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Research Article

Digital Financial Inclusion, Green Energy Adoption and Household Health Outcomes in Nigeria: Evidence from Logit Regression Analysis

Adamu Idi[1]

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ABSTRACT

This study investigates the effects of digital financial inclusion and green energy adoption on household health outcomes in Nigeria, using cross-sectional survey data from 40,047 households across all six geopolitical zones. An ordered logit model is employed as the primary estimation technique, while a logit model is used as a robustness check. The ordered logit results reveal that age and household size significantly influence health outcomes, with larger households and older populations facing higher risks. Income and urban residence provide protective effects under mild conditions but lose significance under severe health shocks, highlighting socioeconomic disparities. Green energy adoption, particularly liquid natural gas (LNG), is consistently associated with reduced probabilities of adverse health outcomes, underscoring its role in mitigating indoor air pollution and respiratory illnesses. Conversely, reliance on electric stoves shows mixed effects, reflecting infrastructural challenges in electricity supply. Digital financial inclusion demonstrates nuanced effects. Mobile phone ownership emerges as a robust determinant of improved health outcomes, facilitating access to health information and financial tools. Mobile banking reduces moderate health risks but is positively associated with severe outcomes, suggesting its role as a coping mechanism during crises. Account ownership alone shows limited effects, indicating that access must be paired with effective utilization. The composite measure of digital finance and green energy adoption highlights the synergistic benefits of integrating financial and energy policies to enhance household resilience. Clean energy adoption directly reduces environmental health risks, while digital financial inclusion enhances resilience against shocks. Policy interventions should therefore prioritize expanding LNG adoption, strengthening digital connectivity, and integrating financial services with health systems to achieve sustainable improvements in household welfare.

1. Department of Economics, Faculty of Arts and Social Sciences, Gombe State University, Nigeria.

*** Corresponding Author Email Address**: adamuidi85@gsu.edu.ng

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1. Introduction

Digital financial inclusion has become a major area of sustainable development discourse globally, due to its role of poverty reduction, economic resilience, and improved social outcomes especially in developing economies. Increasing access to financial services (formal account, credit, savings, and insurance), significantly reduces poverty and inequality, increase employment generation, increase overall output and economic growth and development (Tay, et. al., 2022; Mohammed & Japee, 2025). It has been argued to be tied to the achievement of sustainable development goals (Adamu, et. al., 2024), it accelerates economic growth, contributes to poverty alleviation and increase quality of development outcomes especially in developing economies (Xi & Wang, 2023; Lee, Lou & Wang, 2023; Liu et al., 2021). Mobile banking and financial technology innovations increase financial inclusion (Velez, 2025; and Neltje et al., 2025). It has been argued to improve health resilience, help households gain financial buffers against medical shocks and invest more in preventive care (Xiao & Tao, 2022; Naveenan, et. al., 2024; and Tian, et. al., 2024). Renewable energy adoption is viewed in recent decades as a critical driver of environmental sustainability and public health globally and has become major issue of discourse among policy analyst and academics globally. It has been argued that green technologies reduce carbon emissions, mitigate climate change, and improve health outcomes especially in developing economies (Islam et al., 2024; Qazi et al., 2019). Clean energy adoption has remain a critical issue in developing economies with factors such as financing constraints, and energy infrastructural deficits, remain significant hindrance (Obuseh et al., 2025; Zhindon-Almeida & Ruiz-Carrillo, 2025). Evidence has shown that renewable energy adoption propelled both economic and environmental sustainability, underscoring its role in advancing sustainable development (Adanma & Ogunbiyi, 2024). In Africa, digital financial inclusion has demonstrated remarkable potential in addressing structural inequalities, for instance, Mobile money platforms such as M-Pesa, MTN Mobile money, Orange money, Airtel money, Vodapay, Wave and

Truemoney have significantly shown how digital financial services reduce poverty and inequality, create employment, increase income, and savings, increase household resilience to shock and inclusive growth and development (Neltje et al., 2025). Renewable energy adoption significantly improves health outcomes globally. However, this has remain an issue especially in developing economies like Nigeria majorly aggravated by constrained in access to financial services, improve access to financial services can influence household decision to green energy adoption offers significant health benefits by reducing reliance on biomass and fossil fuels, which are linked to respiratory diseases (Zhindon-Almeida & Ruiz-Carrillo, 2025). Despite being Africa's largest economy, Nigeria continues to grapple with high rate of financial exclusion, especially among the rural dwellers, women and low income groups despite effort made by the government to increase access to financial services, though there is a significant progress in mobile banking and fintech penetration, however, factors such as digital literacy and infrastructural gaps continue to post a serious challenge (Mohammed & Japee, 2025). Nigeria's over dependence on fossil fuels has significantly contributed to environmental degradation and adverse health outcomes. While solar adoption is growing, high cost of its installation and financing constraints remains the major obstacle to its widespread uptake and penetration especially in rural areas and low income settlements (Obuseh et al., 2025). The health implications are profound as reliance on firewood, corn stock, kerosene and diesel generators exposes households to indoor air pollution, increasing risks of anemia, respiratory and cardiovascular diseases (Buba, et. al., 2017). The impact of digital financial inclusion, green energy adoption, on health outcomes operates through different transmission channels; studies has revealed that access to digital financial services enables households and firms to invest in renewable energy technologies, thereby facilitating energy transition (Ozturk & Ullah, 2022); while clean energy adoption has been argued to reduces exposure to pollutants, and directly improves health outcomes (Adanma & Ogunbiyi, 2024). It has also been reported that financial inclusion especial digital dymention enhances household resilience against

health shocks by facilitating access to insurance and emergency funds (Xiao & Tao, 2022; Naveenan et al., 2024). Synergistic effects emerge as digital financial services help in mobilization of financial resources for renewable energy projects, green energy adoption and enhance a sustainable household health outcomes, and lead to a virtuous cycle of inclusive development (Tay, et. al., 2022).

Despite studies on financial inclusion, energy and health outcomes, empirical evidence on the combined impact of digital financial inclusion and green energy adoption on health outcomes in Nigeria remains limited, and it is against this that this study seeks to examine the impact of digital financial inclusion and green energy adoption health outcomes in Nigeria.

The rest of the study has been structured into literature review, methodology, results and discussion and conclusion and policy recommendations.

2. Literature Review

Conceptually, the nexus between financial inclusion, green energy, and health outcomes has been central to sustainable development debates. Green energy is widely recognized as a pathway to improved welfare, reducing indoor air pollution, enhancing environmental quality, and raising living standards. Studies such as Zhindon-Almeida & Ruiz-Carrillo (2025) and Adanma & Ogunbiyi (2024) show that renewable energy adoption in developing countries directly reduces health risks, while Islam et al. (2024) highlight green technologies as enablers of environmental quality, productivity, and inclusive growth. Adoption depends not only on access but also on affordability, reliability, and safety.Digital financial inclusion (DFI) enhances household resilience and capacity to manage health shocks. Tay et al. (2022) argue that digital financial services improve welfare by expanding access, reducing poverty, and enabling investment in health. Lee et al. (2023) and Xi & Wang (2023) emphasize contributions to poverty alleviation and growth quality, while Xiao & Tao (2022) and Naveenan et al. (2024) show improved health outcomes through healthcare financing. Mohammed & Japee (2025) caution that access

alone is insufficient without effective product design, DFI thus complements clean energy adoption, forming dual pathways to inclusive development.

Empirical literature increasingly connects DFI, green energy, and health, though often in pairs rather than as a full nexus. Evidence shows DFI dominates sustainable development discourse, driven by mobile banking and fintech (Tay et al., 2022; Mohammed & Japee, 2025; Neltje et al., 2025). It lowers transaction costs, expands outreach, and reduces inequality when supported by infrastructure and literacy (Xi & Wang, 2023; Lee et al., 2023; Liu et al., 2021). Yet persistent divides across gender, income, and rural–urban status constrain inclusiveness (Tay et al., 2022; Velez, 2025). In China, DFI fosters innovation and green enterprise activities (Xi & Wang, 2023) and contributes to poverty alleviation with heterogeneous effects (Lee et al., 2023).

Cross-country evidence shows financial inclusion improves health indices, with digital inclusion moderating benefits (Naveenan et al., 2024). Xiao & Tao (2022) report increased life expectancy, while Tian et al. (2024) find DFI improves health via insurance, medical access, and diet, especially in low-income regions. Renewable energy studies highlight determinants such as policy, technology, and sociocultural factors (Zhindon-Almeida & Ruiz-Carrillo, 2025; Obuseh et al., 2025). Adoption reduces emissions and creates jobs but faces high costs and regulatory barriers (Adanma & Ogunbiyi, 2024; Islam et al., 2024; Qazi et al., 2019). Financial constraints remain a major impediment (Zhindon-Almeida & Ruiz-Carrillo, 2025).

Evidence also shows DFI's environmental trade-offs. In Belt and Road countries, DFI boosts growth but raises CO_2 emissions absent green policies (Ozturk & Ullah, 2022). At firm level, digital tools ease constraints for green innovation (Xi & Wang, 2023). Other studies confirm DFI raises incomes, smooths consumption, and expands insurance, improving health resilience (Liu et al., 2021; Tian et al., 2024; Ozturk & Ullah, 2022). Higher incomes enable investment in clean energy (Zhindon-Almeida & Ruiz-Carrillo, 2025; Adanma & Ogunbiyi, 2024). Renewable technologies reduce pollution and

disease burdens (Islam et al., 2024; Qazi et al., 2019). Yet if DFI fuels carbon-intensive activity, health gains may be offset unless finance is redirected toward low-carbon investments (Ozturk & Ullah, 2022; Xi & Wang, 2023).

3. Methodology

3.1. Data and Source

To achieve the objectives of this study, secondary data specifically cross sectional data were sourced from the Nigeria Demographic and Health Survey (NDHS, 2024). The NDHS is a nationally representative cross-sectional survey covering 40,047 households across all six geopolitical zones of Nigeria. It is part of the global Demographic and Health Survey programme coordinated by ICF International in collaboration with the National Population Commission (NPC) and the Federal Ministry of Health. It provides detailed information on household health indicators, socio-economic characteristics, energy use, and access to financial services. The survey is widely recognized for its methodological rigor, comparability across countries, and relevance for policy analysis in development studies.

3.2. Model Specification

To achieve the objective of the study, the following model was specified:

$$\mathbf{Log}\left[\frac{\mathbf{Pr(Healthoutcome)}}{\mathbf{1-Pr\ (Healthoutcome)}}\right] = \boldsymbol{\alpha_0} + \sum_{i=1}^{n}\beta_i DFI_i + \sum_{i=1}^{n}\beta_i GEA_i + \sum_{i=1}^{n}\beta_i CVR_i + \mu_i \quad (1)$$

Where health outcome (mild, moderate or severely sick)= are binary variables

$\boldsymbol{\beta_i}$= are the slop parameters to be estimated.

DFI_i are Digital Financial inclusion indicators,

GEA_i are the Green Energy Adoption Indicators,

CVR_i are the vector of control variables

μ_i= error term

Table 1. Variables and Measurement

Variable	Measurement	Source
Health Outcomes (Dependent)	Binary assuming the value of 1 if household reported mild, 2 moderate and 3 severely health outcome.	NDHS
Digital Financial Inclusion Account ownership	Mobile phone ownership (binary), mobile money account ownership (binary)	NDHS
Green Energy Adoption	Household use of electricity (binary), (binary), reliance on LNG (binary)	NDHS
Income Level	Household income quintiles	NDHS
Education	Years of schooling, literacy status	NDHS
Location	Urban or rural residence	NDHS
Demographics	Age, age squared, gender, household size	NDHS

Given the objective of the study, logit regression rather than classical regression was employed sdue to the nature of the dependent variables, which entails qualitative responses and a binary dependent variable. Thus, making the assumptions of conventional regression break down, and ordinary least squares (OLS) methods are not appropriate for the analysis of such discrete choice models (Wooldridge, 2002; Baum, 2006; Cameron & Trivedi, 2009; Greene, 2013).

4. Results

4.1. Descriptive Statistics

Table 2. Descriptive statistics Results

Variable	Obs	Mean	Std. dev.	Min	Max
Health outcome	40,047	.1269758	.6039981	1	3
age	40,047	45.34517	15.59169	15	98
male	40,047	.7896472	.4075643	0	1
Household Size	40,047	4.39596	3.056446	1	30
education	40,047	1.549579	1.136243	0	8
income	40,047	3.228232	1.418656	1	5
urban	40,047	.5052813	.4999783	0	1
electricity	40,047	.5058719	.4968747	0	1
Mobile phone Ownership	40,047	.9010163	.2986439	0	1
Mobile Banking	40,047	.5776712	.4939365	0	1
Account ownership	40,047	.6666417	.4714192	0	1

Source: Authors, Computation using Stata 17

Table 2 reports the descriptive statistics of the main variables. From the Table 2, household health outcomes show that mild conditions are the most prevalent; with an average incidence of 0.12 per household with health problems are less common with average incidence of 0.07. The relatively high standard deviations of 60.4 health outcomes suggest considerable heterogeneity across households. Demographic indicators reveal that the average respondent is 45 years old, with ages ranging from 15 to 98, approximately 79 percent of respondents are male, reflecting the predominance of male household heads. Household size averages 4.4 members, though the maximum of 30 indicates the presence of extended family structures among households. Educational attainment is relatively low, with a mean of 1.55 on a scale of 0–8, underscoring limited human capital accumulation. Socioeconomic indicators show that average household income is situated around 3.23, but the large standard deviation of 1.42 revealed wide inequality, and urban households constitute just over half of the sample that is 50.5 percent, providing a balanced basis for urban–rural comparisons. Access to electricity is reported by 55.6 percent of households. Mobile phone ownership is nearly universal 90 percent, consistent with Nigeria's rapid telecommunications expansion. However, only 57.8 percent of households report using mobile banking services, and despite 66.7 percent being financially included, highlighting a gap between mobile penetration and effective financial inclusion.

Table 3. logit Regression Results of digital financial inclusion, green energy adoption and health outcome

Variables	Health outcome Ordered logit	Mild Health outcomes - logit	Moderate Health Outcomes-logit	Severe Health outcome-logit
age	0.0294**	0.0058	-0.0041	-0.0651
	-0.011	-0.012	-0.012	-0.049
Age square	-0.0002**	-0.0004***	- 0.0003**	0.0004
	0.0000	0.0000	0.0000	0.0000
Male	0.0985	-0.2494***	-0.4926***	0.1002
	-0.065	-0.067	-0.07	-0.417

Variables	Health outcome Ordered logit	Mild Health outcomes - logit	Moderate Health Outcomes-logit	Severe Health outcome-logit
Household Size	-0.0135	0.1739***	0.1792***	0.1654***
	-0.009	-0.007	-0.008	-0.032
Education	0.0301	0.0298	0.0065	-0.0698
	-0.029	-0.029	-0.032	-0.157
Income	0.0941***	0.0714**	-0.0575	-0.3176*
	-0.031	-0.033	-0.036	-0.175
Urban	0.1414**	-0.1228**	-0.1656**	-0.4981
	-0.059	-0.062	-0.069	-0.379
Mobile phone ownership	0.1249	-0.1497	-0.1999**	-0.0618
	-0.087	-0.092	-0.088	-0.375
Mobile banking	0.1101	-0.1043	-0.2165**	0.7975
	-0.083	-0.084	-0.092	-0.534
Account Ownership	0.0997	0.0134	-0.0377	-0.8354
	-0.09	-0.093	-0.097	-0.546
electricity	-0.2528	-0.2266	0.1028	1.3632
	-0.25	-0.263	-0.281	-1.062
Liquid Natural Gas	0.1348	-0.147	-0.3513**	-3.7548
	-0.111	-0.106	-0.153	-334.124
Digital financial inclusion green energy	-0.1078	0.0316	0.2605*	3.5879
	-0.111	-0.106	-0.154	-334.124
/cut1	-3.2245***			
	-0.283			
/cut2	0.3184			
	-0.255			
/cut3	1.5729***			
	-0.256			
Constant		-3.1547***	-2.3704***	-4.3458***
		-0.255	-0.263	-1.133
Observations	40,047	40,047	40,047	40,047

Source: Authors' Computation using Stata 17

Table 3, present the results of ordered logit regression and logit regression results. From the Table 3, the ordered logit result revealed that age is significantly more likely associated with positive health outcomes, while the squared age shows a significant likelihood of decreasing health outcomes. This indicates a non-linear relationship between old age and health outcomes, which is in tandem with the theory, which argued that health risks decline initially with age but rise again after a threshold, consistent with age-related vulnerability. This pattern reflects the reality that younger and middle-aged households are less likely to report adverse health conditions, while older households face increasing risks due to biological fragility and cumulative exposure. This is in tandem with Sokoya et al. (2022) who argued that health indicators vary across age groups, underscoring the importance of accounting for non-linear health trajectories. The coefficient of Household size is positively and significantly associated with mild, moderate, and severe health outcomes, suggesting that larger households face higher health risks, likely due to resource constraints, overcrowding, use of unclean energy and greater exposure to environmental hazards. This suggests that demographic pressures amplify vulnerability when clean energy adoption is limited. Income shows a protective effect in mild outcomes but turns negative in severe outcomes, suggesting that wealthier households can mitigate minor health risks through better access to services, but under severe conditions, income alone may not shield them. This resonates with Liu et al. (2021), who argue that financial inclusion enhances resilience and growth, but its welfare impact depends on effective utilization and integration with broader systems. Urban residence is significantly associated with positive health outcomes in the ordered model but negatively significant in mild and moderate health outcomes. This reflects the paradox of urban living: while infrastructure is better, unreliable electricity supply and pollution can exacerbate health risks. The results highlight the protective role of liquid natural gas (LNG) adoption, which is negatively and significantly associated with moderate health outcomes. LNG reduces indoor air pollution, a major source of respiratory illness in Nigeria. This finding is

consistent with Qazi et al. (2019), who show that renewable energy technologies directly reduce environmental health risks, and Obuseh et al. (2025), who emphasize that overcoming barriers to renewable energy adoption is critical for improving household welfare.

By contrast, electricity use shows mixed effects; having negative likelihood for mild outcomes but positive for severe health outcomes. This suggests that while electricity access improves living standards, unreliable supply or unsafe connections may introduce health risks. This dual role of electricity reflects infrastructural challenges in Nigeria's energy sector. Mobile phone ownership is found be negatively associated with moderate health problems, underscoring its role in facilitating access to health information, financial tools, and services. This supports Tay et al. (2022), who argue that digital financial inclusion is a gateway to sustainable development by enhancing resilience and service delivery. While Mobile banking usage was found to reduce moderate health problems but is positively associated with severe outcomes, this pattern suggests that households adopt mobile banking as a coping mechanism when facing severe health shocks. Naveenan et al. (2024) confirm this intuition, showing that financial inclusion improves health outcomes primarily through shock absorption and healthcare financing. Similarly, Tian et al. (2024) find that digital finance enhances health only when integrated with broader social and health systems. Account ownership is largely insignificant, indicating that access alone does not guarantee improved health outcomes. This aligns with Mohammed & Japee (2025), who emphasize that digital banking must be effectively utilized to deliver welfare gains, and Neltje et al. (2025), who highlight its role in bridging gaps for underserved communities. Velez (2025) further notes that regulatory gaps can limit the effectiveness of mobile banking in achieving inclusion. The interaction of digital financial inclusion and green energy adoption is positively associated with moderate and severe health outcomes, suggesting that households benefit most when both pathways are adopted together. This dual pathway interaction is consistent with Ozturk & Ullah (2022), who argue

that digital finance not only enhances economic growth but also supports environmental sustainability. The Nigerian case demonstrates that green energy adoption and digital financial inclusion are complementary pathways to improved household health outcomes. Clean energy, particularly LNG, directly reduces environmental health risks, while digital financial inclusion enhances resilience and access to services. However, the welfare impact of digital finance depends on effective utilization and integration with broader systems. Policymakers should therefore pursue a dual strategy: expanding clean energy access while strengthening digital financial inclusion, with special attention to vulnerable households and regional disparities. This integrated approach will not only improve household health outcomes but also advance Nigeria's sustainable development goals.

5. Discussion of findings

The results reveal that age is positively associated with household health outcomes in the ordered logit model, but the squared age term is negative and significant. This indicates a non-linear relationship: health risks decline initially with age but rise again after a certain threshold. Younger and middle-aged households are less likely to report adverse health conditions, while older households face increasing risks due to biological fragility and cumulative exposure. This pattern is consistent with Sokoya et al. (2022), who highlight that health indicators vary across age groups and stress the importance of accounting for non-linear health trajectories. While household size is positively and significantly associated with mild, moderate, and severe health outcomes. Larger households face higher risks, likely due to resource constraints, overcrowding, and greater exposure to environmental hazards. This finding underscores the vulnerability of larger households in contexts where clean energy adoption is limited and health shocks are more difficult to absorb. Income shows a protective effect in mild outcomes but turns negative in severe outcomes. Wealthier households can mitigate minor health risks through better access to services, but under severe conditions, income alone

may not shield them. This resonates with Liu et al. (2021), who argue that financial inclusion enhances resilience and growth, but its welfare impact depends on effective utilization and integration with broader systems. While urban residence is significantly associated with positive health outcomes in the ordered model but negatively significant in mild and moderate health outcomes in the logit models. This reflects the paradox of urban living: while infrastructure is better, unreliable electricity supply and pollution can exacerbate health risks. The findings highlight the protective role of liquid natural gas (LNG) adoption, which is negatively and significantly associated with moderate health outcomes. LNG reduces indoor air pollution, a major source of respiratory illness in Nigeria. This result is consistent with Qazi et al. (2019), who show that renewable energy technologies directly reduce environmental health risks, and Obuseh et al. (2025), who emphasize that overcoming barriers to renewable energy adoption is critical for improving household welfare. By contrast, electricity usage shows mixed effects: negative for mild outcomes but positive for severe outcomes. This suggests that while electricity access improves living standards, unreliable supply or unsafe connections may introduce risks. This dual role of electricity reflects infrastructural challenges in Nigeria's energy sector.

Mobile phone ownership is negatively associated with moderate health problems, underscoring its role in facilitating access to health information, financial tools, and services. This supports Tay et al. (2022), who argue that digital financial inclusion is a gateway to sustainable development by enhancing resilience and service delivery. While Mobile banking usage reduces moderate health problems but is positively associated with severe outcomes, this pattern suggests that households adopt mobile banking as a coping mechanism when facing severe health shocks. Naveenan et al. (2024) confirm this intuition, showing that financial inclusion improves health outcomes primarily through shock absorption and healthcare financing. Similarly, Tian et al. (2024) find that digital finance enhances health only when integrated with broader social and health systems.

Account ownership is largely insignificant, indicating that access alone does not guarantee improved health outcomes. This aligns with Mohammed & Japee (2025), who emphasize that digital banking must be effectively utilized to deliver welfare gains, and Neltje et al. (2025), who highlight its role in bridging gaps for underserved communities. Velez (2025) further notes that regulatory gaps can limit the effectiveness of mobile banking in achieving inclusion. The interaction of digital financial inclusion and green energy adoption is positively associated with moderate and severe outcomes, suggesting that households benefit most when both pathways are adopted together. This dual pathway interpretation is consistent with Ozturk & Ullah (2022), who argue that digital finance not only enhances economic growth but also supports environmental sustainability.

6. Conclusion and Policy Recommendations

The analysis of household health outcomes in Nigeria reveals that both digital financial inclusion and green energy adoption play critical but distinct roles in shaping welfare. Demographic factors such as age, gender, and household size strongly influence vulnerability, with larger households and older populations facing higher risks. Socioeconomic variables like income and urban residence provide some protective effects, though these benefits diminish under severe health shocks. Green energy adoption, particularly liquid natural gas (LNG), consistently reduces the likelihood of adverse health outcomes, underscoring its importance in mitigating indoor air pollution and respiratory illnesses. Conversely, reliance on electric stoves shows mixed effects, reflecting infrastructural challenges in electricity supply. Digital financial inclusion demonstrates nuanced impacts. Mobile phone ownership emerges as a robust determinant of improved health outcomes, facilitating access to health information and financial tools. Mobile banking reduces moderate health risks but is positively associated with severe outcomes, suggesting its role as a coping mechanism during crises. Account ownership alone shows limited effects, highlighting that access must be paired with effective utilization.

Generally, the results revealed that clean energy adoption directly reduces environmental health risks, while digital financial inclusion enhances resilience and access to services. However, the welfare impact of digital finance depends on integration with broader health and social systems. This duality aligns with global evidence that renewable energy adoption improves health outcomes (Qazi et al., 2019; Obuseh et al., 2025), while digital finance strengthens resilience and growth when effectively utilized (Liu et al., 2021; Tay et al., 2022; Naveenan et al., 2024; Tian et al., 2024).

Policy Recommendations

- Expand LNG adoption Subsidize and promote clean cooking fuels to reduce indoor air pollution. Public awareness campaigns should highlight the health benefits of LNG, while infrastructure investments ensure affordability and accessibility.
- Improve electricity reliability Address infrastructural weaknesses to ensure safe and consistent supply. Policies should focus on upgrading distribution networks and reducing risks associated with unsafe connections.
- Strengthen digital inclusion Expand mobile phone penetration and affordable connectivity, as mobile ownership is a strong determinant of improved health outcomes. This requires investment in rural telecom infrastructure and affordable data services.
- Integrate mobile banking with health **systems** Link financial services to healthcare financing and insurance schemes. This integration will ensure households can absorb shocks effectively and access medical services when needed.
- Target vulnerable households Larger and low-income households should be prioritized in clean energy and financial inclusion programs. Tailored interventions, such as micro-financing for energy-efficient appliances, can reduce their vulnerability.
- Bridge urban-rural disparities Invest in rural energy infrastructure while improving reliability in urban areas. Bridging these disparities will reduce location-based inequalities in health outcomes.

- Promote cross-sector collaboration Encourage partnerships between energy, finance, and health sectors. Joint programs can leverage digital finance to fund clean energy adoption, thereby simultaneously improving health and sustainability.

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Authors' contributions

All authors had contribution in preparing this paper.

Conflicts of interest

The authors declare no conflict of interest

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