

The nexus between digital financial inclusion and measles vaccination coverage in low- and middle-income countries

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Abstract

Digital finance represents a more accessible financial system that facilitates timely access to funds for health-related needs, particularly in low-resource settings. This study examines the relationship between digital financial inclusion (DFI) and vaccination coverage against measles, a highly contagious disease. Using data from 74 countries over the period 2011 - 2021, we first employ OLS for our estimations. We find that DFI, measured by the number of mobile money transactions per adult, is positively associated with measles vaccination coverage. Further analysis indicates no evidence of differences in the association across income levels. By contrast, additional findings suggest that the relationship between DFI and measles vaccination coverage is more pronounced in settings with greater investment in healthcare. Finally, we use the Two-Step System GMM (2SSGMM) estimator to mitigate potential reverse causality, and the results remain consistent with the OLS estimates.

Keywords: Digital financial inclusion, Measles, Vaccination coverage.

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1. Introduction

Measles, one of the most contagious vaccine-preventable diseases, claimed the lives of approximately 95,000 people worldwide in 2024, most of whom were children under the age of five (WHO, 2025a). Notwithstanding this concerning situation, an estimated 20.6 million children failed to receive their routine first dose of the measles vaccine (WHO, 2025b). Low- and middle-income countries bear the greatest burden of the global measles crisis, accounting for 96% of children who miss their first dose of the vaccine (Vaccher et al., 2025). The majority of measles-related deaths occur in countries with low per capita incomes or fragile health systems, where reaching all children with immunization remains a significant challenge (WHO, 2025a). Bidari & Yang, (2024) documented that lower income levels are associated with a higher incidence of measles. Indeed, coverage of the first dose of the measles vaccine is lowest in low- and middle-income countries, at 64% and 86%, respectively (Minta, 2024), well below the 95% immunity threshold (Moussa and Takeuchi, 2022).

The first dose of the measles vaccine is included into the national immunization programs of all countries worldwide (CDC, 2025). The vaccine is provided free of charge or at low cost to populations, particularly to children in low- and middle income countries. However, some indirect and hidden costs can pose barriers for many people in lower-income countries. Many people may lack the financial means to cover travel expenses to reach health facilities (Ozawa et al., 2019; Wolfe et al., 2020). In addition, potential fees for registration and health cards can pose additional financial burdens.

The improvement of mobile technologies has fostered the expansion of digital financial inclusion, particularly in lower-income countries, where mobile money account ownership has surpassed that of traditional bank accounts (Statista, 2025). This facilitates timely access to financial resources and improves saving behavior, which are crucial for overcoming some of the financial obstacles to vaccination access. Sabbaghi, (2024) provided evidence of a positive association between saving and borrowing behaviors and access to mobile money accounts across countries with differing income levels. Ky et al., (2018) documented that the use of mobile money increases the likelihood that disadvantaged groups save for health emergencies.

This study investigates the nexus between digital financial inclusion and immunization coverage in low- and middle-income countries. Particularly, we examine whether an increase in mobile money transactions per adult is associated with higher measles vaccination coverage. Overall, the findings suggest the existence of a positive association between mobile money transactions and measles vaccination coverage. Further analyses showed no significant differences across income-level tertiles but indicated a stronger positive relationship in the tertile with the highest health expenditures.

This research contributes to the literature in a few ways. First, it extends the existing literature on the socioeconomic effects of financial inclusion by investigating its relationship with vaccination coverage. Previous studies show that financial inclusion reduces poverty (Churchill and Marisetty, 2020; Inoue, 2018; Koomson et al., 2020; Lal, 2018; Nyarko et al., 2023; Omar and Inaba, 2020; Tran and Le, 2021),

fosters economic growth (Sethi and Acharya, 2018; Sethi and Sethy, 2018; Siddiki and Bala-Keffi, 2024; Van et al., 2021) and reduces gender inequalities (Faton et al., 2025; Ohiomu and Ogbeide-Osaretin, 2019). Second, we provide new insights into the literature on the association between financial inclusion and health outcomes. Most studies focus on health outcomes such as life expectancy, mortality rates, and mental health. Some studies suggest that financial inclusion improves life expectancy and reduces mortality rates (Acheampong and Tetteh, 2024; Banerjee et al., 2023; Immurana et al., 2021), while others report improvements in mental health (Ajefu et al., 2020; Wang et al., 2025). Other studies document a positive association between financial inclusion and the utilization of healthcare services (Malak and Arshad, 2024; Singh et al., 2019). Lastly, while most studies focus on access to traditional financial services such as banking, we examine the effects of digital financial service use, which is more accessible, particularly in low-income countries. Despite the existence of several plausible mechanisms (see section 2) linking digital financial inclusion (DFI) to vaccination coverage, there is a lack of studies exploring this relationship. The strand of the literature analyzing the relationship between DFI and health outcomes is limited and focuses on depression and self-reported health status. Existing studies indicate that greater access to digital finance improves self-rated health and reduces depression (Lei et al., 2023; Tian et al., 2024; Yin and Wang, 2025).

The remainder of the paper proceeds as follows. Section 2 discusses the mechanisms through which DFI affects immunization coverage. Section 3 presents the study's data and methodology. Section 4 reports and discusses the results from the OLS estimations. Section 5 provides the results of various robustness checks. In Section 6, we conclude the study.

2. Mechanisms linking DFI to vaccination coverage

While examining the mechanisms empirically falls outside the scope of this study, we discuss the potential pathways through which DFI may affect vaccination coverage. Two sets of potential mechanisms may underlie the relationship between DFI and vaccination coverage.

First, DFI may influence vaccination coverage through demand-side channels. Improved access to credit and savings practices represent important ways through which DFI can enhance immunization coverage. By enhancing financial access, DFI helps reduce barriers to vaccine uptake associated with both direct and indirect costs, such as vaccination fees and cards (where not provided free of charge), as well as transportation to health facilities. Indeed, many studies suggest that DFI improves borrowing and saving behaviors for health-related emergencies (Al-Hanawi et al., 2020; Ky et al., 2018; Sabbaghi, 2024). It enhances risk management and resilience, enabling individuals to buffer financial shocks through digital loans or remittances, thereby reducing delays in preventive care, such as vaccination (Riley, 2018; Suri et al., 2021; Xu et al., 2025).

Second, DFI may also affect vaccination coverage through supply-side channels. Digital payments to health workers involved in vaccination campaigns enhance motivation and retention. According to the World Health Organization, over 80 percent of workers report a preference for digital payments (WHO,

2024). Digital payments enable the timely disbursement of allowances to frontline workers, sustaining their motivation during campaigns, whereas traditional cash-based systems are often inefficient, causing delays, high transaction costs, and security risks (WHO, 2023). A prior study reported that implementing digital payments can reduce payment processing from several weeks to only a few hours (Waiswa et al., 2026). Empirical evidence suggests a positive relationship between digital payments and the perceived satisfaction, motivation, and performance of health campaign workers (Adeniji et al., 2025). Mobile money platforms are often integrated with health worker registries and campaign management systems (WHO, 2025c). Linking payments to the worker's ID, campaign location, and date facilitates better monitoring and enhances vaccination coverage.

3. Data and methodology

3.1 Data

The data used in this study are drawn from multiple sources. First, the data on our dependent variable, Measles vaccination coverage, are from the WHO immunization database. Second, the data on our independent variable of interest, digital financial inclusion, are taken from the Global Partnership for Financial Inclusion (GPFI). Third, the study includes several control variables obtained from the World Bank's World Development Indicators (WDI) and the UNDP Human development reports. Initially, our dataset consisted of 132 low and middle income countries. However, due to missing data for several countries, only 74 countries are included in this study. Table A presents the list of the countries included in the current study. Data on our independent variable of interest are available only for the period 2011 - 2021. Given variations in data availability across countries and years, the analysis relies on an unbalanced panel dataset spanning 11 years. Table 1 reports the summary statistics of all variables used in this study.

Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Measles vaccination coverage (%)	517	82.24	14.77	35	99
Mobile money transactions per adult	522	14.82	29.20	0	228.88
Government effectiveness	522	-0.52	0.60	-2.10	1.15
Access to electricity (% of population)	521	66.73	29.66	7.4	100
Health expenditure percent of GDP	521	5.62	2.39	2.22	21.97
GDP per capita (US \$)	522	8339.35	7176.54	1073.95	37732.54
Urban population (% of total population)	521	43.67	17.56	13.17	91.63
Average years of education	521	6.80	2.72	1.25	11.69

Government effectiveness measures perceptions of the quality of public and civil services, with scores ranging approximately from -2.5 to 2.5.

3.2 Econometric model

To analyze the relationship between digital financial inclusion and Measles vaccine uptake, we employ a model similar to that used by Banerjee et al. (2023) to estimate the effect of financial inclusion on infant mortality and life expectancy. The econometric model is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 DFI_{it} + \beta_2 X_{it} + \alpha_t + \mu_{it} \quad (1)$$

where Y_{it} is Measles vaccination coverage in a country i at time t . DFI_{it} represents the digital financial inclusion indicator, defined as the number mobile money transactions per adult. X_{it} is a vector of control variables summarized in Table 1. α_t denotes time-fixed effects and μ_{it} is the error term.

The estimate from Equation (1) could be driven by cross-country heterogeneity that influences both the dependent and independent variables. For instance, higher-income countries may have stronger health systems and more developed digital financial infrastructures, which may lead to both higher vaccination coverage and greater digital financial inclusion. The baseline estimate may partly reflect country-level structural differences rather than the true relationship between digital financial inclusion and vaccination coverage. To mitigate this issue, we define a specification that allows the effect of digital financial inclusion to vary across different income tertiles. The model is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 DFI_{it} + \beta_2 (DFI \times MIncome) + \beta_3 (DFI \times HIncome) + \beta_4 X_{it} + \alpha_t + \mu_{it} \quad (2)$$

Where MIncome and HIncome represent the middle- and high-income tertiles, with the low-income tertile serving as the baseline category for comparison.

We further investigate whether the relationship between DFI and vaccination coverage is stronger in settings with higher healthcare resources. Similarly, the model is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 DFI_{it} + \beta_2 (DFI \times MHealthExp) + \beta_3 (DFI \times HHealthExp) + \beta_4 X_{it} + \alpha_t + \mu_{it} \quad (3)$$

Where MHealthExp and HHealthExp denote the middle- and high-health-expenditure tertiles, respectively, while the low tertile serves as the reference category.

Equation (1) could also suffer from reverse causality, since health systems might foster financial inclusion. Indeed, vaccination programs may be linked to digital identification systems or mobile payment platforms, potentially promoting the adoption of mobile money accounts. In addition, higher vaccination rates reduce morbidity, which lowers medical expenses. This could improve financial stability and potentially increase participation in financial systems. Improved health outcomes resulting from vaccination may increase labour force participation and foster economic growth, which can

subsequently contribute to greater financial inclusion (Well, 2007; Zhang et al., 2009). This positive feedback between vaccination and financial inclusion may lead to an upward bias in the estimated coefficient. To mitigate this issue, we include the lagged dependent variable in the model and estimate the following dynamic specification:

$$Y_{it} = \alpha_0 + \alpha_1 Y_{it-1} + \alpha_2 DFI_{it} + \alpha_3 X_{it} + \delta_t + \varepsilon_{it} \quad (4)$$

Where δ_t and ε_{it} represent time-fixed effects and the error term, respectively.

4. Results and discussions

4.1 Baseline results

We estimated Equation 1 using pooled OLS and presented the results in Table 2. Column 1 includes government effectiveness, access to electricity, health expenditure as a percentage of GDP, and real GDP per capita as control variables¹. The results suggest that higher DFI is associated with higher vaccination coverage. A one-unit increase in the number of mobile money transactions is associated with a 0.12 percentage point increase in the vaccination rate. In Column 2, we added additional control variables such as average education and percentage of urban population, the estimated coefficient remained similar to that in Column 1. The findings are in line with existing literature exploring the relationship between DFI and health outcomes. Previous studies suggest that DFI improves health conditions and reduces symptoms of depression (Lei et al., 2023; Tian et al., 2024; Yin and Wang, 2025).

Table 2: Relationship between DFI and vaccination coverage

VARIABLES	(1)	(2)
Mobile money transaction	0.123*** (0.018)	0.118*** (0.019)
Control variables	YES ⁻	YES ⁺
Observations	517	517
R-squared	0.435	0.444

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

YES⁻ = not all control variables included. YES⁺ = all control variables included. Time fixed effect is included in all specifications.

4.2 Heterogeneity analysis

We further investigated the heterogeneities in the relationship between DFI and vaccination coverage, and reported the results in Table 3. We began by examining heterogeneity in the association across

¹ Health expenditure as a percentage of GDP and real GDP per capita were divided into tertiles for inclusion in the regression and are also used for the heterogeneity analysis. We refer to these groups as health expenditure tertiles and income tertiles, respectively. Each tertile corresponds to low, middle, and high levels of health expenditure and income.

income levels by interacting DFI with income tertiles, using the low-income tertile as the baseline category. (Equation 2). In Column 1, the baseline coefficient is positive and statistically significant, suggesting that higher DFI is associated with greater vaccination coverage in low-income settings. However, the coefficients on the interaction terms for the middle- and high-income tertiles are not statistically significant, indicating no evidence that the association differs from that observed in the low-income tertile. Overall, the association between DFI and vaccination coverage appears broadly similar across countries at different income levels. We also analyzed heterogeneity across health expenditure tertiles, using the low-health-expenditure tertile as the baseline (Equation 3). In Column 2, the statistical significance of the baseline estimate indicates that DFI is associated with higher vaccination coverage in low-health-resource settings. The coefficient on the interaction term for the middle-health-expenditure tertile is not statistically significant, indicating no evidence of a difference in the relationship relative to the low-health-expenditure tertile. In contrast, the statistically significant coefficient for the high-health-expenditure tertile suggests that DFI has a stronger effect in settings with greater health resources.

Table 3: Heterogeneity analysis

VARIABLES	(1)	(2)
Mobile money transaction	0.118*** (0.023)	0.101*** (0.023)
Mobile money transaction × Middle income	0.001 (0.033)	
Mobile money transaction × High income	-0.014 (0.071)	
Mobile money transaction × Middle HealthExp		0.008 (0.030)
Mobile money transaction × High HealthExp		0.124** (0.049)
Control variables	YES ⁺	YES ⁺
Observations	517	517
R-squared	0.444	0.452

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

YES⁺ = all control variables included. Time fixed effect is included in all specifications

5. Robustness checks

5.1 Addressing potential endogeneity

We attempt to address potential reverse causality that could bias our baseline estimates by employing a dynamic model that includes the lagged dependent variable as an independent variable (Equation 4). We estimate Equation 4 using Two-Step System GMM (2SSGMM) and present the results in Table 4. Unlike Column 1, which does not include all control variables, Column 2 presents results with the full set of controls. The results show that the estimated coefficients for the lagged dependent variable and DFI are both positive and statistically significant. The estimated coefficients on DFI are considerably smaller in magnitude compared to those reported in Columns 1 and 2 of Table 2. This suggests that estimating the dynamic models helps mitigate the upward bias in OLS estimates arising from the positive feedback between DFI and vaccination.

Table 4: Estimating a dynamic model

VARIABLES	(1)	(2)
Mobile money transaction	0.021** (0.008)	0.023*** (0.009)
L1. Measles vaccination	0.913*** (0.060)	0.887*** (0.061)
AR(2) test P-value	0.100	0.100
Hansen test P-value	0.280	0.335
Number of lags	Three and four	Three and four
Control variables	YES ⁻	YES ⁺
Observations	498	498

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1
YES⁻ = not all control variables included. YES⁺ = all control variables included. Time fixed effect is included in all specifications

5.2 Alternative sample

As discussed earlier, due to variations in data availability across countries and years, the analysis is conducted using an unbalanced panel dataset. To assess the robustness of our main findings, we use alternative, relatively more balanced samples that exclude countries with fewer than three and fewer than four observations, respectively. This results in the exclusion of roughly 2.5% and 4.2% of the total observations, respectively. Using these samples, we conduct OLS and 2SSGMM estimations and report the results in Table 5. For both samples, the OLS estimates are similar to that reported in Column 2 of Table 2. The 2SSGMM estimates are also consistent with the estimate obtained in Column 2 of Table 4.

Table 5: Alternative samples

VARIABLES	(1)	(2)	(3)	(4)
	≥ 3 Observations		≥ 4 Observations	
	OLS	SGMM	OLS	SGMM
Mobile money transaction	0.127*** (0.019)	0.019** (0.007)	0.130*** (0.020)	0.022*** (0.008)
L1. Measles vaccination		0.933*** (0.062)		0.916*** (0.055)
AR(2) test P-value		0.101		0.100
Hansen test P-value		0.385		0.330
Number of lags		Three and four		Three and four
Control variables	YES ⁺	YES ⁺	YES ⁺	YES ⁺
Observations	504	485	495	476
R-squared	0.458		0.457	

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

YES⁺ = all control variables included. Time fixed effect is included in all specifications

6. Conclusion

This study investigated the nexus between digital financial inclusion and measles vaccination coverage in low- and middle income countries. Our findings suggest a positive relationship between digital financial inclusion, measured by the number of mobile money transactions per adult, and measles vaccination coverage, with a stronger association in settings with substantial health resources. Policy efforts should enhance access to mobile money and other digital financial services, particularly in areas with low adoption. Since the association is more pronounced in settings with greater health resources, investments in health facilities should accompany the expansion of digital financial services.

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8. Appendix

Table A: Country list

Afghanistan	Madagascar
Albania	Malawi
Angola	Malaysia
Armenia	Maldives
Azerbaijan	Mali
Bangladesh	Mauritania
Benin	Mauritius
Bolivia	Mongolia
Botswana	Morocco
Burkina Faso	Mozambique
Cambodia	Myanmar
Cameroon	Namibia
Central African Republic	Nepal
Chad	Niger
Colombia	Nigeria
Comoros	Pakistan
Côte d'Ivoire	Panama
Democratic Republic of the Congo	Papua New Guinea
Egypt	Paraguay
El Salvador	Philippines
Eswatini	Romania
Fiji	Rwanda
Gambia	Samoa
Ghana	Senegal
Guinea	Solomon Islands
Guinea-Bissau	South Africa
Guyana	Sudan
Haiti	Thailand
Honduras	Timor-Leste
India	Togo
Indonesia	Tonga
Iraq	Türkiye
Jamaica	Uganda
Jordan	United Republic of Tanzania
Kenya	Zambia
Lesotho	Zimbabwe
Liberia	Palestine