethical standards and participant safety, informed consent was obtained from all respondents, no personally identifiable information was collected, and all anonymised data were stored securely and accessed only by designated research staff. Ethical approval for the study was obtained from relevant research ethics committees in both Vietnam (from the Ethics Review Board of the University of Social Sciences and Humanities, Vietnam National University, Ho Chi Minh City) and the UK (from the Research Ethics Committee at the National Centre for Social Research).

3.3 Analysis

This paper examines six dichotomous outcome variables reflecting three dimensions of climate-related vulnerability: (1) physical health impacts from extreme weather, (2) mental health impacts from extreme weather, and (3) reduced income due to extreme weather. The remaining three outcomes capture aspects of adaptive capacities: (4) perceived ability to cope with extreme weather, (5) medical insurance coverage, and (6) reliance on traditional or digital sources for climate change information.

To examine the social determinants of these outcomes, we employ binary logistic regression models, estimating a separate model for each outcome. Predictor variables were selected based on the study's conceptual framework, which draws on Sen's capability approach and Venkatapuram's health capability approach. In this framework, climate vulnerability is understood not only as exposure to hazards, but as the result of constrained capabilities; that is, limited real freedoms to achieve well-being due to structural barriers. We therefore include indicators of economic, social, and human capital as proxies for the conditions that shape individuals' capabilities to adapt to climate risks, reflecting both theoretical considerations and empirical precedent. Economic capital (income, home ownership, occupation, education) captures access to financial and material resources, which are necessary, but not sufficient, for adaptation. Social capital (residency status, city of residence, marital status, association membership) reflects embeddedness in legal, civic and interpersonal support structures that influence access to information, networks, and social protection. Human capital (gender,

age, and chronic illness) represents personal and physiological characteristics that affect individuals' ability to convert resources into functioning outcomes under climate stress. These variables are not direct measures of capability, but they reflect the personal and structural factors that impact an individual's freedom to maintain health and livelihood security in the face of climate stress. This typology builds on Bourdieu's (1986) distinctions between different forms of capital and aligns with the literature on social determinants of health and adaptive capacity in informal labour contexts (e.g., Masuda et al., 2024; WHO, n.d.).

A control variable – whether a respondent continues to work during extreme weather – was also included to account for direct exposure to extreme weather conditions from the outset. All explanatory variables were derived from survey data (see Appendix for descriptive statistics). For each binary outcome, a separate binary logistic regression model was estimated. To prevent overfitting, a minimum of 10 observations per outcome category was maintained for each predictor. All predictors were checked for multicollinearity prior to inclusion in the model. When necessary, predictors were selected using forward stepwise regression, starting from bivariate models and sequentially adding variables, while monitoring the area under the ROC curve (AUC). Only predictors that maintained or improved model AUC were retained. All models achieved an AUC ≥ 0.7.

Model assumptions were evaluated as follows: linearity of predictors with the log-odds, absence of multicollinearity (variance inflation factor < threshold; "years of experience" was removed due to correlation > 0.5 with age), and absence of influential observations (four outliers removed, leaving n = 396). Residuals were uniformly distributed. Observations were independent, as workers were surveyed individually.

Although intersectionality informs our theoretical framework, we do not include interaction terms in the regression models due to sample size limitations. Given the number of predictors and outcome variables, including interactions would have reduced statistical power and increased the risk of overfitting. Additionally, sparse data in several subgroups, such as female workers with chronic illness, would limit the reliability of interaction estimates. Instead, we analysed the independent effects of each variable and interpreted them with attention to how overlapping disadvantages may compound capability constraints, consistent with an intersectional reading of our results.

Descriptive statistics are presented in the results section and average marginal effects (AMEs) are used to interpret results, reflecting average percentage point (pp) changes in outcome probabilities associated with changes in key predictors, holding other variables constant. Only findings significant at $p < 0.05$ are reported unless stated otherwise.

4. Results

This section presents findings from our survey of 400 informal outdoor workers (n=396 with outliers removed) across four Vietnamese cities. The results are organised into the following domains: (i) climate-related health risks, (ii) climate-related livelihood risks and (iii) determinants of adaptive capacities. Informed by the capability approach, our analysis highlights how intersecting inequalities—across economic, social, and human capital—constrain workers' real freedoms to avoid harm, maintain health, and secure livelihoods under climate stress. We report both descriptive statistics and average marginal effects (AMEs) from logistic regression models to identify the social and structural predictors of vulnerability. Across all domains, the findings demonstrate how intersecting deprivations, for example, related to age, gender, underlying medical conditions and access to digital technology, constrain informal workers' ability to maintain good health and cope with climate-related stressors.

4.1 Descriptive Overview

The survey revealed that most respondents were men (72%), married (71%), migrant workers from other provinces (52%), and had not received education beyond secondary level (91%). On average, they were 47 years old, had 11 years working experience in their current occupation, and earned a monthly income of VND 7.34 million (≈ USD 280), similar to the national average including formal workers (National Statistics Office Vietnam, 2023). Among the four target cities, workers in Ho Chi Minh had the highest mean monthly income, while those in Can Tho had the lowest. Among the four target occupations, construction workers had the highest mean monthly income while street vendors had the lowest. Table 1 below summarises this data; full descriptive statistics of the demographics of survey respondents can be found in the Appendix.

Table 1: Descriptive statistics of surveyed informal workers (n=396)

		N	%
Demographics			
Gender	Male	285	72
	Female	111	28
Marital status	Married	281	71
	Single	115	29
Health indicators			
Underlying medical conditions	Yes	224	56.6
	No	172	43.4
Physical health problems	Yes	285	72
	No	111	28
Mental health problems	Yes	228	57.6
	No	168	42.4

	Mean	SD	Min	Median	Max
Monthly income (million VND)	7.3	3.3	0.1	7.0	18.0
Age	46.7	13.4	18.0	48.0	79.0
Average daily working hours	8.6	2.2	1.5	8.0	18.0

4.2 Climate-related health risks: constrained physical and mental capabilities

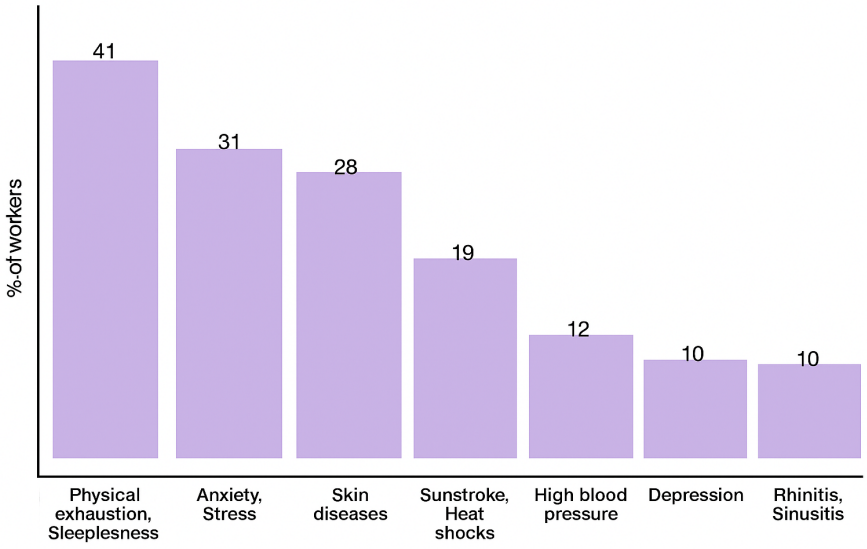
Key findings:

- Workers with chronic illnesses are ~25% more likely to report heat-related physical symptoms.
- Female workers, those with income loss, and those with low perceived coping ability report higher mental health risk.
- Workers who stayed home during extreme weather were significantly less likely to face physical health issues.

The survey revealed that workers faced significant physical and mental health risks under climate change. The top three extreme weather events experienced were: prolonged intense heat above 35°C (94% of respondents), heavy rain, hail and thunderstorms with rainfall above 50 mm per day (76% of respondents), and hurricanes, tropical depressions, and tornadoes (32% of respondents). When asked which weather hazards were the most difficult for their work, respondents reported that heavy rainfall (48%) and intense heat (36%) posed the most difficulty.

Respondents reported that extreme weather events caused them a series of physical and mental health issues. Over 70% of respondents reported physical health problems due to extreme weather, and a majority (57%) reported mental health problems related to extreme weather. As shown in Figure 1, when asked what health problems related to extreme weather they have experienced at work in the past 12 months, the most common symptoms workers reported experiencing included physical exhaustion and sleeplessness (41%), anxiety and stress (31%), skin disease (28%), sunstroke and heat shock (19%), high blood pressure (12%), rhinitis and sinusitis (10%), and depression (10%). These are not only individual health outcomes, but expressions of deeper structural vulnerabilities shaped by occupational exposure, chronic conditions, and lack of institutional protection. Such vulnerabilities can be characterised as capability deprivations that constrain workers real freedom to maintain their health under climate change.

Figure 1: Top health issues experience at work by informal outdoor workers in Vietnam as a result of extreme weather in the past 12 months



The survey findings indicate a strong relationship between physical and mental health risks. Workers experiencing mental health issues were over 20 percentage points (hereafter, pp) more likely to report physical health problems, and vice versa.

With regard to physical health, over half (57%) of survey respondents had underlying medical conditions that required long-term treatment. The most commonly reported were high blood pressure (14%); digestive, liver and bile diseases (10%); immune diseases like lupus, rheumatoid arthritis, and HIV/AIDS (9%); respiratory diseases such as asthma, chronic obstructive pulmonary disease, bronchitis (7%); and bone and joint diseases (7%). Our analysis found that workers with underlying medical conditions were 25 pp more likely than those without medical conditions to face additional physical health issues under extreme weather, compounding their health risks. Workers who stayed at home under extreme weather were nearly 15 pp less likely than those who went to work to face physical health issues.

Mental health issues were found to be associated with gender, income, and perceived ability to cope with extreme weather. Female workers (28%) were nearly 14 pp more likely than male workers to face mental health issues due to extreme weather conditions. This finding affirms previous studies suggesting that women are particularly at risk under climate change (Valero & Kaul, 2023; Paul & Suresh, 2024). Most workers (75%) saw their income reduced by extreme weather, and those that did were 11 pp more likely than those who did not to experience mental health problems. About half of the workers (46%) found it difficult to cope with extreme weather and these respondents were 16 pp more likely than those who did not to face mental health issues. These findings echo Venkatapuram's concept of health capability, showing how social conditions, rather than just access to health services, structure opportunities to be healthy.

While physical and mental health risks were interrelated, they were shaped by distinct but intersecting factors. Experiencing physical health issues because of extreme weather was most strongly associated with respondents having existing chronic health conditions and continuing to work during extreme weather. This is none too surprising as those who were already coping with chronic conditions are especially susceptible to extreme weather events. Their exposures are amplified, as are those who continue to work during extreme weather. Mental health risks, however, showed a different pattern and were more closely linked to gender, income loss, and perceived coping ability. These findings highlight how multiple layers of disadvantage – including health status, gender, economic insecurity, and working conditions – interact to shape vulnerability. This supports an intersectional perspective informed by the capability approach, in which an individual's ability to avoid harm and maintain well-being under climate stress is unequally distributed across social and contextual lines.

Crucially, these findings reveal that climate-related health risks were not experienced equally, nor were they determined solely by environmental exposure. Rather, they reflected capability deprivations, especially in health and gendered autonomy. For example, individuals with pre-existing conditions were not only physiologically vulnerable, but also structurally disadvantaged in their ability to prevent or treat illness under climate stress. Similarly, the gendered distribution of mental health risk points to social roles and systemic constraints that undermine women's health capability. The full results of the logistic regression can be found in the Appendix.

4.3 Livelihood risks: economic impacts of capability deprivation

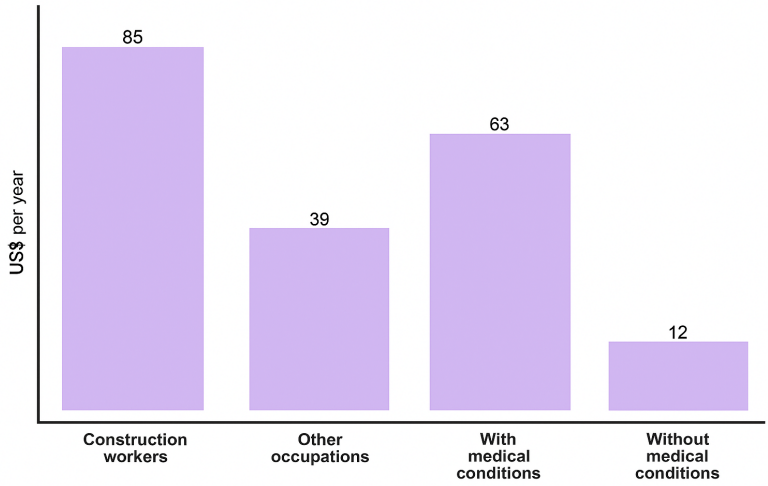
Key findings:

- A majority of those surveyed saw reduced income because of extreme weather conditions, with those who are older or who do not own their own home more likely to face financial losses.
- Workers faced different financial impacts due to extreme weather, with construction workers and those with underlying medical conditions facing some of the highest costs as a result of climate change.
- Workers who stayed home when encountering extreme weather were significantly less likely to see reduced income.

Beyond health risks, climate events also disrupted the economic stability of informal workers. Three out of four respondents (75%) experienced reduced income due to extreme weather in the past year. Additionally, 43% reported increased household expenses, and 26% faced job losses. These risks were unevenly distributed across demographic and socioeconomic lines, with older workers significantly more likely to report income losses, with each additional year of age increasing this risk by 0.6 pp. This means that the retiring worker (60 years old) was 24 pp more likely to see reduced income than the youngest worker (18 years old). Workers who did not own their home (64%) were more than 13 pp more likely than those who did to see reduced income due to extreme weather. Workers who reported that they typically stayed home when encountering extreme weather were 25 pp less likely than those who still went to work to see reduced income. This may be explained by differences in their perception: workers who went to work in extreme weather directly experienced a sharp decline in customers or available jobs, while those who stayed at home did not. These findings show how livelihood risks are determined by intersecting vulnerabilities; these vulnerabilities amount to capability deprivations that constrain the feel freedoms that outdoor workers have to secure their livelihood.

Furthermore, workers bear very different costs in response to climate health risks. When asked how much money they had to spend to treat health problems caused by unusual weather in the past year, construction workers and those with underlying medical conditions reported paying considerably more than their peers (see Figure 2). While street vendors, motorbike taxi riders, and porters paid an average of VND 1 million (≈ USD 40) per year to deal with climate health risks, construction workers paid VND 2.7 million (≈ USD 110), more than double that of the other occupations. This may be due to their heavier workloads under even harsher outdoor conditions in dangerous construction sites. These figures point to a financial capability erosion, where the cost of managing health under climate pressure directly undermines economic resilience. While workers without underlying medical conditions paid an average of VND 0.3 million (≈ USD 10) per year addressing climate health risks, those with pre-existing medical conditions paid an average of VND 1.9 million (≈ USD 70), more than seven times that of healthy workers. These annual costs may not seem extreme in the context of advanced economies, but for workers with a mean monthly income of VND 7.34 million (≈ USD 280), they amount to a heavy financial burden.

Figure 2: Average amount spent by informal outdoor workers to deal with health issues caused by unusual weather in the past year



These findings show that climate-related livelihood risks are not experienced by all outdoor workers equally. Livelihood risks among those surveyed were determined by intersecting vulnerabilities and reduced capabilities, rather than exposure to climate change alone. Older workers and those who did not own their home were more likely to report income loss due to extreme weather, highlighting how livelihood impacts are mediated by

economic and human capital. Similarly, those with underlying health conditions reported incurring higher costs in treating health problems caused by extreme weather, demonstrating how biological vulnerability leads to reduced financial capabilities. As a result, workers with multiple and intersecting vulnerabilities, such as elderly construction workers suffering from underlying medical conditions, face capability deprivations that pose higher risks to their livelihood. See the Appendix for the full logistic regression results regarding climate-related health and livelihood risks.

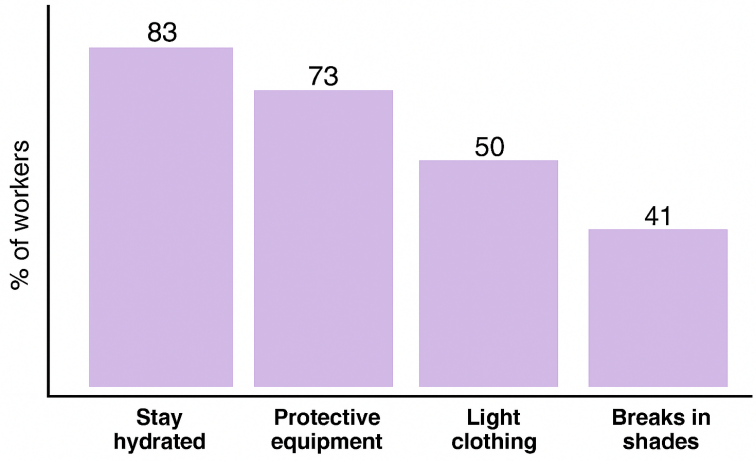
4.4 Determinants of adaptive capacities

Key findings:

- Workers self-assessed ability to cope with extreme weather was found to be associated with mental health and digital literacy.
- Whether or not informal workers had medical insurance was linked to their educational attainment, marital status, and age.
- How workers received information about climate change was associated with their income, education, and age.

To live with such health and livelihood risks, workers adopted a wide range of coping mechanisms. This includes everyday practices at work (see Figure 3) like drinking water frequently before feeling thirsty (83%); using personal protective equipment like sunglasses, hats, and masks (73%); wearing loose, lightweight and light-coloured clothing (50%); and scheduling regular breaks in shaded or sheltered areas (41%). Despite these measures, workers still faced difficulties in adapting to extreme weather, mainly due to poor health (38%), poor working and living conditions (33%), a lack of knowledge and skills (32%), and a lack of protective tools and equipment (30%). More than half of those surveyed never received any form of support in addressing health issues related to extreme weather (54%). Only 13% had ever received medical support, 1% livelihood support, and less than 1% employment support. The vast majority had never studied, learned, or been provided with knowledge and skills to respond to climate change (90%). With such an absence of support, when workers got sick due to extreme weather, most either purchased their own medicine or let their body recover on its own (83%), rather than seeking treatment at a medical facility (33%).

Figure 3: Top coping mechanisms adopted by informal outdoor workers in Vietnam



Workers' perceived ability to cope with extreme weather was found to be associated with mental health and digital literacy. Workers who faced mental health issues (58%) were 15 pp more likely than those who did not to

find it difficult to cope. This corresponds with our earlier finding that mental health is associated with perceived ability to cope, indicating that the two variables influence each other. Workers who faced difficulty using digital technologies (38%) were also 28 pp more likely than those who did not to find it difficult to cope. Among respondents who faced difficulty with digital technologies, 47% said that they did not know how to use smartphones and applications, 32% said they could not afford to buy a phone or pay for 3G/4G connectivity, and 14% said there was no cellular signal at home or work. Therefore, workers' digital literacy and financial capability, and their cities' digital infrastructures, all contributed to their accessibility to digital technologies and, in turn, to their perceived ability to cope. This digital exclusion has implications for how workers are able to adapt to climate change. Workers understood that without access to smartphones and mobile applications, they missed out on essential features when they were on-the-go or at work, such as weather forecasts, early warnings, and instant communication with friends and family, as well as access to support facilities such as clinics, the authorities, and their own personal support networks. Resultantly, digital illiteracy and/or exclusion impacts the capabilities of outdoor workers, potentially constraining their real freedoms in coping with climate change.

The findings also indicate that the higher the workers' monthly income, the more likely they were to find it difficult to cope with extreme weather. For every one-million VND increase in workers' monthly income, they were 2.4 pp more likely to find it difficult to cope. This means that the highest earning worker in the survey (VND 18 million per month) was 26 pp more likely than the average earning worker (VND 7.34 million per month) to find it difficult to cope. This finding resonates with Wu et al (2022) who similarly found that more educated residents in Xiamen, China reported lower adaptive capacity to extreme heat than their less educated counterparts. Counterintuitively, socio-economic status and perceived adaptive capacity were negatively associated with each other in both cases. One possible explanation may be that people who are relatively worse off are used to harsher working and living conditions in general. If a worker's life beyond the risks of extreme weather is one of multiple challenges, then they may become inured at a general level. The relationship between socio-economic background and perceived ability to cope with climate stress could be an interesting topic for future research.

In addition to workers' self-evaluation, their adaptive capacities were also measured by looking at the proxy measures of medical insurance and the source they relied on for climate change information. While most workers surveyed were medically insured (73%), over half (57%) of them purchased insurance plans out of their own pockets. Only 15% were medically covered by their contracts or employers. Ownership of medical insurance was found to be associated with education, marital status, and age. College educated workers were significantly more likely than workers educated up to primary or secondary level to be medically insured, with those educated up to secondary level 19 pp more likely to remain uninsured, rising to 41 pp for those educated up to primary level only. This link between education level and likelihood of medical insurance is potentially explained by higher awareness of medical and financial risks among those with higher educational attainment, as well as increased ability in navigating the procedures of purchasing a suitable insurance plan and submitting a claim. Single workers were 10 pp more likely than married workers to remain medically uninsured, possibly because of married workers' wider concern for their entire family's livelihoods on top of just their own. Lastly, older workers were significantly more likely to be medically insured, with each additional year of age decreasing the chance of being medically uninsured by 0.62 pp. This means that the retiring worker (60 years old) would be 26 pp more likely to be medically insured than the youngest worker (18 years old). This can be explained by the increased need for medical attention as one ages. These trends reflect how institutional exclusion, based on education, age, and family status, constrains access to basic protective resources and limits workers' capabilities.

The source that workers rely on for climate change information was found to be associated with income, education, and age. Workers who received up to primary education were 20 pp more likely than college-

educated workers to rely on traditional sources for climate change information, such as TV and radio, newspapers, and friends and relatives, rather than digital sources such as weather updates on websites and social media, as well as weather apps on smartphones. For every one-million VND increase in workers' monthly income, workers were 1.69 pp less likely to rely on traditional sources. This means that the highest earning worker in the survey (VND 18 million per month) was 18 pp less likely than the average earning worker (VND 7.34 million per month) to rely on traditional sources. Likewise, for every one-year increase in workers' age, they were 0.67 pp more likely to rely on traditional sources. This means that the retiring worker (60 years old) was 28 pp more likely to rely on traditional sources than the youngest worker (18 years old). These associations are expected because more educated, younger workers on higher incomes are likely to be better able to afford and use digital devices to find more accurate and updated information online. Therefore, workers who faced difficulty with digital technologies were 14 pp more likely than those who did not to rely on traditional sources; and workers who did not own a personal smartphone were 42 pp more likely than those who did to rely on traditional sources. However, workers who had underlying medical conditions were 11 pp less likely than those without to rely on traditional sources. This may be because workers with underlying medical conditions were more experienced in finding the best information online for their own medical care over the years.

In sum, climate-related adaptive capacities, like health and livelihood risks, varied across the workers surveyed. Workers perceived ability to cope was associated with mental health, showing how those who are biologically vulnerable are disadvantaged in their ability to cope with climate change. Furthermore, digital literacy was also associated with perceived ability to cope, and access to digital technology (through which workers learn about climate risks) was determined by financial constraints and digital infrastructure. Resultantly, deprivations in capabilities lead to reduced ability to adapt to climate change. Access to medical insurance was associated with education, marital status, and age, revealing how aspects of economic, social and human capital impact workers capabilities in adapting to climate risks. See the Appendix for the full logistic regression results about adaptive capacities.

5. Discussion

This study offers new empirical evidence on the climate-related health and livelihood vulnerabilities faced by informal outdoor workers in urban Vietnam, interpreted through a capabilities-based framework. While climate change generates environmental hazards that, in theory, affect all workers, our findings show that the ability to maintain good health and secure livelihoods under climate stress is profoundly uneven. These disparities are not explained by exposure alone, but by structural inequalities that shape workers' real freedoms to avoid harm, adapt, and recover. In this sense, climate-related risks are mediated through unequal capabilities, producing systematically differentiated outcomes among informal workers.

5.1 Intersecting constraints on health, livelihoods, and adaptation

Our analysis shows that climate-related health risks, income loss, and limited adaptive capacity are shaped by capability deprivation, defined here as the structural barriers that limit what people are effectively able to do or be in the face of climate stress. Across our models, chronic illness, gender, and age, emerged as a central axis through which these constraints operate. Workers with pre-existing physical health conditions were significantly more likely to experience additional physical health issues during extreme weather and to incur higher treatment costs compared to those without underlying medical conditions. Similarly, workers with pre-existing mental health issues were also significantly more likely than those without to report finding it difficult to cope with extreme weather. This reflects how health disadvantages compound over time, eroding workers' health capability – their real freedom to achieve and sustain physical and mental well-being – particularly under conditions of repeated climatic stress.

Gender and age further structured vulnerability in distinct ways. Female workers were more likely than men to report experiencing climate-related mental health issues, pointing to gendered burdens of stress and care in informal labour contexts. Older workers were more likely to experience income loss due to climate change and to rely on traditional rather than digital sources of information (such as TV and radio), suggesting both economic fragility and digital exclusion that could undermine adaptive capacity. These patterns suggest the presence of intersecting constraints linked to physical endurance, labour market position, and digital exclusion, which undermine both livelihood security and adaptive potential. These are not individual shortcomings, but systemic constraints embedded in social and institutional arrangements that restrict workers' freedom to protect their health and livelihoods.

5.2 Unequal resources and unequal resilience

Our findings indicate that disparities in economic capital – especially housing status, income, and education – played a central role in shaping both risk and resilience. Workers who did not own their homes and those with lower incomes were more likely to report income loss during extreme weather events, reflecting how material insecurity amplifies exposure to livelihood disruption. These outcomes are not simply the result of environmental conditions, but of constrained livelihood capabilities; that is, limited real freedoms to sustain income and economic stability in the face of climate stress. Conversely, workers with higher income and educational attainment were more likely to be medically insured and to access digital sources of climate information. These resources function not only as material assets but as enabling conditions that support anticipatory action and expand the range of adaptation strategies available to workers. Education appears to play a mediating role by enabling access to information and institutional protection, thereby strengthening adaptive capacity. Taken together, these findings show that economic capital not only buffers against immediate income shocks but also

facilitates longer-term adaptive agency (such as access to technology and climate information), while economic precarity narrows protective options and constrains future responses.

The role of digital access deserves particular attention. Workers who lacked digital literacy or relied solely on traditional media reported lower perceived coping capacity and more limited access to timely climate information. These findings reinforce the importance of digital inclusion as a contemporary determinant of adaptive freedom – a factor often overlooked in climate-health discourse. This also reflects deeper structural exclusions in digital access, which intersect with income, education, and age, raising important questions about climate justice in urban adaptation.

Marital status – our proxy for a dimension of social capital – was positively associated with health insurance coverage, hinting at how interpersonal ties may mediate access to formal protection mechanisms. However, other social capital indicators (e.g. residency status) were not significant in multivariate models, despite appearing important in bivariate analysis and in previous studies (Ngo et al., 2023; Schwerdtle et al., 2020). This gap warrants further exploration; it may reflect the limits of our proxy measures or suggest that certain aspects of social embeddedness are more difficult to quantify.

5.3 From individual risks to structural capability deprivation

Taken together, these findings reinforce the analytical value of an intersectional capabilities lens in understanding climate-related disadvantage. Vulnerabilities are not experienced in isolation; rather they cluster and compound across domains of disadvantage. For instance, an older, single, chronically ill woman with low income and limited digital literacy may face compounding barriers to accessing information, institutional support, and safe working conditions – barriers that would not be fully understood through a single-variable analysis. Such configurations represent multidimensional capability deprivations, reducing not only resilience to climate stress but also the range of real freedoms available to respond, adapt, or recover. In doing so, they deepen both immediate exposure and longer-term precarity among informal outdoor workers.

5.4 Implications for research

This paper contributes to critical debates in climate-health scholarship by reframing climate-related vulnerability as not merely a matter of exposure, but as a product of constrained capabilities; that is, the limited real freedoms individuals have to protect their health and livelihoods under conditions of environmental stress. Drawing on Sen (1999) and Venkatapuram (2011), our analysis demonstrates how structural inequalities in health status, income, education, digital access, and institutional inclusion interact to shape informal workers' capacity to avoid harm and pursue well-being in the face of climate disruption.

Our findings demonstrate the value of integrating capability theory with an intersectional analytical lens in empirical climate-health research. This combined framing enables a move beyond reductionist, exposure-based or single-variable models, offering instead a nuanced understanding of how overlapping social, economic, and health-related disadvantages structure climate-related outcomes. In doing so, climate-health research can more fully account for the social production of risk and better inform interventions aimed at equitable and just adaptation. It also invites a reorientation of measurement, away from outcomes alone (e.g. illness, income loss), and toward the conditions and constraints that govern people's agency, choices, and adaptive strategies.

5.5 Policy implications

From a policy perspective, a capabilities-based framework calls for a paradigm shift in how climate adaptation is conceptualised and implemented, particularly in contexts of informality and precarity. Rather than targeting

outcomes alone (e.g. reducing health burden or income loss), adaptation strategies should aim to expand the real freedoms of informal workers to live and work in ways that do not jeopardise their health or livelihoods and instead maximise their adaptive capacities. This entails addressing the structural conditions that underpin constrained capabilities. Specifically, our findings suggest that effective policy interventions should focus on:

- Expanding access to public healthcare and insurance for informal workers, especially those with chronic conditions;
- Investing in digital infrastructure and skills training, particularly for older, lower-income, and digitally excluded workers;
- Enhancing occupational protections and legal recognition for informal outdoor labour, to reduce exposure and increase bargaining power;
- Strengthening education and adult learning opportunities, which are strongly associated with adaptive capacity;
- Developing inclusive climate communication strategies that account for varied information access modes.

Importantly, adaptation policy must be sensitive to intersectionality, recognising that the most at-risk workers often face multiple overlapping constraints. Policies that target only one dimension (e.g. income) without addressing others (such as gender, health status, digital access) are unlikely to substantively expand adaptive capacity. A holistic, capability-oriented approach would enable more equitable and effective responses to climate-health risks in rapidly urbanising, climate-vulnerable contexts such as Vietnam.

5.6 Limitations

This paper presents findings from the quantitative strand of our broader Wellcome Trust-funded research project examining the health impacts of climate change on precarious outdoor workers in urban Vietnam. While this paper focuses on survey-based analysis using logistic regression, the wider project employs a mixed-methods design, including co-constructed approaches and participatory qualitative methods, which will be reported separately. As such, the present analysis provides an important survey-based view of the dynamics shaping workers' experiences under climate stress.

Some limitations should be acknowledged. First, the cross-sectional nature of the survey limits causal inference; while we identify associations between capital indicators and climate-related outcomes, we cannot determine the direction or timing of these relationships. Second, the study relies on self-reported data, which may be affected by recall bias or social desirability, particularly around sensitive issues such as mental health or income loss. Third, although the sample was purposively stratified across occupations and urban contexts, it remains a non-probability sample, which limits the generalisability of findings beyond the study sites. Fourth, due to limitations in sample size and subgroup distribution, we did not include interaction terms in our regression models. While our conceptual framework is intersectional – emphasising how multiple disadvantages may combine to deepen climate-related harms – testing these interactions statistically would have required a larger sample with sufficient representation across key subgroups. Including interaction terms without adequate data could reduce model reliability and produce unstable estimates. Instead, we focused on the independent effects of key predictors (e.g. gender, illness, income) and interpreted them through an intersectional lens, recognising that real-world experiences of disadvantage are likely to be compounded rather than isolated. Finally, while quantitative analysis is well suited to identifying broad patterns and predictors of capability constraints, it cannot fully capture the lived experiences, perceptions, or contextual meanings that shape workers' responses to climate-related risks.

6. Conclusions

This paper contributes to the existing climate-health literature by moving beyond exposure-focused framings to analyse how structural constraints shape the climate-related risks faced by informal outdoor workers in the urban Global South. Drawing on our original survey data from Vietnam, we demonstrate that workers' vulnerability to health impacts, livelihood disruption, and reduced adaptive capacity is mediated by intersecting inequalities in economic, social and human capital. These dimensions of disadvantage – such as chronic illness, insecure housing, low income, limited education, and digital exclusion – undermine the real freedoms that workers have to protect their well-being under climate stress.

Using a capabilities-based lens, we show that climate-related harm is not merely the result of environmental exposure, but of constrained opportunities to anticipate, avoid, or respond to that exposure. Income, occupation, education, age, gender, and health status all interact with broader institutional conditions to determine which workers are most at risk and which have the fewest means to adapt. This highlights the need to view vulnerability not as a fixed characteristic, but as a dynamic outcome of social structures that limit health capability and adaptive freedom.

The study highlights the importance of framing climate adaptation as a matter of justice. Ensuring that informal workers have the real freedom to maintain their health and livelihoods in the face of climate change will require systemic investments in housing, healthcare, labour protections, digital infrastructure, and education. These findings call for integrated policy responses that address the structural roots of capability deprivation, rather than narrowly targeting exposure or individual behaviour.

By applying a health capability approach to an understudied population, this working paper lays the groundwork for more equitable, evidence-informed approaches to climate adaptation – ones that center those most exposed, yet least protected.

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Appendix – Methods and Statistical Results

This appendix provides further details on the methods used for the analysis presented in this paper and displays the descriptive statistics and full logistic regression results from the analysis. Logistic regression results for the six models are presented in three separate tables, grouping the results thematically according to climate related health risks, climate related livelihood risks, and adaptive capacities. Each table displays odd ratios and 95% confidence intervals.

Methods

Corresponding to the six dichotomous outcomes, six binary logistic regression models were run. To prevent overfitting, it is ensured that for every predictor included in each model there are at least 10 events or observations in the outcome categories. For example, in the model for physical health issues, the outcome categories have 109 ('Yes') and 285 ('No') observations, which means that only 10.9, or 10, predictors can be fitted into the model at most. In cases where some predictors must be dropped to satisfy this rule, predictors were selected in a stepwise manner. This means starting with a bivariate model and adding more predictors one-by-one to ensure that every inclusion does not decrease the model's area-under-the-ROC-curve (AUC), a measure of how much of the outcome was explained by the predictors in the model. With a value between 0 and 1, an AUC of 0.5 means that the model predicts the outcome no better than random chance, and an AUC of 0.7 or above is usually considered satisfactory. All our models achieved an AUC of 0.75 or above.

The models also satisfied the three basic assumptions of logistic regression. First, linearity which means that the relationship between the predictors and the log odds of outcomes is linear, rather than an exponential, quadratic, or any other kinds of relationship. Second, absence of multicollinearity, which means that no predictors are highly correlated with each other and therefore effectively measuring the same attribute. To this end, workers' experience, or the number of years they spent on their current job, was removed as a predictor because it is moderately correlated with workers' age at a level higher than 0.5. Third, absence of influential observations or outliers. To this end, 4 data points with unusually high income and short working hours were removed, leading to a total of 396 observations for analysis. Although logistic regression, unlike linear regression, does not require homoscedasticity, all models have uniform residuals. Due to small sample sizes, interaction terms cannot be included into the models, which means the regression analysis assumes that the effect of predictors does not depend on the value of other predictors. It also assumes that the observations are independent of each other, which means that workers' responses are not affected by other workers' responses. This is achieved by surveying workers individually rather than in groups, where social dynamics may influence responses.

Descriptive statistics

Table 1 presented in the results section outlines some selected descriptive statistics, with full descriptive statistics presented in Table 2 below.

Table 2: Full descriptive statistics of surveyed informal workers (n=396)

	N (%) *N = 396*

Demographics		
Gender	Male	285 (72%)
	Female	111 (28%)
Marital status	Married	281 (71%)
	Single	115 (29%)
City of residence	Ho Chi Minh	100 (25.3%)
	Da Nang	97 (24.5%)
	Ha Noi	99 (25%)
	Can Tho	100 (25.3%)
Education	>College	34 (8.6%)
	Secondary	269 (67.9%)
	Primary	93 (23.5%)
Home ownership	Yes	141 (35.6%)
	No	255 (64.4%)
Residency status	Permanent	190 (48%)
	Temporary	206 (52%)
Health indicators		
Underlying medical conditions	Yes	224 (56.6%)
	No	172 (43.4%)
Physical health problems	Yes	285 (72%)
	No	111 (28%)
Mental health problems	Yes	228 (57.6%)
	No	168 (42.4%)
Medical insurance	Insured	287 (72.5%)
	Uninsured	109 (27.5%)
Occupational indicators		
Job	Builder	100 (25.3%)
	Porter	98 (24.7%)
	Driver	98 (24.7%)
	Vendor	100 (25.3%)
Joined Associations	Organised	116 (29.3%)
	Unorganised	280 (70.7%)
Climate exposure outcomes		
Stay home or work under extreme weather	Stay home	136 (34.3%)
	Work	260 (65.7%)
Reduced income due to extreme weather	Yes	296 (74.7%)
	No	100 (25.3%)
Coping with climate change	Easy to cope	216 (54.5%)
	Difficult to cope	180 (45.5%)
Digital and information access		
Sources for climate change information	Digital	224 (56.6%)
	Analogue	172 (43.4%)
Digital literacy	Easy	246 (62.1%)
	Difficult	150 (37.9%)
Smartphone ownership	Yes	303 (76.5%)
	No	93 (23.5%)

	Mean	SD	Min	Median	Max

Monthly income (million VND)	7.3	3.3	0.1	7.0	18.0
Age	46.7	13.4	18.0	48.0	79.0
Average daily working hours	8.6	2.2	1.5	8.0	18.0

Logistic regression results

The tables presented here report odds ratios from logistic regression models; the average marginal effects are discussed in the main text of this paper.

Table 3: Logistic regression results – odds ratios for climate health risks

	Face physical health problems *OR* *95% CI*	**Face mental health problems** *OR* *95% CI*
Monthly income (millions VND)	1.069	-
	[0.980, 1.167]	
Porters (1 = Builders)	0.796	0.855
	[0.376, 1.687]	[0.431, 1.699]
Drivers (1 = Builders)	1.144	0.487*
	[0.525, 2.493]	[0.245, 0.968]
Vendors (1 = Builders)	1.467	0.740
	[0.544, 3.956]	[0.314, 1.741]
Do not own a home (1 = Own)	-	1.277
		[0.724, 2.253]
Secondary Education (1 = >College)	1.322	0.832
	[0.541, 3.234]	[0.332, 2.083]
Primary Education or less (1 = >College)	1.107	1.068
	[0.395, 3.100]	[0.368, 3.104]
Temporary residents (1 = Permanent)	1.210	-
	[0.670, 2.188]	
Da Nang (1 = Ho Chi Minh)	0.409*	0.716
	[0.200, 0.836]	[0.357, 1.436]
Ha Noi (1 = Ho Chi Minh)	0.880	3.232**
	[0.350, 2.215]	[1.555, 6.717]
Can Tho (1 = Ho CHi Minh)	0.740	2.313*

	[0.333, 1.644]	[1.132, 4.727]
Single (1 = Married)	0.876	0.635
	[0.498, 1.540]	[0.367, 1.097]
Did not join organizations (1 = Joined)	-	0.917
		[0.514, 1.634]
Female (1 = Male)	0.956	2.099*
	[0.439, 2.083]	[1.057, 4.168]
Age	-	1.011
		[0.988, 1.035]
With chronic condition (1 = Without)	4.488***	1.103
	[2.572, 7.831]	[0.630, 1.931]
Stay home (1 = Go work)	0.364**	1.648+
	[0.188, 0.706]	[0.929, 2.925]
With physical health issues (1 = Without)	-	2.949***
		[1.672, 5.199]
With mental health issues (1 = Without)	3.450***	-
	[2.009, 5.926]	
Reduced income (1 = Not reduced)	-	1.799*
		[1.018, 3.179]
Difficult to cope (1 = Not difficult)	-	2.297**
		[1.394, 3.783]
Medically uninsured (1 = Insured)	-	0.678
		[0.384, 1.195]
Rely on traditional sources (1 = Digital)	-	0.927
		[0.545, 1.576]
Digitally illiterate (1 = Literate)	-	1.035
		[0.611, 1.753]
Intercept	0.732	0.113*
	[0.130, 4.127]	[0.021, 0.614]

Observations	396	396
AUC	0.812	0.778

+ p < 0.1,* p < 0.05,** p < 0.01,*** p < 0.001

Table 4: Logistic regression results – odds ratios for livelihood risks

	Reduced income *OR* *95% CI*
Monthly income (millions VND)	1.088+
	[0.996, 1.189]
Porters (1 = Builders)	1.035
	[0.495, 2.167]
Drivers (1 = Builders)	1.118
	[0.519, 2.406]
Vendors (1 = Builders)	1.920
	[0.736, 5.006]
Do not own a home (1 = Own)	2.231**
	[1.213, 4.103]
Secondary Education (1 = >College)	0.602
	[0.222, 1.637]
Primary Education or less (1 = >College)	0.385+
	[0.125, 1.182]
Temporary residents (1 = Permanent)	-
Da Nang (1 = Ho Chi Minh)	0.755
	[0.378, 1.508]
Ha Noi (1 = Ho Chi Minh)	1.585
	[0.732, 3.429]
Can Tho (1 = Ho CHi Minh)	2.731**
	[1.287, 5.796]
Single (1 = Married)	0.704

	[0.395, 1.255]
Did not join organizations (1 = Joined)	-
Female (1 = Male)	0.800
	[0.383, 1.668]
Age	1.037**
	[1.010, 1.065]
With chronic condition (1 = Without)	1.413
	[0.793, 2.516]
Stay home (1 = Go work)	0.168***
	[0.083, 0.342]
With physical health issues (1 = Without)	-
With mental health issues (1 = Without)	-
Reduced income (1 = Not reduced)	-
Difficult to cope (1 = Not difficult)	-
Medically uninsured (1 = Insured)	-
Rely on traditional sources (1 = Digital)	-
Digitally illiterate (1 = Literate)	-
Intercept	0.753
	[0.106, 5.341]
Observations	396
AUC	0.751

+ p < 0.1,* p < 0.05,** p < 0.01,*** p < 0.001

Table 5: Logistic regression results – odds ratios for adaptive capacities

	Difficult to cope *OR* *95% CI*	**Medically uninsured** *OR* *95% CI*	**Rely on traditional sources** *OR* *95% CI*
Monthly income (millions VND)	1.129*	0.946	0.900*
	[1.015, 1.257]	[0.866, 1.033]	[0.821, 0.987]

Porters (1 = Builders)	0.741	0.556	0.874
	[0.316, 1.737]	[0.275, 1.122]	[0.405, 1.883]
Drivers (1 = Builders)	3.128*	0.527	1.105
	[1.279, 7.651]	[0.245, 1.132]	[0.512, 2.387]
Vendors (1 = Builders)	3.261*	0.605	1.054
	[1.175, 9.053]	[0.250, 1.465]	[0.409, 2.717]
Do not own a home (1 = Own)	-	0.716	1.334
		[0.314, 1.633]	[0.610, 2.918]
Secondary Education (1 = >College)	1.100	7.035**	1.945
	[0.356, 3.397]	[1.849, 26.768]	[0.650, 5.820]
Primary Education or less (1 = >College)	0.685	22.481***	3.413*
	[0.190, 2.463]	[5.418, 93.286]	[1.025, 11.369]
Temporary residents (1 = Permanent)	1.062	1.395	0.637
	[0.559, 2.017]	[0.630, 3.093]	[0.292, 1.390]
Da Nang (1 = Ho Chi Minh)	1.043	0.420*	1.148
	[0.439, 2.475]	[0.212, 0.830]	[0.541, 2.436]
Ha Noi (1 = Ho Chi Minh)	0.976	0.255**	1.651
	[0.416, 2.291]	[0.104, 0.624]	[0.711, 3.835]
Can Tho (1 = Ho CHi Minh)	2.626*	0.853	1.155
	[1.054, 6.543]	[0.422, 1.724]	[0.521, 2.562]
Single (1 = Married)	1.202	1.797*	1.525
	[0.608, 2.376]	[1.025, 3.150]	[0.829, 2.803]
Did not join organizations (1 = Joined)	0.980	-	1.400
	[0.503, 1.910]		[0.754, 2.602]
Female (1 = Male)	1.117	1.322	0.832
	[0.499, 2.500]	[0.652, 2.678]	[0.386, 1.791]
Age	-	0.962**	1.043**
		[0.939, 0.986]	[1.016, 1.070]
With chronic condition (1 = Without)	1.722	0.691	0.503*

	[0.858, 3.456]	[0.386, 1.238]	[0.266, 0.949]
Stay home (1 = Go work)	0.897	-	1.140
	[0.472, 1.704]		[0.626, 2.076]
With physical health issues (1 = Without)	5.091	-	1.524
	[0.522, 49.613]		[0.795, 2.922]
With mental health issues (1 = Without)	2.105*	-	0.771
	[1.100, 4.028]		[0.441, 1.346]
Reduced income (1 = Not reduced)	0.688	-	-
	[0.320, 1.483]		
Medically uninsured (1 = Insured)	0.854	-	-
	[0.426, 1.712]		
Rely on traditional sources (1 = Digital)	0.632	-	-
	[0.325, 1.226]		
Digitally illiterate (1 = Literate)	3.964***	-	2.304**
	[2.141, 7.340]		[1.338, 3.967]
Do not own smartphone (1 = Own)	0.693	-	8.972***
	[0.328, 1.462]		[4.369, 18.424]
Intercept	0.018*	0.950	0.036**
	[0.001, 0.405]	[0.119, 7.601]	[0.004, 0.307]
Observations	274	396	396
AUC	0.766	0.779	0.836

+ p < 0.1,* p < 0.05,** p < 0.01,*** p < 0.001


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