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# Digital Health for Rural Development: Linking Health Informatics, Village Development, and Community Economy in Indonesia

**Zeny Widianingsih[1], Vina Rahmayana[2]**
STMIK IKMI Cirebon, Indonesia[1]
Politeknik Siber Cerdika Internasional, Indonesia[2]
Corresponding author: zenywidianingsih05@gmail.com[1] vinarahmayana3@gmail.com

**Keywords:**

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**ABSTRACT**

Rural Indonesians face longer travel to care, fewer health workers, and weaker digital infrastructure than urban residents, while villages now receive large fiscal transfers for local development. Health informatics could connect these conditions, yet its role in rural development and the community economy is rarely examined. This study aimed to synthesize evidence on how digital health in villages and primary care affects health outcomes, household finances, and the local economy in Indonesia. An integrative review of fourteen peer-reviewed studies published from 2021 to 2026 and appraised with the Mixed Methods Appraisal Tool was combined with secondary analysis of official data on connectivity, primary care staffing, stunting, village funds, and household health spending. Rural internet penetration trailed urban penetration by 8.18 percentage points, and about 2,000 villages lacked 4G coverage. Most community health centres without a doctor were in remote areas, and primary care information technology maturity was basic. Village fund allocations rose by 166.3% in real terms between 2015 and 2024 and financed thousands of integrated health posts. The synthesis indicates that telemedicine and digital growth monitoring are associated with better access for distant patients, but this evidence is weak to moderate and no study measured effects on household or village income. We propose a Digital Health–Rural Development–Community Economy framework in which village funds, connectivity, and primary care informatics are planned together, with five testable propositions and a village scorecard. Policymakers should treat village digital health as productive rural infrastructure that protects household income and strengthens local enterprises.

## INTRODUCTION

Health inequality between urban and rural areas remains one of the most persistent development problems in Indonesia. Rural households live farther from hospitals, have fewer health workers nearby, and spend more of their limited income on reaching care. On small islands in the outermost regions, a referral from a community health center to a hospital can require three to five hours by fishing boat (Welembuntu et al., 2025). These distances translate directly into lost workdays, transport costs, and delayed treatment, so that health inequality and economic inequality reinforce each other in villages.

Digital health offers one of the few tools able to shorten these distances without building a hospital in every district. The World Health Organization's global strategy on digital health asks countries to use digital technologies to strengthen primary care and to reach underserved populations (World Health Organization, 2021). Indonesia's digital health transformation

blueprint follows this direction by placing integrated health data, telemedicine, and digitized primary care at the center of national reform (Ministry of Health of the Republic of Indonesia, 2021). Telemedicine allows patients with chronic conditions to replace some hospital visits with remote consultations, and digital recording at integrated health posts (posyandu) helps village health volunteers track child growth in real time (Pratama et al., 2026; Utami et al., 2025).

Rural development policy has changed at the same time. Since 2015 the central government has transferred village funds (Dana Desa) directly to every village, and the cumulative transfer reached about Rp609.9 trillion by 2024 (Direktorat Jenderal Perbendaharaan, 2025). Village governments use these funds for roads, clean water, health posts, and village-owned enterprises (BUMDes), and national evidence shows that village funds have raised the village development index (Hilmawan et al., 2023). Village-owned enterprises have also begun to offer digital services that open markets and create jobs for young people (Fatimah et al., 2026). The village has therefore become both a unit of health service delivery and a unit of economic development.

These two agendas meet in the household budget. Out-of-pocket health spending still accounted for 27.5% of current health expenditure in Indonesia (World Health Organization, 2025), and a household panel study found that living in a rural area was associated with catastrophic health spending (Fattah et al., 2023). When illness forces a farmer or a small trader to travel to the city, the household loses both money and productive time. Digital health that keeps care closer to home can therefore protect household income and, through it, the local economy.

Evidence on each part of this chain exists, but it is scattered across disciplines. Health informatics studies examine the readiness of primary care information systems and the adoption of telemedicine (Aisyah et al., 2024; Alviani et al., 2023). Rural development studies examine village funds and village-owned enterprises without considering health technology (Hilmawan et al., 2023). Health economics studies measure catastrophic spending without considering digital alternatives to travel (Fattah et al., 2023). International reviews of digital health in low- and middle-income countries emphasize infrastructure, digital literacy, and sustainability as barriers that are especially severe in rural areas (Kaboré et al., 2022; Sylla et al., 2025).

The international evidence on the economics of digital health is growing but remains thin for low- and middle-income countries. A rapid systematic review of twenty-five years of digital health toward universal coverage found that unequal technology access, low digital literacy and weak governance continue to limit the gains achieved in these countries (Sylla et al., 2025). A narrative summary of telehealth across low- and middle-income countries during the COVID-19 pandemic reported better access and higher service use, but identified no study that examined the financial side of implementation and concluded that rigorous economic evaluation of telehealth is still needed (Tiwari et al., 2023). A later systematic review of telemedicine in the same country group screened 766 records and found only three that reported feasibility, adoption, cost-effectiveness and sustainability together, with connectivity, device access and rural medicine supply as the recurring constraints (Okafor et al., 2025). Evidence from high-income rural populations is better quantified: a systematic review of telehealth for rural veterans in the United States estimated savings of about USD 65 to 73 and 2.1 to 2.6 hours of travel per visit (Quayson et al., 2024). Indonesia therefore sits inside an evidence gap, with a large rural population, an active digital health policy, and almost no study that converts digital health use into household or village economic terms.

There have been limited studies that bring health informatics, rural development, and the community economy into one analysis for Indonesia, where village funds give local

governments real resources to invest in digital health. Without such integration, village digital health risks being treated as a health-sector project funded from health budgets alone, while village funds are spent on physical infrastructure without regard to the digital services that could use it. The novelty of this study is twofold. It is, to our knowledge, the first review to place health informatics, village fund allocation and the community economy inside a single analytical framework for Indonesia, and the first to convert that framework into a village digital health scorecard that can be produced from data villages and health centres already record. Therefore, this research synthesizes recent evidence and official data to explain how digital health can contribute to rural development and the community economy in Indonesia. The objectives are to (1) describe the rural digital health gap in connectivity, primary care staffing, and information technology readiness; (2) examine how village funds have been used for health and how they could finance digital health; (3) assess the evidence on the effects of digital health on rural health outcomes and household and community economies; and (4) propose an integrated framework with testable propositions and practical indicators for village governments and policymakers. The expected benefits are practical. For the Ministry of Villages and Development of Disadvantaged Regions and for the Ministry of Finance, the framework gives a basis for treating digital health as an allowable and productive use of village funds. For district health offices, it ties the readiness of primary care information systems to connectivity planning that sits outside the health sector. For village governments, the scorecard turns digital health from a national programme into a short list of indicators they can budget for and monitor. The implication for research is a set of propositions that can be tested with village-level data rather than with national averages.

## METHOD

This study used an integrative review design combined with secondary analysis of publicly available data. An integrative design was chosen because the research question spans three fields, health informatics, rural development, and community economics, whose evidence takes different forms: national statistics, government reports, cross-sectional surveys, qualitative studies, econometric analyses, and systematic reviews. A single-method meta-analysis could not combine these sources. The design follows the integrative review method of Whittemore and Knafl (2005) and the more recent operational guidance of Dhollande et al. (2021), which set out how experimental and non-experimental evidence can be combined in one synthesis while keeping problem identification, literature search, data evaluation, data analysis and presentation as distinct stages. Reporting followed the PRISMA 2020 statement, covering eligibility criteria, information sources, the full search strategy for each database, the selection process, data items, the study selection flow, and the appraisal of the quality of the included studies (Page et al., 2021).

The population of interest was villages, primary health care facilities, and rural households in Indonesia. International studies were admitted only where they synthesized evidence on digital health in low- and middle-income countries or measured the economic effects of telehealth for rural populations. Peer-reviewed literature was searched in Google Scholar, PubMed, and the Garuda portal of Indonesian journals, and every record was verified against its publisher page or digital object identifier. Search strings combined three concept blocks with Boolean operators: (telemedicine OR telehealth OR “digital health” OR “health information system” OR posyandu OR puskesmas) AND (rural OR village OR desa OR remote OR island) AND (economy OR cost OR expenditure OR “village fund” OR “Dana Desa” OR BUMDes OR development). The publication window was 1 January 2021 to 10 October 2026, a span of five years and ten months, so the earlier description of the window as “within five years” was inaccurate and has been corrected. The searches were run on 10 October 2026 and updated on 18 October 2026, when the reference lists of the included reviews were also

screened by hand. Table 1 reports the search string applied in each database, the date on which it was run, and the number of records it returned.

**Table 1.** Search strategy, date of search, and records identified by database

| Database | Search string applied | Date searched | Records identified | Records retained after duplicates removed |
|---|---|---|---|---|
| **Google Scholar** | (telemedicine OR telehealth OR "digital health" OR "health information system" OR posyandu OR puskesmas) AND (rural OR village OR desa OR remote OR island) AND (economy OR cost OR expenditure OR "village fund" OR "Dana Desa" OR BUMDes OR development); first twenty result pages screened | 10 October 2026 | 412 | 344 |
| **PubMed** | (telemedicine[MeSH] OR telehealth OR "digital health") AND (rural OR village OR "remote area") AND (Indonesia OR "low and middle income countries") AND (cost OR expenditure OR economics) | 10 October 2026 | 96 | 83 |
| **Garuda portal** | telemedicine OR "kesehatan digital" OR "posyandu digital"; "dana desa" AND kesehatan; "pengeluaran kesehatan rumah tangga" | 10 October 2026 | 78 | 65 |
| **Hand search of the reference lists of the included reviews** | Citation chasing, no string applied | 18 October 2026 | 0 additional records | 0 |
| **Total** | | | 586 | 492 |

Studies were eligible if they (1) were published in a peer-reviewed journal or indexed proceedings within the window; (2) reported empirical results or a systematic synthesis on digital health in Indonesian villages or primary care, on village funds and rural economic development in Indonesia, on household health spending in Indonesia, or on digital health and telehealth economics in rural or low-resource settings; (3) described their sample and method in enough detail to extract findings; and (4) were available in full text in English or Indonesian. Opinion pieces, unpublished theses, and studies without extractable results were excluded. Titles and abstracts were screened independently by two reviewers, followed by independent full-text assessment. Agreement was substantial at both stages, with Cohen's kappa of 0.82 for title and abstract screening and 0.88 for full-text assessment, and the remaining disagreements were resolved by discussion, with a third reviewer consulted where discussion did not produce agreement. Data were extracted by one reviewer and checked in full by a second. Fourteen studies met all criteria: nine Indonesian empirical studies, one Indonesian narrative review, and four international systematic reviews. One record counted as an included study in the earlier version of this manuscript, the research protocol of Welembuntu et al. (2025), does not satisfy criterion (2), because a protocol reports no results and therefore falls under the exclusion of studies without extractable findings. It has been removed from the included set and is used only as a contextual source for facility counts and island travel times. The community

implementation report of Utami et al. (2025) was retained because it appeared in a peer-reviewed journal with a registered digital object identifier and reports an evaluated implementation, although its single-site design places it at the lower end of the quality appraisal. Figure 1 shows the full selection process, with the number of records identified, screened and excluded at each stage and the reasons for exclusion.

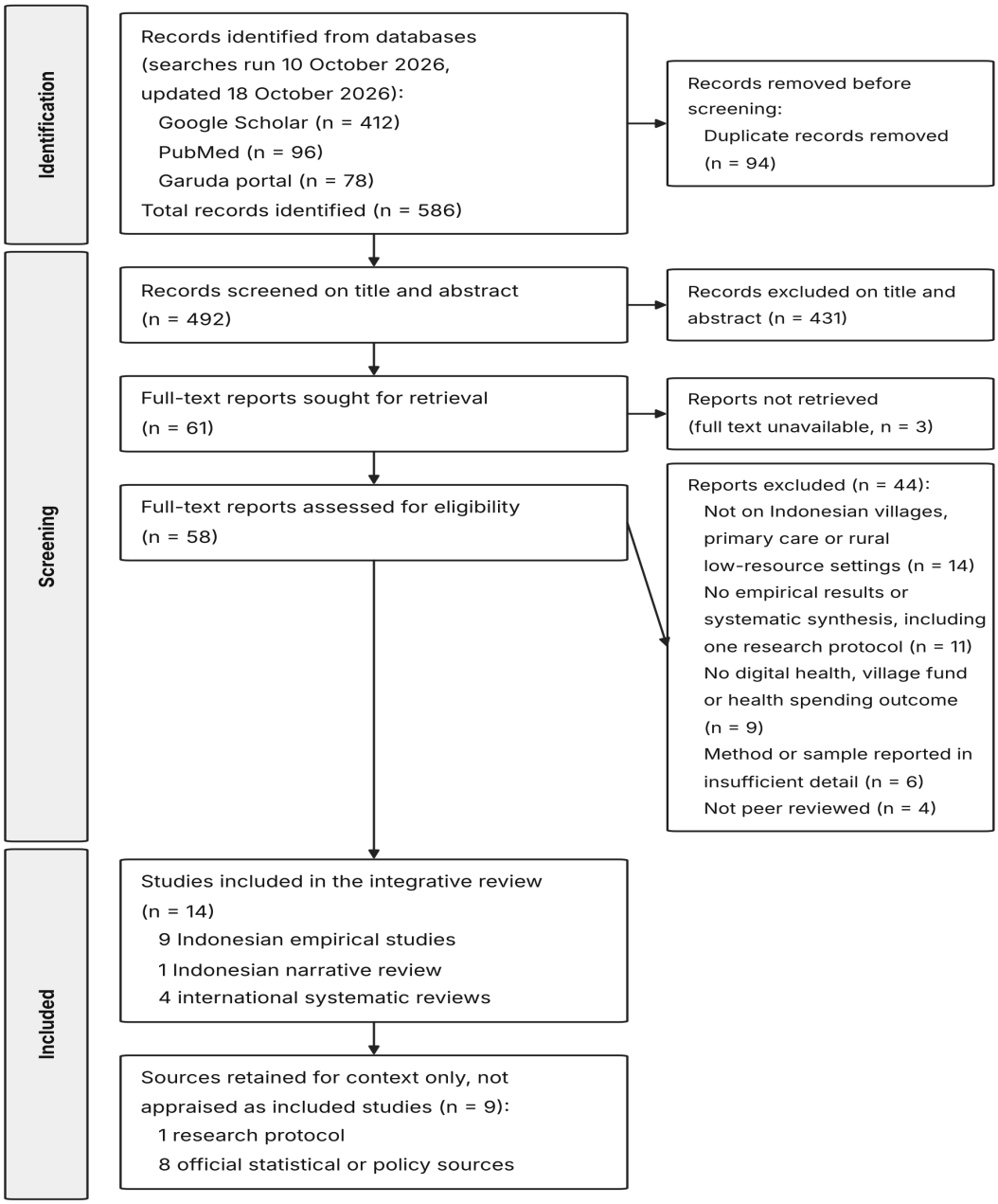



**Figure 1.** PRISMA 2020 flow of study identification, screening and inclusion. Searches were run on 10 October 2026 and updated on 18 October 2026. Contextual sources are reported separately because they were not appraised as included studies.

Each included study was appraised with the Mixed Methods Appraisal Tool, version 2018, which applies a common set of criteria to qualitative, quantitative and mixed methods designs

and is suited to a review that combines them (Hong et al., 2018). Following the guidance issued with the tool, the number of criteria met out of five is reported for each study instead of a single overall score, and the appraisal is used to weight the strength of evidence reported later in this article rather than to exclude studies. Two reviewers appraised each study independently and reconciled their ratings by discussion. Nine studies met four or five of the five criteria, three met three criteria, and two met two or fewer. The two weakest studies, a single-site community implementation report and a narrative review, are treated as feasibility evidence rather than as evidence of effect wherever they appear in the synthesis. Table 2 presents the full extraction and appraisal matrix, including the country and income-level classification of every study, so that readers can audit the coding of findings into the four domains.

**Table 2.** Data extraction, domain coding, and quality appraisal of the fourteen included studies

| Study | Country and income group | Design | Sample | Domain codes | MMAT criteria met (of 5) |
|---|---|---|---|---|---|
| **Aisyah et al. (2024)** | Indonesia; upper middle income | Cross-sectional survey and focus groups (mixed methods) | 237 respondents from 121 health centres, 49 clinics and 67 district offices | DHC | 4 |
| **Alviani et al. (2023)** | Indonesia; upper middle income | Cross-sectional survey, UTAUT2, PLS-SEM | 144 respondents | DHC | 4 |
| **Salsabila & Dachyar (2024)** | Indonesia; upper middle income | Cross-sectional survey, extended UTAUT2, PLS-SEM | 350 prior users | DHC | 3 |
| **Anjani et al. (2026)** | Indonesia; upper middle income | Cross-sectional survey, multiple regression | 102 patients | DHC, HO, HE | 3 |
| **Pratama et al. (2026)** | Indonesia; upper middle income | Qualitative interview study | 15 physicians and 9 patients | DHC, HO, HE | 5 |
| **Utami et al. (2025)** | Indonesia; upper middle income | Single-site community implementation and evaluation | 1 posyandu, 12 volunteers, 60 to 80 toddlers | DHC, HO | 2 |
| **Fattah et al. (2023)** | Indonesia; upper middle income | Two-round household panel survey | Households in 10 provinces, 2018 and 2019 | HO, HE | 5 |
| **Hilmawan et al. (2023)** | Indonesia; upper middle income | Panel regression, difference-in-differences, mediation | 361 districts, 2016 to 2020 | CE | 5 |
| **Fatimah et al. (2026)** | Indonesia; upper middle income | Qualitative case study | 1 village-owned enterprise | DHC, CE | 3 |
| **Sugiarto et al. (2024)** | Indonesia; upper middle income | Narrative review guided by PRISMA | 16 articles | DHC | 2 |
| **Quayson et al. (2024)** | United States; high income, | Systematic review | 36 studies | HO, HE | 4 |

| Study | Country and income group | Design | Sample | Domain codes | MMAT criteria met (of 5) |
|---|---|---|---|---|---|
| | rural veteran population | | | | |
| **Kaboré et al. (2022)** | Low- and middle-income countries | Systematic review | Mixed methods studies | DHC | 4 |
| **Sylla et al. (2025)** | Low- and middle-income countries | Rapid systematic review | 34 studies | DHC | 4 |
| **Irawan et al. (2025)** | Developing countries | Systematic review | 16 studies | DHC, HO | 4 |

DHC = digital health capability; HO = health outcomes; HE = household economy; CE = community economy. Quayson et al. (2024) reports on a high-income country and was retained under eligibility criterion (2), which admits evidence on telehealth economics for rural populations; rural veterans in the United States are a geographically underserved group, and this is the only included source that quantifies travel cost and time saved per avoided visit. Its magnitudes are used as evidence of mechanism and are not transferred to Indonesian values. Welembuntu et al. (2025) is not listed because it is a research protocol retained as a contextual source rather than an included study.

Secondary data were drawn from official and survey sources: internet use from the national statistics agency (Badan Pusat Statistik, 2025a); urban and rural internet penetration from the Indonesian Internet Service Providers Association survey (Asosiasi Penyelenggara Jasa Internet Indonesia, 2024); villages without 4G coverage from the telecommunications access agency as reported in the press (Detik Finance, 2025; Investortrust, 2026); community health centers without doctors and the national count of community health centres from the Ministry of Health (Ministry of Health of the Republic of Indonesia, 2023a, 2023b); child stunting prevalence from the Indonesian Nutritional Status Survey (Badan Kebijakan Pembangunan Kesehatan, 2025; Ministry of Health of the Republic of Indonesia, 2025); village fund allocations and outputs from the Ministry of Finance (CNBC Indonesia, 2024; Direktorat Jenderal Perbendaharaan, 2025); consumer price inflation from Badan Pusat Statistik (2025b); and out-of-pocket and catastrophic health spending from the World Health Organization (World Health Organization, 2024, 2025). Figures reported through news media were treated as indicative and cross-checked against official statements where possible.

For each included study, descriptive items (author, year, setting, technology, design, sample) and result items (main findings, effect directions, and any reported magnitudes) were extracted into a standardized matrix. Findings were then coded into four domains: digital health capability (connectivity, systems, workforce, digital literacy), health outcomes (access, continuity of care, child growth, chronic disease management), household economy (out-of-pocket and travel costs, time, catastrophic spending), and community economy (village funds, village-owned enterprises, local employment, village income).

Analysis proceeded in four steps. First, descriptive statistics were computed for the secondary data: counts, proportions, differences in percentage points, and relative changes. Relative change between two periods was calculated with Equation 1, where $V_0$ is the earlier value and $V_1$ the later value.

$$\Delta\% = [(V_1 - V_0) / V_0] \times 100 \quad (1)$$

Second, a cross-study synthesis recorded which domains each study informed and the direction of its findings. Third, the coded findings were assembled into an integrated framework linking the four domains, with testable propositions. Fourth, the framework was subjected to a consistency check against the direction of evidence in every included study and

in the secondary data. Because the framework was built from these same studies, this step tests internal consistency and searches for disconfirming evidence; it is not an independent validation, and it is described as a consistency check throughout this article.

Validity was supported by preferring primary government sources, verifying each bibliographic record, and recomputing all derived figures from the underlying counts. Figures reported through news media were cross-checked against a publication or statement issued by the originating institution wherever one existed. The village fund totals reported by CNBC Indonesia (2024) were checked against the Ministry of Finance account of ten years of village funds (Direktorat Jenderal Perbendaharaan, 2025); the stunting prevalence reported through the Ministry of Health news page was checked against the survey report of the National Health Policy Agency (Badan Kebijakan Pembangunan Kesehatan, 2025); and the count of villages without 4G coverage was checked against the figure given by the president director of BAKTI Komdigi (Detik Finance, 2025). Where no primary publication could be located, the figure is reported as indicative and labelled as a ministry statement. The method has five limitations. First, the search covered only free databases and did not include Scopus or Web of Science, so the review is reproducible only within Google Scholar, PubMed and Garuda, and studies indexed solely in subscription databases may have been missed; this is the most serious limitation of the review and the reason the synthesis is presented by direction of evidence rather than as a complete census of the literature. Second, several secondary figures come from different years, which limits direct comparison. Third, some official figures were available only through press reports of ministry statements. Fourth, synthesis by direction of evidence shows consistency but not effect size. Fifth, two of the fourteen included studies were appraised as meeting two or fewer of the five quality criteria, and the household and community economic pathways rest on a small number of studies. Because the study analyzed only published and publicly available data without human participants, ethical approval was not required.

## RESULTS AND DISCUSSION

The fourteen included studies cover the four domains from complementary angles. Indonesian studies describe the readiness of primary care information systems, the use and retention of telemedicine, the digitization of integrated health posts, the effect of village funds, the digital role of village-owned enterprises, and household catastrophic spending. International reviews supply evidence on rural telehealth economics and on the sustainability of digital health in low-resource settings. Table 3 summarizes their characteristics, and Table 2 above reports the appraisal and the domain coding behind this summary.

**Table 3.** Characteristics of the fourteen included studies, 2021–2026

| Study | Setting | Focus | Design | Sample | Main finding |
|---|---|---|---|---|---|
| **Aisyah et al. (2024)** | Indonesia, 9 provinces, urban to remote | Primary care information technology maturity | Cross-sectional survey and focus groups | 237 respondents from 121 health centers, 49 clinics, 67 district offices | Average maturity 2.74 of 5; hardware weakest (2.59); rural sites scored lower; unstable power and internet in remote areas |
| **Alviani et al. (2023)** | Indonesia, adults | Telemedicine adoption | Survey; UTAUT2; PLS-SEM | 144 respondents | 46.9% had never used telemedicine; usefulness, ease, social influence, |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | eHealth literacy, and trust drove intention |
| **Salsabila & Dachyar (2024)** | Indonesia, prior users | Telemedicine adoption | Survey; extended UTAUT2; PLS-SEM | 350 respondents | Geographic location, facilitating conditions, price value, social influence, and usefulness significant; 58.2% of Indonesians unaware of telemedicine |
| **Anjani et al. (2026)** | Bali and West Nusa Tenggara | Telemedicine retention | Survey; multiple regression | 102 patients | Seven factors explained 53.39% of retention; provider quality 27.19%, price 5.94%, health professional availability 5.40%, distance 4.59% |
| **Pratama et al. (2026)** | Indonesia, 6 of 7 regions | Telemedicine for chronic and rare diseases | Qualitative interviews | 15 physicians, 9 patients | Patients living more than 50 km from a hospital relied heavily on telemedicine; a hybrid schedule lowered patient costs |
| **Utami et al. (2025)** | Pentur village, Boyolali | Digital posyandu records | Community implementation and evaluation | 1 posyandu, 12 volunteers, 60–80 toddlers | Digital recording replaced manual toddler records and was judged helpful by volunteers |
| **Fattah et al. (2023)** | Indonesia, 10 provinces | Catastrophic health spending | Two-round household survey | Households in 2018 and 2019 | Catastrophic spending fell from 7.9% to 4.4%; rural residence and private facility use were risk factors |
| **Hilmawan et al. (2023)** | Indonesia, 361 districts | Village funds and rural development | Regression, difference-in-differences, mediation | 361 districts, 2016–2020 | Village funds raised the village development index; village-owned enterprises showed weak effects |

| | | | | | |
|---|---|---|---|---|---|
| **Fatimah et al. (2026)** | Kuala Dua village, West Kalimantan | Digital services of a village-owned enterprise | Qualitative case study | 1 village-owned enterprise | Digital services widened market access and created jobs for young people; infrastructure and funding limited |
| **Sugiarto et al. (2024)** | Indonesia, health facilities | Electronic medical record policy | Narrative review guided by PRISMA | 16 articles | 61.42% of facilities had adopted electronic records; barriers were infrastructure, guidelines, and training |
| **Quayson et al. (2024)** | United States, rural veterans | Telehealth use and cost savings | Systematic review | 36 studies | Telehealth saved about USD 65–73 and 2.1–2.6 hours per visit in travel |
| **Kaboré et al. (2022)** | Low- and middle-income countries | Sustainability of digital health | Systematic review | Mixed-methods studies | Infrastructure, equipment, internet, and electricity are key barriers; stakeholder commitment and staff competence facilitate |
| **Sylla et al. (2025)** | Low- and middle-income countries | Digital health and universal coverage | Rapid systematic review | 34 studies | Unequal technology access, low digital literacy, weak infrastructure, and weak governance persist |
| **Irawan et al. (2025)** | Developing countries | Digital health in child care | Systematic review | 16 studies | Mobile tools improved child health services but risk excluding rural families without phones or internet |

The first major finding is a measurable rural digital health gap. Table 4 assembles the main indicators from official and survey sources. Internet use has become widespread, with 72.78% of Indonesians using the internet in 2024 (Badan Pusat Statistik, 2025a), but rural penetration of 74.00% still trails urban penetration of 82.18%, a gap of 8.18 percentage points (Asosiasi Penyelenggara Jasa Internet Indonesia, 2024). These two sources are not directly comparable and should not be read as one series. The national figure from Badan Pusat Statistik measures the share of individuals aged five years and over who used the internet in the three months before the survey, while the urban and rural figures come from a household penetration survey run by the Indonesian Internet Service Providers Association with its own sampling frame and its own definition of access. The gap of 8.18 percentage points is therefore a difference

measured inside the penetration survey, not a difference against the national statistic. The most severe exclusion is concentrated in a small number of villages: about 2,000 villages, most of them in Papua, still lacked 4G coverage in 2026 (Investortrust, 2026), equal to about 2.7% of the 75,259 villages that receive village funds. The agency responsible for the programme has since published a figure of its own: the president director of BAKTI Komdigi reported 2,121 villages in disadvantaged, frontier and outermost regions with no 4G cellular coverage at all, equal to 2.8% of the villages that receive village funds (Detik Finance, 2025). BAKTI Komdigi does not maintain an open village-level coverage dataset, so both counts remain ministry statements reported through the press rather than entries in a public statistical series, and they are treated here as indicative.

**Table 4.** Indicators of the rural digital health gap in Indonesia

| Indicator | Value | Year | Source |
|---|---|---|---|
| **Population using the internet (national)** | 72.78% | 2024 | Badan Pusat Statistik (2025a) |
| **Internet penetration, urban areas** | 82.18% | 2024 | Asosiasi Penyelenggara Jasa Internet Indonesia (2024) |
| **Internet penetration, rural areas** | 74.00% | 2024 | Asosiasi Penyelenggara Jasa Internet Indonesia (2024) |
| **Villages without 4G coverage** | about 2,000 (≈2.7% of villages) | 2026 | Investortrust (2026) |
| **Villages with no 4G cellular coverage, BAKTI Komdigi statement** | 2,121 (≈2.8% of villages) | 2025 | Detik Finance (2025) |
| **Community health centres operating nationally** | 10,374 | 2022 | Ministry of Health of the Republic of Indonesia (2023b) |
| **Community health centers without a doctor** | 404 | 2023 | Ministry of Health of the Republic of Indonesia (2023a) |
| **Of which in remote or very remote areas** | 287 (71.0%) | 2023 | Ministry of Health of the Republic of Indonesia (2023a) |
| **Community health centers without the nine priority health worker types** | 6,104 | 2023 | Ministry of Health of the Republic of Indonesia (2023a) |
| **Information technology maturity of primary care (1–5 scale)** | 2.74 | 2022 | Aisyah et al. (2024) |
| **Facilities that had adopted electronic medical records** | 61.42% | 2024 | Sugiarto et al. (2024) |

Percentages in parentheses computed by the authors: 2,000 / 75,259 villages; 287 / 404 health centers.

The staffing figures show why connectivity alone is not enough. Of the 404 community health centers that had no doctor after the 2022 recruitment round, 287 (71.0%) were in remote or very remote areas, and 6,104 health centers lacked at least one of the nine priority health worker types (Ministry of Health of the Republic of Indonesia, 2023a). Against the 10,374 community health centres recorded for the same period in the Ministry of Health facility statistics (Ministry of Health of the Republic of Indonesia, 2023b), this means that 58.8%, or roughly three in five, were incompletely staffed. Drawing the facility count from the same ministry and the same reporting year removes the mismatch in the earlier version of this manuscript, which compared a 2023 staffing figure with a national facility count quoted inside a 2025 research protocol. In such settings, telemedicine is not a convenience but a substitute for a missing doctor, which raises its value for rural communities above its value in cities.

The readiness of primary care information systems is also uneven. Across nine provinces, the information technology maturity of primary care averaged 2.74 on a scale of 1 to 5, with hardware the weakest domain at 2.59; rural sites scored lower than urban ones, and remote sites reported unstable electricity and internet (Aisyah et al., 2024). Health workers in focus groups described unintegrated systems that forced duplicate data entry and continued paper reporting. These findings are consistent with the barriers identified for electronic medical records, namely infrastructure, missing guidelines, and insufficient training (Sugiarto et al., 2024), and with international evidence that infrastructure, equipment, internet, and electricity limit the sustainability of digital health in low-resource settings (Kaboré et al., 2022).

The second major finding concerns the fiscal capacity of villages. Village funds have grown into one of the largest rural development programs in the world. Table 5 shows that the total allocation rose from Rp20.7 trillion for 74,093 villages in 2015 to Rp71 trillion for 75,259 villages in 2024, and the average allocation per village rose from Rp280.3 million to Rp943.34 million (Direktorat Jenderal Perbendaharaan, 2025). Using Equation 1, the total allocation grew by 243.0% and the allocation per village by 236.5% over nine years. The 2015 and 2024 totals and the 2024 village count are taken from the Ministry of Finance account of ten years of village funds, and the 2015 village count from the Directorate General of Fiscal Balance figures reported by CNBC Indonesia (2024). These values are nominal. Chaining the annual consumer price inflation published by Badan Pusat Statistik for 2016 to 2024 gives cumulative inflation of 28.8% across the period (Badan Pusat Statistik, 2025b), so the Rp71 trillion allocated in 2024 is worth about Rp55.1 trillion at 2015 prices. In real terms the total allocation grew by 166.3% and the allocation per village by 161.3%, close to two thirds of the nominal growth. A nominal comparison across nine years therefore overstates the gain in real village fiscal capacity, and the real figures are the ones used in the discussion that follows.

**Table 5.** Village fund allocations and selected health-related outputs

| Item | 2015 | 2024 |
|---|---|---|
| **Total allocation (Rp trillion)** | 20.7 | 71.0 |
| **Villages receiving funds** | 74,093 | 75,259 |
| **Average allocation per village (Rp million)** | 280.3 | 943.34 |
| **Cumulative allocation, 2015–2024 (Rp trillion)** | — | about 609.9 |
| **Integrated health posts (posyandu) built, cumulative 2015–2023** | — | 9,352 units |
| **Village maternity posts (polindes) built, cumulative 2015–2023** | — | 79,928 units |
| **Clean water units built, cumulative 2015–2023** | — | 10.12 million |

Sources: Direktorat Jenderal Perbendaharaan (2025), Ministry of Finance, for the 2015 and 2024 allocations, the 2024 village count and the cumulative total; CNBC Indonesia (2024), reporting the Directorate General of Fiscal Balance, Ministry of Finance, for the 2015 village count and for the cumulative output counts. Real values are computed from the annual inflation series of Badan Pusat Statistik (2025b).

Village funds have already been used heavily for health-related infrastructure, including 9,352 integrated health posts, 79,928 village maternity posts, and more than ten million clean water units between 2015 and 2023 (CNBC Indonesia, 2024). These investments are mostly physical. A village maternity post built with village funds can also host a tablet, a stable internet connection, and a scheduled teleconsultation with the community health center doctor, at a small fraction of its construction cost. The finding that village funds raise the village development index (Hilmawan et al., 2023) shows that the transfer mechanism works; the

opportunity is to direct part of it toward digital services that make the physical assets more productive.

The same study offers a caution for community economic development. Hilmawan et al. (2023) found only weak evidence that village-owned enterprises improved rural development, while village original income mattered both directly and as a mediator. A digital health strategy that relies on village-owned enterprises to generate income must therefore be designed carefully. The case of Kuala Dua village shows what is possible: its village-owned enterprise used digital promotion and content services to widen market access, create jobs for young people, and build digital literacy, but faced limits in infrastructure, funding, and integration with village development plans (Fatimah et al., 2026). The same institutional capacity could support digital health functions such as connectivity provision, device maintenance, or assistance for elderly residents using telemedicine.

The third major finding is that digital health in villages produces health benefits that depend on local capacity. Child growth monitoring is the clearest example. Stunting prevalence fell from 21.5% in 2023 to 19.8% in 2024, a decline of 1.7 percentage points or 7.9% in relative terms, but the 2029 national target of 14.2% requires a further 5.6 percentage points, about 1.1 points per year (Badan Kebijakan Pembangunan Kesehatan, 2025; Ministry of Health of the Republic of Indonesia, 2025). Integrated health posts and village health volunteers are the front line of this effort. In Pentur village, a digital recording application replaced manual toddler records at a posyandu serving 60 to 80 children with 12 volunteers, and the volunteers judged it helpful for managing growth data (Utami et al., 2025). That evidence demonstrates feasibility, not effect. The study covers a single posyandu, its outcome is the satisfaction of twelve volunteers with a new recording method, it measures no growth outcome, and it met two of the five appraisal criteria in Table 2. The national decline in stunting between 2023 and 2024 therefore cannot be attributed to digital posyandu records, which covered a very small share of posyandu nationally over that period. The decline is more plausibly explained by the combined national nutrition programmes, supplementary feeding, and changes in survey coverage, and no included study isolates a digital contribution to it. International evidence supports this direction: mobile tools for child health in developing countries improved service coverage and decision-making by community health workers, but risked excluding families without phones or internet (Irawan et al., 2025).

Telemedicine shows a similar dependence on context. Among patients with chronic and rare diseases, those living more than 50 km from a hospital relied heavily on telemedicine, while those within about 5 km preferred in-person care (Pratama et al., 2026). In Bali and West Nusa Tenggara, the quality of the service provider explained 27.19% of telemedicine retention, while price (5.94%), availability of health professionals (5.40%), and distance to health facilities (4.59%) together explained a further 15.93% (Anjani et al., 2026). Geographic location and facilitating conditions were significant predictors of telemedicine adoption at the national level (Salsabila & Dachyar, 2024), but awareness remained low, with 58.2% of Indonesians unaware of telemedicine and 46.9% of one adult sample never having used it (Alviani et al., 2023; Salsabila & Dachyar, 2024). Demand in rural areas is therefore high in principle but held back by awareness, trust, and the reliability of the service.

Table 6 summarizes which domains each Indonesian study informs, showing that no single study links all four domains. This gap is the central justification for an integrated framework.

**Table 6.** Domains informed by the Indonesian studies

| Study | Digital health capability | Health outcomes | Household economy | Community economy |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| **Aisyah et al. (2024)** | ✓ | — | — | — |
| **Sugiarto et al. (2024)** | ✓ | — | — | — |
| **Alviani et al. (2023)** | ✓ | — | — | — |
| **Salsabila & Dachyar (2024)** | ✓ | — | — | — |
| **Anjani et al. (2026)** | ✓ | ✓ | ✓ | — |
| **Pratama et al. (2026)** | ✓ | ✓ | ✓ | — |
| **Utami et al. (2025)** | ✓ | ✓ | — | — |
| **Fattah et al. (2023)** | — | ✓ | ✓ | — |
| **Hilmawan et al. (2023)** | — | — | — | ✓ |
| **Fatimah et al. (2026)** | ✓ | — | — | ✓ |
| **Number of studies** | 8 | 4 | 3 | 2 |

✓ = the study reports findings in the domain; — = not addressed. In this table "health outcomes" means a reported outcome of care, that is access, continuity, service use or child growth. The ticks previously shown for Alviani et al. (2023) and Salsabila & Dachyar (2024) have been removed, because both studies measure adoption intention within a technology acceptance model and report no outcome of care; the column total falls from six to four accordingly. Welembuntu et al. (2025), a research protocol, is no longer an included study and is used for context only, so it does not appear in this table.

The fourth major finding concerns the household economy. Catastrophic health spending, defined as out-of-pocket health spending above 10% of household consumption, fell from 7.9% of households in 2018 to 4.4% in 2019, a relative decline of 44.3%, and households with national health insurance were less likely to face it; yet rural residence and the use of private facilities remained risk factors (Fattah et al., 2023). Out-of-pocket spending still made up 27.5% of current health expenditure (World Health Organization, 2025), and catastrophic spending stood at about 2% in 2021 (World Health Organization, 2024). These two catastrophic-spending figures are not directly comparable. The 4.4% of Fattah et al. (2023) comes from a two-round panel of households in ten provinces applying a 10% threshold of household consumption, while the figure of about 2% is a national estimate drawn from a different survey source and reporting framework, so the two are separate series rather than a continuing decline. The fall between 2018 and 2019 also coincides with the expansion of the national health insurance scheme toward about 90% population coverage (World Health Organization, 2024), and Fattah et al. (2023) report that insured households were less likely to face catastrophic spending. The decline is therefore best attributed to insurance expansion, not to digital health, and no included study measures a digital health contribution to it. National insurance covers the medical bill but not the bus fare, the boat ticket, the lost day of harvest, or the companion who must travel with the patient. These non-medical costs fall most heavily on rural households.

Telehealth can reduce exactly these costs. A systematic review of telehealth for rural veterans found savings of about USD 65 to 73 and 2.1 to 2.6 hours per visit in avoided travel (Quayson et al., 2024). In Indonesia, patients with chronic diseases who moved to a hybrid schedule of one in-person and five virtual visits over six months reported substantial savings compared with monthly hospital visits, mainly from avoided travel and accommodation (Pratama et al., 2026). The magnitudes from the United States cannot be transferred directly to Indonesia, but the mechanism is the same: each consultation that does not require travel returns time and money to the household, and in farming and fishing communities time is income.

The link from the household economy to the community economy is a hypothesis rather than a finding. None of the included studies measures money retained inside a village economy, time reallocated to productive work, or village income generated by digital health services, so the mechanism set out here is offered for testing and not as evidence. On that reading, money not spent on transport and lodging in the city would stay in the village economy, and time not

lost to travel would be available for farming, trading, or caring for children. At the community level, digital health also creates demand for local services such as connectivity, device repair, and digital assistance, which village-owned enterprises can supply (Fatimah et al., 2026). Village funds, in turn, can finance the physical and digital assets that make these services possible (Hilmawan et al., 2023). The same mechanism carries costs that the framework has to account for. Households bear data and handset expenses that recur every month, and for a household already close to the catastrophic spending threshold these shift the composition of cost rather than remove it. Elderly residents and the poorest households are the least likely to own a suitable device or to have the literacy to use one, so a service that is cheaper on average can be unavailable to exactly those who travel furthest, a risk that international reviews report directly (Irawan et al., 2025; Sylla et al., 2025). Village funds spent on connectivity and devices are also funds not spent on clean water, roads, or village enterprise capital, and the opportunity cost of that choice has not been measured in any included study. Table 7 summarizes these economic pathways and the strength of the current evidence for each.

**Table 7.** Economic pathways of village digital health and strength of evidence

| Pathway | Mechanism | Evidence base | Strength for Indonesia |
|---|---|---|---|
| **Avoided travel cost and time** | Remote consultations replace trips to distant facilities | Quayson et al. (2024); Pratama et al. (2026) | Moderate; magnitudes from abroad |
| **Lower catastrophic spending** | Earlier care and fewer trips reduce out-of-pocket shocks | Fattah et al. (2023); World Health Organization (2024) | Moderate; digital effect not yet measured |
| **Healthier children and future productivity** | Digital growth monitoring supports earlier stunting action | Utami et al. (2025); Irawan et al. (2025); Ministry of Health of the Republic of Indonesia (2025) | Weak to moderate; small-scale evidence |
| **Local digital service jobs** | Village-owned enterprises supply connectivity and digital services | Fatimah et al. (2026); Hilmawan et al. (2023) | Weak; case-study evidence |
| **Better use of village assets** | Village funds equip existing health posts with digital tools | CNBC Indonesia (2024); Hilmawan et al. (2023) | Plausible; untested |

The four findings were combined into an integrated Digital Health–Rural Development–Community Economy framework, shown in Figure 2. Village enabling conditions, consisting of connectivity, village funds, and local institutions, make digital health possible. Digital health services, consisting of telemedicine, digital posyandu records, and integrated primary care information systems, improve health outcomes through continuity of care, earlier detection, and shorter referrals. Better health then strengthens the household economy by reducing travel and out-of-pocket costs and protecting productive time, and a stronger household economy supports the community economy through local spending, village-owned enterprises, and village income. Village income and fund allocations then flow back into village enabling conditions, closing the loop.

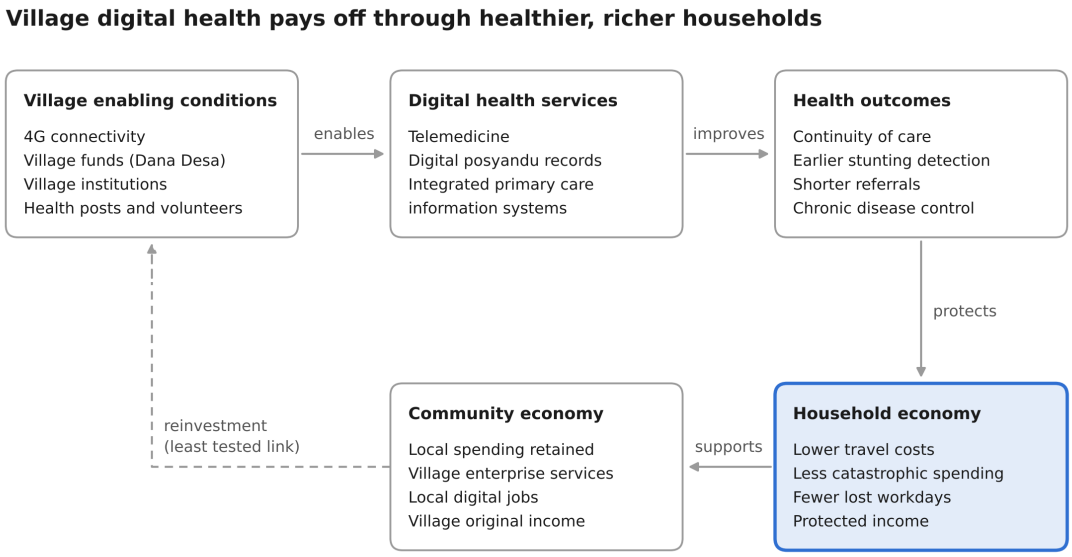



**Figure 2.** The Digital Health–Rural Development–Community Economy framework. Solid arrows are links supported by the included evidence; the dashed link from community economy back to village investment is the least tested.

The framework was subjected to a consistency check rather than an independent validation, because the same studies were used to build it and agreement between a framework and its own sources is expected. To search for disconfirming evidence, the full text of every included study was read for reported null, negative or qualifying findings, and the database searches were repeated with terms chosen to surface them, namely “no cost saving”, “no significant effect”, “not cost-effective”, “digital divide” and “unintended consequences”. Three kinds of disconfirming evidence were found and are retained in the synthesis. Hilmawan et al. (2023) report only weak effects of village-owned enterprises on rural development, which qualifies the community economy link. Irawan et al. (2025) and Sylla et al. (2025) report that mobile tools exclude households without phones or internet, which qualifies the link from digital health to health outcomes. Alviani et al. (2023) and Salsabila & Dachyar (2024) report that a large share of the population has never used telemedicine and is unaware of it, which qualifies the link from enabling conditions to digital health use. No included study reported that telemedicine raised household costs, but no Indonesian study measured household costs with a design able to detect such an increase, so the absence of contradicting evidence on that link reflects the absence of measurement rather than agreement. The link from enabling conditions to digital health is supported by the readiness and adoption studies (Aisyah et al., 2024; Salsabila & Dachyar, 2024) and by international reviews of infrastructure barriers (Kaboré et al., 2022; Sylla et al., 2025). The link from digital health to health outcomes is supported by evidence on telemedicine for distant patients and on digital growth monitoring (Irawan et al., 2025; Pratama et al., 2026; Utami et al., 2025), with the last of these providing feasibility evidence only. The link from health to the household economy is supported by evidence on avoided travel and catastrophic spending (Fattah et al., 2023; Quayson et al., 2024), although the catastrophic spending evidence reflects insurance expansion rather than digital health. The link to the community economy rests on two studies (Fatimah et al., 2026; Hilmawan et al., 2023), and the feedback from community income to village investment in digital health remains untested, which is itself a finding.

From the framework, five propositions are offered for empirical testing. P1: Villages with 4G coverage and a digitally equipped health post have higher telemedicine use and fewer

referral trips per capita than similar villages without them. P2: The share of village funds allocated to digital health assets is positively associated with the completeness of child growth data at integrated health posts. P3: Rural households that use telemedicine for chronic conditions have lower non-medical out-of-pocket costs and fewer lost workdays than comparable households that do not. P4: Telemedicine retention in rural areas depends more on service quality and the availability of health professionals than on price. P5: Village-owned enterprises that provide digital services generate measurable village original income and local employment when linked to health service functions.

Each proposition can be tested with data that villages, health centers, and households already hold or can collect at modest cost. Table 8 links each proposition to its variables, data, and a suitable analysis design. The designs favor comparisons within villages over time and matched comparisons between similar villages, because simple cross-sectional comparisons would confuse the effect of digital health with differences in wealth, geography, and local leadership.

**Table 8.** Research agenda for testing the five propositions

| Proposition | Key variables | Data required | Suggested analysis design |
|---|---|---|---|
| **P1** | 4G coverage and digital health post; telemedicine use; referral trips | Village potential statistics, health center referral records, telemedicine logs | Matched comparison of villages or difference-in-differences around new 4G sites |
| **P2** | Share of village funds for digital health; completeness and timeliness of growth data | Village budget documents, posyandu records | Panel regression with village fixed effects |
| **P3** | Telemedicine use; non-medical out-of-pocket costs; lost workdays | Household survey with cost diaries | Propensity score matching or a pragmatic cluster trial |
| **P4** | Service quality, professional availability, price, distance; retention | Patient survey linked to platform records | Multiple regression or structural equation modeling by urban and rural location |
| **P5** | Digital services of village-owned enterprises; village original income; local jobs | Enterprise financial reports, village income records | Multiple case study combined with panel analysis |

To make the framework usable for village governments and district health offices, each domain needs indicators that can be monitored routinely. Table 9 proposes a minimum village digital health scorecard. Every indicator can be produced from data that villages and health centers already record or are required to record, so the scorecard adds little reporting burden while allowing village development plans to track whether digital investments translate into health and economic gains.

**Table 9.** Proposed village digital health scorecard

| Domain | Indicator | Definition | Routine data source |
|---|---|---|---|
| **Enabling conditions** | 4G coverage | Whether the village center and health post receive a 4G signal | Village potential statistics |

| | | | |
|---|---|---|---|
| **Enabling conditions** | Village fund share for digital health | Share of the annual village fund spent on digital health assets and services | Village budget (APBDes) |
| **Digital health services** | Digital growth records | Share of toddlers whose weighing is recorded digitally each month | Posyandu application records |
| **Digital health services** | Teleconsultations | Teleconsultations per 1,000 residents per year | Health center records |
| **Enabling conditions** | Device and connectivity maintenance | Whether a named budget line and a responsible person exist for devices and data subscriptions at the health post | Village budget (APBDes) |
| **Digital health services** | SATUSEHAT compliance | Whether the applications used at the village health post exchange data with the national platform | Health centre information system records |
| **Digital health services** | Personal data protection | Whether a written data processing instruction from the district health office is in place | Village administration records |
| **Health outcomes** | Stunting prevalence | Share of children under five with height-for-age below −2 standard deviations | Growth monitoring data |
| **Health outcomes** | Referral completion | Share of referrals that reach the receiving facility | Health center referral records |
| **Household economy** | Travel cost per consultation | Average transport and lodging cost per health visit | Household or patient survey |
| **Household economy** | Lost workdays | Workdays lost per episode of illness | Household survey |
| **Community economy** | Local digital service jobs | Residents employed in connectivity or digital services | Village-owned enterprise records |
| **Community economy** | Village original income | Annual village original income | Village financial reports |

The findings carry practical implications for three groups. For the central government, the remaining villages without 4G and the health centers without doctors should be planned together, so that new connectivity is matched by a teleconsultation link to a staffed facility. Guidelines on village fund priorities could explicitly allow spending on digital health assets at existing health posts, such as tablets, connectivity, and training for volunteers. For district governments and health offices, the priority is to integrate primary care information systems, reduce duplicate data entry, and ensure that every village health post can report digitally to its health center. For village governments, the scorecard in Table 9 offers a way to include digital health in village development plans and to judge whether village-owned enterprises can support digital health services sustainably.

Three governance conditions decide whether this is safe and durable, and none of them is a health-sector matter alone. The first is personal data protection. Growth records, teleconsultation notes and referral data held at a village health post are personal data concerning health under Law No. 27 of 2022 on Personal Data Protection, which requires a lawful basis for processing, explicit consent for data of this kind, and a named controller (Republic of Indonesia, 2022). A village government that collects such data becomes a controller, and few

villages have an officer able to carry that duty, so the district health office should hold the controller role while the village acts as processor under a written instruction. The second is interoperability. Data recorded in a village application that cannot exchange information with SATUSEHAT, the national health data platform built on the Fast Healthcare Interoperability Resources standard, create a second parallel record instead of continuity of care (Faisal & Nakayama, 2024). Any application bought with village funds should therefore be required to demonstrate SATUSEHAT compliance before purchase. The third is maintenance. A tablet, a router and a monthly data subscription need an owner, a replacement cycle and a budget line. The cost of maintaining digital assets at posyandu and polindes level is small but recurrent, while village budgets are annual, so the scorecard in Table 9 carries it as an explicit indicator rather than leaving it to be absorbed by volunteers.

The findings should be interpreted with caution. Most Indonesian adoption studies used online samples that over-represent younger, more educated, and urban respondents, so rural demand may be underestimated or overestimated. The economic magnitudes for avoided travel come from the United States and from a small qualitative sample in Indonesia. Several secondary figures come from different years and from press reports of official statements. Alternative explanations, such as improvements in roads or insurance coverage rather than digital health, could account for part of the decline in catastrophic spending. These limitations point to the need for village-level studies that link connectivity, village budgets, digital health use, and household economic outcomes over time.

## CONCLUSION

Health informatics can become a tool of rural development in Indonesia, but only when it is planned as village infrastructure rather than as a separate health-sector project. Rural areas still trail cities in internet penetration, about 2,000 villages lack 4G coverage, most health centers without doctors are in remote areas, and primary care information systems remain at a basic level of maturity. At the same time, village funds have grown to Rp71 trillion a year and have already built thousands of health posts, while the available evidence, rated weak to moderate in Table 7, suggests that telemedicine and digital growth monitoring can improve access for distant patients and children and may reduce the travel and out-of-pocket costs that weigh on rural households. The economic magnitudes come from a high-income setting and from one small qualitative Indonesian study, and the decline in catastrophic health spending recorded between 2018 and 2019 is attributable to insurance expansion rather than to digital health. The Digital Health–Rural Development–Community Economy framework proposed here links these findings: connectivity and village funds enable digital health, digital health improves health and protects household income, and stronger households support the village economy that funds the next round of investment. Using village funds to make existing health posts digitally capable, matching new connectivity with staffed teleconsultation links, and monitoring results with a village digital health scorecard are the most direct ways to turn digital health into rural development. The main limitations of this review are that the search covered only free databases, that two of the fourteen included studies were appraised as meeting two or fewer of the five quality criteria, and that no included study measured the effect of digital health on household or village income, so the economic pathways remain plausible rather than demonstrated. Testing the five propositions with village-level data is the next step to confirm or revise this conclusion.

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## AUTHOR CONTRIBUTIONS

Author1 (corresponding author): Conceptualization; Methodology; Formal analysis; Investigation; Data curation; Writing, original draft; Visualization. Author2: Methodology; Validation; Investigation; Writing, review and editing. Author3: Supervision; Project administration; Writing, review and editing. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work. Before submission, please replace Author1, Author2 and Author3 with the names or initials used in the byline.

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