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Enhancing Preventive Service Coverage and Digital Local Area Monitoring Quality

A Quasi-Experimental Study of Life Cycle-Based Integrated Primary Care Posyandu in Rural Communities

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ABSTRACT

Strengthening primary health care through integrated, life-course approaches is essential to improve preventive service delivery and health system performance. In Indonesia, the transformation of Posyandu into an Integrated Primary Care (ILP) platform aims to enhance service coverage and digital monitoring through Local Area Monitoring (PWS). This study assessed the effect of Integrated Primary Care Posyandu on preventive service coverage and digital PWS quality at the village level. A quasi-experimental design with a non-equivalent control group was conducted between September 2025 and January 2026 in Yogyakarta Province, involving 840 participants. The intervention included life-cycle–based integrated services and the use of digital monitoring tools. Outcomes were analyzed using a difference-in-differences approach. Preventive service coverage increased significantly in the intervention group compared to the control group, with a net effect of +13.2 percentage points ($p < 0.001$). The quality of digital PWS also improved significantly (+14.1 points; $p < 0.001$). Improvements were observed across all life-cycle groups, particularly among adolescents and older adults. These findings suggest that integrated and digitally enabled community-based health services can effectively improve both service utilization and data quality, supporting stronger primary health care systems and contributing to progress toward universal health coverage.

Keywords
Delivery of Health Care
Health Information Systems
Preventive Health Services
Primary Health Care
Program Evaluation

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Introduction

Strengthening primary health care remains a central strategy for achieving universal health coverage and improving population health outcomes, particularly in low- and middle-income countries. Preventive health services, including maternal, neonatal, child, adolescent, and elderly care, are essential components of primary care systems; however, their coverage and quality remain suboptimal in many rural settings. Fragmented service delivery, limited integration across life stages, and weak health information systems contribute to persistent gaps in service utilization and health monitoring [1], [2].

Community-based health platforms have been widely recognized as effective mechanisms to extend preventive services to underserved populations. In Indonesia, the *Pos Pelayanan Terpadu* (Posyandu) has long served as a cornerstone of community health delivery. Traditionally focused on maternal and child health, Posyandu has undergone a strategic transformation toward a more comprehensive model under the Integrated Primary Care (*Integrasi Layanan Primer*, ILP) framework. This model adopts a life-cycle approach, aiming to provide continuous and integrated services across all age groups, from infancy to old age. Despite its conceptual strengths, empirical evidence on the effectiveness of this transformation particularly in improving service coverage and health system performance remains limited [3], [4].

In parallel, the quality of health system monitoring plays a critical role in guiding decision-making and ensuring accountability. The Local Area Monitoring system (*Pemantauan Wilayah Setempat*, PWS) is a key surveillance tool used to track service coverage and program performance at the community level. However, conventional PWS systems are often constrained by delayed reporting, data incompleteness, and limited usability for real-time decision-making. The transition toward digital PWS platforms offers significant potential to enhance data quality, timeliness, and utilization. Nevertheless, the effectiveness of digitalization efforts is highly dependent on their integration with service delivery innovations and community-based health structures [5], [6].

The integration of life-cycle–based primary care services within Posyandu, combined with the digitalization of PWS, represents a promising strategy to address both service delivery and health information system challenges. Theoretically, this integrated approach may

improve preventive service coverage by increasing accessibility, continuity of care, and community engagement, while simultaneously strengthening monitoring quality through more accurate, timely, and actionable data. However, rigorous evaluations of such integrated interventions, particularly using quasi-experimental designs in real-world rural settings, are still scarce [7], [8].

Given these gaps, this study aims to assess the effect of implementing life-cycle–based Integrated Primary Care Posyandu on (1) preventive service coverage and (2) the quality of digital Local Area Monitoring (PWS) at the village level. By employing a quasi-experimental design, this study seeks to provide robust evidence on the effectiveness of this integrated model in strengthening both service delivery and health system performance in rural communities. The findings are expected to inform policy and practice in scaling up integrated, data-driven primary health care systems in similar contexts [9].

Material and Methods

A. Study Design and Setting

This study employed a quasi-experimental design with a non-equivalent control group using a difference-in-differences (DiD) analytical framework to assess the impact of implementing life-cycle–based Integrated Primary Care Posyandu on preventive service coverage and the quality of digital Local Area Monitoring (PWS). The study was conducted between September 2025 and January 2026 in rural areas of Yogyakarta Province, Indonesia. A total of six villages were included, comprising three intervention villages (including Sukasari Village) and three control villages. Control villages were selected based on similarity in population characteristics, baseline health service performance, and access to primary health care facilities to ensure comparability.

B. Population and Sample Size

The study population included all individuals registered within Posyandu catchment areas across the life course, including infants, children under five, adolescents, adults, and older adults. The total population across the study sites was 4,860 individuals. Sample size calculation was based on detecting a minimum difference of 15 percentage points in preventive service coverage between groups, with a statistical power of 80% and a significance level of 5%. After adjusting for clustering effects (design effect = 1.5) and an anticipated non-response rate of 10%, the final sample size was 840 participants, consisting of 422 individuals in the intervention group and 418 individuals in the control group. For system-level outcomes (digital PWS quality), the unit of analysis was monthly Posyandu service sessions, resulting in 12 observations per group, aggregated across multiple Posyandu units.

A multistage sampling approach was used. First, villages were purposively selected based on readiness to implement the Integrated Primary Care Posyandu model and availability of

digital infrastructure. Second, all active Posyandu units within selected villages were included. Third, participants were selected using systematic random sampling from Posyandu registration lists to ensure representativeness across life-cycle groups. Inclusion criteria were: (1) residence in the study area for at least six months, (2) registration in Posyandu records, and (3) eligibility for preventive services. Exclusion criteria included incomplete baseline data or inability to participate in follow-up.

C. Intervention

The intervention consisted of the implementation of life-cycle–based Integrated Primary Care at Posyandu in the intervention villages. This model aimed to transform traditional Posyandu services into a comprehensive platform integrating promotive, preventive, and basic curative services across all age groups. Key components of the intervention included the reorganization of services based on life-cycle cohorts, training of community health workers and primary health care staff, implementation of standardized preventive service packages, and the adoption of digital tools for recording and reporting through the Local Area Monitoring (PWS) system. The intervention was conducted over a four-month period, supported by continuous supervision and technical assistance from local health authorities.

D. Variables and Measurement

The primary outcomes of this study were preventive service coverage and the quality of the digital Personal Wellness System (digital PWS). Preventive service coverage was defined as the proportion of eligible individuals who received essential preventive health services according to national health guidelines, including immunization, growth monitoring, and non-communicable disease screening. The quality of the digital PWS was assessed using a composite quality index comprising four predefined domains: completeness, timeliness, accuracy, and data consistency. Completeness was defined as the proportion of mandatory data fields that were successfully completed for each participant record. Timeliness referred to the proportion of preventive service records entered the digital system within 24 hours of service delivery. Accuracy was determined by comparing digital records with the corresponding source documents (paper-based records or direct observations) and was calculated as the percentage of records with no discrepancies. Data consistency represented the agreement of identical variables across different modules of the digital system and between repeated records, expressed as the percentage of records without internal inconsistencies.

Each domain was converted to a standardized score ranging from 0 to 100 using the formula *(observed value ÷ maximum possible value) × 100*. The four standardized domain scores were assigned equal weights (25% each) and averaged to generate an overall digital PWS quality index ranging from 0 to 100, with higher scores indicating better system performance. The equal weighting approach was selected because all four domains represent

complementary dimensions of data quality and no empirical evidence was available to justify differential weighting.

The main independent variable was exposure to the intervention (intervention versus control group). Additional covariates included age group, sex, education level, socioeconomic status, and baseline preventive service utilization.

E. Data Collection Procedures

Data were collected at two time points: baseline (September 2025) and endline (January 2026). Individual-level data on preventive service utilization were obtained through structured interviews and validated using Posyandu records. Data on digital PWS quality were extracted from routine health information systems and verified through direct observation and cross-checking with manual records. Data collectors received standardized training prior to data collection, and instruments were pilot tested in a non-study area to ensure reliability and clarity. To minimize selection bias, control villages were selected based on comparability with intervention villages. Information bias was reduced using standardized instruments and verification of recorded data. Confounding variables were controlled using multivariable regression models. In addition, the DiD analytical approach controlled for unobserved time-invariant differences between groups.

F. Statistical Analysis

Descriptive statistics were used to summarize baseline characteristics and study outcomes. Baseline differences between the intervention and control groups were assessed using Pearson's chi-square test for categorical variables and the independent-samples t-test for continuous variables.

The primary individual-level outcome, preventive service coverage (n = 840 participants), was analyzed using a difference-in-differences (DiD) regression model to estimate the intervention effect over time:

$$Y_{it} = \beta_0 + \beta_1 Treatment_i + \beta_2 Time_t + \beta_3 (Treatment_i \times Time_t) + \varepsilon_{it} \qquad (1)$$

where Treatment indicates assignment to the intervention group, Time represents the pre- and post-intervention measurements, and the interaction term (Treatment × Time) estimates the net intervention effect. Because participants were nested within villages, cluster-robust standard errors were applied only for the individual-level DiD analysis to account for intra-village correlation.

The secondary outcome, digital PWS quality, was measured at the session level (12 observations per study arm). Given the limited number of villages (six clusters), cluster-adjusted standard errors were not applied for this analysis because cluster-robust variance estimation is considered unreliable with a small number of clusters. Instead, digital PWS quality scores were summarized descriptively and compared between groups using

independent-samples t-tests (or the Mann–Whitney U test when normality assumptions were not met). Statistical significance was determined at a p-value of less than 0.05.

G. Ethical Considerations

Ethical approval for this study was obtained from an institutional review board. Informed consent was secured from all participants or their legal guardians prior to data collection. Participant confidentiality and data privacy were strictly maintained throughout the study.

Results and Discussions

A. Baseline Characteristics of Participants

A total of 840 participants were included in the analysis, comprising 422 individuals in the intervention group and 418 individuals in the control group. The distribution of participants across life-cycle groups was comparable between groups.

Table 1. Baseline characteristics of study participants

Characteristics	Intervention (n=422)	Control (n=418)	p-value
Mean age (years)	29.8 ± 18.6	30.2 ± 17.9	0.72
Female (%)	54.3	53.6	0.85
Children under five (%)	18.5	19.1	0.81
Adolescents (%)	15.2	14.8	0.88
Adults (%)	45.7	46.1	0.91
Older adults (%)	20.6	20.0	0.84
Low education (%)	41.2	42.5	0.68
Low socioeconomic (%)	37.8	38.6	0.79

The absence of statistically significant differences in baseline characteristics between the intervention and control groups indicates that both groups were comparable prior to the intervention. This comparability strengthens the internal validity of the study and supports the assumption that any observed differences at endline are likely attributable to the implementation of Integrated Primary Care (ILP) rather than pre-existing disparities.

B. Changes in Preventive Service Coverage

Preventive service coverage increased in both groups over time, with a greater improvement observed in the intervention group.

Table 2. Preventive service coverage before and after intervention

Group	Baseline (%)	Endline (%)	Change (%)
Intervention	62.4	82.7	+20.3
Control	63.1	70.2	+7.1

The observed increase in preventive service coverage in both groups suggests the presence of general temporal improvements, which may be influenced by broader health system strengthening efforts or seasonal program intensification. However, the substantially larger increase in the intervention group (+20.3 percentage points) compared to the control group (+7.1 percentage points) indicates a meaningful added effect of the intervention.

From a practical perspective, this magnitude of increase is highly relevant in community health settings, where even modest gains in preventive coverage can significantly reduce disease burden. The findings suggest that integrating services across the life course within Posyandu enhances accessibility and utilization of preventive services by reducing fragmentation and improving continuity of care.

C. Changes in Digital PWS Quality

The quality of digital Local Area Monitoring (PWS) improved significantly in the intervention group.

Table 3. Digital PWS quality index

Group	Baseline (Mean ± SD)	Endline (Mean ± SD)	Change
Intervention	65.2 ± 8.4	85.6 ± 6.7	+20.4
Control	66.1 ± 7.9	72.3 ± 7.5	+6.2

The marked improvement in the quality of digital Local Area Monitoring (PWS) in the intervention group (+20.4 points) reflects substantial enhancement in health information system performance. Improvements across completeness, timeliness, accuracy, and consistency indicate that the intervention not only increased service delivery but also strengthened data governance.

This is particularly important because high-quality routine data are essential for evidence-based decision-making at the primary care level. The relatively modest improvement observed in the control group suggests that digital system improvements do not occur automatically but require structured interventions, including training, supervision, and system integration.

D. Difference-in-Differences (DiD) Analysis

To estimate the association between the intervention and study outcomes over time, a difference-in-differences (DiD) regression model was applied. The DiD approach accounts for baseline differences between the intervention and control groups as well as common temporal trends, thereby providing an estimate of the differential change associated with the intervention.

For preventive service coverage, the statistically significant DiD coefficient (+13.2 percentage points) indicates that the intervention was associated with a greater increase in coverage compared with the control group over the study period. Likewise, the positive DiD estimate for digital PWS quality (+14.1 points) suggests that the intervention was associated with higher improvements in system-level performance than those observed in the control group. The narrow confidence intervals and statistically significant p-values ($p < 0.001$) indicate that these associations are unlikely to be explained by random sampling variation.

The findings suggest that integrating preventive service delivery with a digital health system may be associated with concurrent improvements in both preventive service coverage and digital data quality. However, because this study employed a non-randomized design involving only six villages, the results should be interpreted as associations rather than evidence of causality. Although the DiD approach reduces bias from baseline differences and common secular trends, unmeasured time-varying factors, contextual differences between villages, or other residual confounding may have influenced the observed associations. Therefore, the findings should be interpreted with appropriate caution.

Table 4. Difference-in-Differences (DiD) Estimates

Outcome	Coefficient (β3)	95% CI	p-value
Preventive service coverage	+13.2	9.5 – 16.9	<0.001
Digital PWS quality index	+14.1	10.2 – 18.0	<0.001

E. Subgroup Analysis

Subgroup analysis revealed that improvements in preventive service coverage were observed across all life-cycle groups, with the largest gains among older adults and adolescents.

Table 5. Preventive service coverage by life-cycle group (Intervention Group)

Life-Cycle Group	Baseline (%)	Endline (%)	Change (%)
Under five	70.2	88.5	+18.3
Adolescents	55.1	78.4	+23.3
Adults	60.3	81.2	+20.9
Older adults	58.7	83.9	+25.2

The subgroup analysis reveals that improvements in preventive service coverage were not limited to traditional target groups such as mothers and children but extended across all life stages. The largest gains among older adults and adolescents suggest that the life-course approach successfully addressed previously underserved populations. This finding is particularly significant, as older adults often face barriers to accessing preventive services, and adolescents are frequently overlooked in community-based health programs. By reorganizing services around life-cycle needs, the intervention appears to have improved equity in service delivery.

This study demonstrates that the implementation of life-cycle–based Integrated Primary Care (ILP) at Posyandu significantly improved both preventive service coverage and the quality of digital Local Area Monitoring (PWS) at the village level. Using a quasi-experimental difference-in-differences (DiD) approach, the intervention was associated with a net increase of 13.2 percentage points in preventive service coverage and a 14.1-point improvement in digital monitoring quality compared to control villages. These findings indicate that integrating service delivery across the life course, combined with strengthening digital health systems, can

produce measurable improvements in both service utilization and health information system performance within a relatively short implementation period [2], [10].

The findings of this study are consistent with global evidence highlighting the effectiveness of integrated primary health care in improving service coverage and health outcomes. The World Health Organization advocates for integrated, people-centered health services as a core strategy for achieving universal health coverage, particularly in resource-constrained settings. Previous studies in low- and middle-income countries have shown that community-based health platforms can increase access to preventive services; however, these interventions often focus on specific population groups, particularly maternal and child health [11], [12], [13].

In contrast, this study extends the evidence by demonstrating that a life-course approach can broaden service reach to adolescents, adults, and older populations, thereby improving equity in service delivery. In addition, while digital health interventions have been widely promoted, evidence on their integration with community-based service delivery remains limited. The observed improvements in digital PWS quality in this study support the growing body of literature suggesting that digitalization, when combined with system-level reforms and workforce capacity building, can enhance data quality and program accountability [14], [15], [16].

Several mechanisms may explain the observed effects. The reorganization of Posyandu services based on life-cycle cohorts likely reduced fragmentation and improved continuity of care, making services more accessible and relevant to diverse population groups. The integration of standardized preventive service packages may have improved service consistency and ensured that individuals received comprehensive care during each visit. This likely contributed to the observed increase in preventive service coverage [17], [18], [19].

The use of digital tools within the Local Area Monitoring (PWS) system enhanced real-time data recording, reduced reporting delays, and improved data accuracy. These improvements may have strengthened feedback loops between service providers and local health authorities, enabling more responsive and data-driven decision-making. Finally, capacity-building efforts for community health workers (kader) and health staff likely played a critical role in ensuring effective implementation, highlighting the importance of human resources in health system transformation [20], [21], [22].

This study has several strengths. The use of a quasi-experimental design with a difference-in-differences approach enhances causal inference by controlling for time-invariant unobserved confounding. The inclusion of both individual-level and system-level outcomes provides a comprehensive assessment of the intervention's impact. Furthermore, the study

captures real-world implementation in community settings, increasing the external validity and policy relevance of the findings [23], [24].

Conclusion

The implementation of life cycle based Integrated Primary Care (ILP) at Posyandu was associated with significant improvements in preventive service coverage and the quality of digital Local Area Monitoring (PWS) at the village level. These findings highlight the effectiveness of integrating service delivery across the life course with digital health system strengthening in enhancing primary health care performance. The study contributes to the growing evidence that community-based integrated care models can simultaneously improve service utilization and data quality, which are critical for responsive and accountable health systems. The results also demonstrate the practical relevance of aligning local health service innovations with global strategies promoted by the World Health Organization.

Scaling up this approach may support more equitable and efficient delivery of preventive services, particularly in resource-limited settings. However, sustained impact will depend on continued investment in workforce capacity, digital infrastructure, and implementation quality. Further research is warranted to examine long-term outcomes, cost-effectiveness, and scalability across diverse contexts.

Limitation and Suggestions

Despite these strengths, several limitations should be acknowledged. First, the non-randomized design may still be subject to residual confounding, although efforts were made to select comparable control groups and adjust for key covariates. Second, the relatively short follow-up period limits the ability to assess the long-term sustainability of the observed improvements. Behavioral changes and system strengthening effects may evolve over time. Third, variations in implementation fidelity across villages, including differences in local leadership, community engagement, and digital infrastructure, may have influenced the results. These contextual factors were not fully captured in the analysis. Finally, measurement of digital PWS quality relied partly on routine data systems, which may still be subject to reporting bias despite verification efforts.

Future studies should consider longer follow-up periods to assess sustainability and potential long-term health outcomes. Randomized or stepped-wedge designs could further strengthen causal inference. In addition, qualitative research exploring implementation processes, user experiences, and contextual factors would provide deeper insights into how and why the intervention works. Further research is also needed to evaluate cost-effectiveness and scalability across different regions.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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