K-Means Segmentation of Family Planning Service Capacity by Area and Couple Workloads: Association with Unmet Need in North Sumatra

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Abstract

Disparities in family planning (FP) unmet need across the regencies and cities of North Sumatra call for segmentation-based policy, yet service workload is commonly measured only as the number of couples of reproductive age (CRA) per worker. This study segments 33 regencies/cities using four service-load ratios, namely couples per FP field worker, villages per field worker, couples per health facility, and villages per health facility, with K-Means clustering, and tests the association of the segments with unmet need, modern contraceptive prevalence (mCPR), and contraceptive prevalence (CPR). Secondary 2025 data came from the BKKBN Family Information System and Statistics Indonesia. Features were log-transformed and Min-Max normalised; the number of clusters was selected using the Davies-Bouldin Index; stability was assessed with the Adjusted Rand Index; and external validation used Kruskal-Wallis tests with Bonferroni correction, complemented by a feature ablation study and a data-source sensitivity analysis. Four stable clusters were identified (Silhouette 0.398; DBI 0.774; ARI 0.97), consistent with official geographic categories (Cramér's V 0.55). The ablation study shows that segmentation based on area workload is strongly associated with unmet need, mCPR, and CPR ($p \leq 0.004$; ε^2 0.36–0.42), whereas segmentation based on couple workload is not ($p \geq 0.18$). The association of area workload with contraceptive use is consistent with the 2025 Family Data Update, whereas its association with unmet need depends on the data source. Field worker and health facility allocation should therefore account for the number of villages served, not only the number of couples.

Keywords*:* K-Means Clustering; Family Planning Field Worker Workload; Health Facilities; Unmet Need; Ablation Study

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2nd International Conference on Islamic Community Studies (ICICS)
Theme: History of Malay Civilisation and Islamic Human Capacity and Halal Hub in the Globalization Era
https://proceeding.pancabudi.ac.id/index.php/ICIE/index

Introduction

Universal access to reproductive health services, including family planning (FP), is target 3.7 of the Sustainable Development Goals (SDGs) [1] . One of the main indicators of progress towards this target is FP unmet need, defined as the condition of women of reproductive age who wish to postpone or stop childbearing but are not using any contraceptive method [2]. On Sumatra Island, unmet need forms a pattern of spatial clustering, and 20 of the 27 hotspot regencies/cities are located in North Sumatra Province [3]. In 2025, regency/city-level unmet need in the province ranged from 3.31% to 16.16%, so a uniform policy for all areas is inadequate.

The determinants of unmet need are generally examined from the demand side, such as attitudes, social support, and the socio-economic characteristics of couples. However, access to quality services and information has also been shown to be related to unmet need [4]. This access is determined by two supply-side components: FP field workers (PKB/PLKB), who carry out counselling and mobilisation, and health facilities, which provide contraceptive services. Visits by field workers are associated with approximately threefold higher odds of intending to use contraception among women not yet using a method [5], and contraceptive provision by community-based workers is effective when supported by training and supervision [6].

A key challenge is the limited number of field workers relative to the number of villages they serve; a case study in Cianjur Regency reported one field worker covering two to three villages at once [7]. In North Sumatra, 1,588 field workers serve 6,113 villages (*desa/kelurahan*) and 1,731,743 couples of reproductive age (CRA; hereafter "couples"), with the ratio of villages per field worker across regencies/cities ranging from 1.0 to 12.1. In programme planning, field worker workload is generally expressed as the number of couples per field worker. This measure ignores the spatial dimension, namely the number of villages that must be reached. Empirical findings on the role of distance are also inconsistent; proximity to a facility is not associated with modern contraceptive use in a dense urban setting [8]. Thus, which workload dimension is more relevant to programme outcomes remains an open question, particularly in areas with high geographic diversity.

On the technical side, clustering has been applied in FP programmes, including K-Means to group sub-districts by the characteristics underlying unmet need [9], K-Medoids to group sub-districts by contraceptive type [10], and K-Means to group villages by long-acting contraceptive use [11] . These studies focus on demand characteristics and contraceptive use patterns. No study has yet been found that (a) builds a regional segmentation from supply-side service-capacity workload, (b) separates this workload into an area dimension and a couple dimension, and (c) tests the relevance of the segmentation to programme outcomes through external validation.

This study aims to segment the 33 regencies/cities of North Sumatra by FP field worker workload and health facility service load using K-Means clustering, and to test the association of the resulting segments with unmet need, the modern contraceptive prevalence rate (mCPR), and the contraceptive prevalence rate (CPR). The contributions of this study are: (1) a two-dimensional service-workload feature framework, namely area workload (villages per field worker, villages per facility) and couple workload (couples per field worker, couples per facility); (2) an external validation procedure free of circularity because programme outcome variables are not used as features, complemented by solution stability tests; and (3) a feature ablation study and a data-source sensitivity analysis that identify the decisive workload dimension, as an empirical basis for field worker and facility allocation policy.

Literature Review

2.1 Unmet Need and Supply-Side Service Capacity

Unmet need is divided into unmet need for spacing, the desire to postpone the next birth, and unmet need for limiting, the desire to have no more children, among women not using contraception [2]. The indicator reflects the gap between people's needs and the ability of the service system to reach them. The demand side (knowledge, attitudes, social norms) and the supply side (availability of personnel, facilities, and information) jointly determine the level of unmet need [4].

On the supply side, FP field workers are responsible for counselling, mobilising prospective acceptors, and data collection and monitoring. Outreach by workers has been shown to be related to intention to use FP [5], while services provided by community-based workers are effective when supported by supervision [6]. A village-level case study shows that the limited number of field workers leads to one worker covering several villages at once, and that some monitoring activities have not been carried out [7]. Health facilities complement this role by providing contraceptive methods, including those that require a medical procedure such as implants, IUDs, and sterilisation.

2.2 Area Workload and Couple Workload

Service-capacity workload can be viewed from two dimensions. **Couple workload** measures the number of CRA, the target group of the FP programme, to be served per service unit, for example couples per field worker or couples per facility. This differs from target workload, namely PPM-PA (*Perkiraan Permintaan Masyarakat – Peserta KB Aktif*), an Indonesian programme term for the estimated demand for active FP users that is set as a performance target. **Area workload** measures the geographic coverage per service unit, for example the number of villages per field worker or per facility; it therefore counts administrative villages to be reached, not land area. The two dimensions do not always move together: urban areas may have a high couple workload but a low area workload, whereas mountainous and island areas may have few couples per field worker but many villages to cover. Evidence on the effect of geographic proximity on contraceptive use is also inconsistent and depends on the regional context [8]. Therefore, the two dimensions need to be modelled separately so that the contribution of each can be identified.

2.3 K-Means Clustering and Cluster Validation

K-Means is a partitional clustering algorithm that groups objects by proximity to centroids by minimising the within-cluster sum of squares [12], [13] . The k-means++ initialisation selects initial centroids probabilistically based on distance, thereby reducing the risk of converging to a local optimum [14]. Cluster quality is generally evaluated with internal validity indices such as the Silhouette and the Davies-Bouldin Index (DBI) [12]. Internal indices only assess the geometric structure of clusters; the substantive relevance of a segmentation requires external validation against variables not used to form the clusters.

Table 1 summarises relevant previous studies.

Table 1. Relevant previous studies

Study	Units and variables	Method	Gap relative to this study
Mukti and Prabawa [3]	131 regencies/cities of Sumatra; unmet need 2022	Moran's I, LISA	Spatial pattern of unmet need without service-capacity variables
Pramudiyanti et al. [9]	25 sub-districts; causes of unmet need	K-Means	Demand-side variables; internal validation
Sahri et al. [10]	18 sub-districts; contraceptive types	K-Medoids PAM	Contraceptive use patterns; no unmet need
Rahmad et al. [11]	90 villages; long-acting method use	K-Means	Contraceptive use patterns; no unmet need
This study	33 regencies/cities of North Sumatra; four service-workload ratios	K-Means, ablation, external validation	—

Research Methodology

This study uses a quantitative cross-sectional design with the 33 regencies/cities of North Sumatra Province in 2025 as the unit of analysis. The research stages comprise (1) data compilation, (2) feature construction, (3) preprocessing, (4) clustering and selection of the number of clusters, (5) stability testing, (6) external validation, (7) feature ablation, and (8) data-source sensitivity analysis.

3.1 Data Sources and Variables

FP programme data were obtained from the records of the BKKBN Representative Office of North Sumatra Province through the Family Information System (SIGA), as of 31 December 2025 [15]; operational definitions follow the SIGA routine FP service data metadata [16]. The number of CRA and active FP users by contraceptive method were taken from SIGA Table 11 and form the basis for calculating CPR and mCPR. The number of couples with unmet need was taken from SIGA Table 16, namely non-user couples who wish to postpone childbearing or want no more children, whether pregnant or not, with a provincial value of 9.36%. The number of health facilities (1,429) was taken from SIGA Table 1 and includes FP facilities, independent midwife practices equivalent to facilities, and registered networks. The number of field workers (1,588) was taken from SIGA Tables 2A and 3A and includes PKB/PLKB with civil servant status (PNS and PPPK). The number of villages (6,113, including Transmigration Settlement Units) refers to BPS Head Decree No. 750 of 2025 as amended by BPS Head Decree No. 135 of 2026 [17], [18]. All 33 regencies/cities have complete data with no missing values.

mCPR was calculated as all active users of modern methods, namely injectables, pills, condoms, implants, IUDs, female sterilisation (MOW), male sterilisation (MOP), and the lactational amenorrhoea method (LAM), divided by the number of CRA, in line with the SIGA classification of modern methods and the standard definition [19]; the provincial value is 60.84%. Sterilisation is included because field workers and facilities, the objects of the workload measurement, also serve these methods. CPR was calculated as all active users divided by CRA (61.25%). SIGA unmet need (9.36%) is lower than the 2025 Family Data Update (PK-2025) value of 22.52% [20]. The difference stems from the type of data and the calculation method: SIGA consists of routine service records, whereas PK-2025 is a household-visit family enumeration that follows the classification of unmet need for spacing and for limiting [2]. SIGA data are used as the main source so that all indicators come from the same system and period as the workload variables, while PK-2025 is used in the sensitivity analysis (Subsection 3.8). The data are part of the 2025 North Sumatra FP programme data compilation that was also used in the author's thesis on the same 33 regencies/cities, but with a different objective (comparison of the K-Means and K-Medoids PAM algorithms), different clustering variables (distribution of five contraceptive types per couple and unmet need), and a different

research question. In this study, unmet need is not used as a feature but as an external validation variable.

Regional categories by location and natural conditions were taken from the official grouping of the North Sumatra Provincial Government, namely West Coast (7), Highlands (9), East Coast (12), and Nias Islands (5) [21]. The research variables are summarised in Table 2.

Table 2. Research variables

Role	Variable	Operational definition	Dimension
Feature	Couples/Worker	Number of CRA ÷ number of PKB+PLKB	Couple workload
Feature	Villages/Worker	Number of villages ÷ number of PKB+PLKB	Area workload
Feature	Couples/Facility	Number of CRA ÷ number of facilities	Couple workload
Feature	Villages/Facility	Number of villages ÷ number of facilities	Area workload
Main validation	Unmet need (%)	Unmet need (SIGA Table 16) ÷ CRA × 100	Outcome
Main validation	mCPR (%)	Modern-method users including MOW, MOP, and LAM ÷ CRA × 100	Outcome
Main validation	CPR (%)	All active users ÷ CRA × 100	Outcome
Exploratory	Active-user attainment (%)	Active users ÷ estimated demand for active users (PPM-PA) × 100	Outcome

3.2 Preprocessing

All four features are positively skewed (skewness 0.29–1.39). A logarithmic transformation was applied to dampen the influence of extreme values, followed by Min-Max normalisation to the range [0, 1] so that each feature contributes equally to the Euclidean distance [22]:

$$z_{ij} = \ln(1 + x_{ij}), \qquad x'_{ij} = \frac{z_{ij} - \min_i z_{ij}}{\max_i z_{ij} - \min_i z_{ij}}$$

The transformation reduced the skewness of Couples/Worker from 0.90 to 0.14, Villages/Worker from 1.39 to 0.21, and Couples/Facility from 1.39 to 0.08. Villages/Facility, whose skewness was already low (0.29), became slightly negatively skewed (−0.55); the transformation was nevertheless applied uniformly to all four features, and the effect of this choice is tested in Subsection 4.5.

3.3 K-Means Algorithm

K-Means minimises the sum of squared distances of each object to its cluster centroid [13]:

$$J = \sum_{k=1}^{K} \sum_{x_i \in C_k} \| x_i - \mu_k \|^2$$

where C_k is the set of members of cluster k and μ_k is its centroid. Initialisation uses k-means++ [14] with n_init = 1,000, max_iter = 300, Euclidean distance, and random_state = 42.

3.4 Determining the Number of Clusters

Values of K = 2 to 6 were evaluated using the within-cluster sum of squares (WCSS), the Silhouette [23], and the DBI [24]:

$$s(i) = \frac{b(i) - a(i)}{\max\{a(i),\, b(i)\}}, \qquad \text{DBI} = \frac{1}{K}\sum_{k=1}^{K} \max_{l \neq k} \frac{S_k + S_l}{M_{kl}}$$

where a(i) is the mean distance of object i to members of its own cluster, b(i) is the smallest mean distance to another cluster, S_k is the within-cluster dispersion of cluster k, and M_{kl} is the distance between centroids. The decision rule was set before interpretation: K is chosen by the smallest DBI, provided that the Silhouette is ≥ 0.35 and every cluster has at least three regencies/cities so that between-cluster tests can be performed. Clusters were named after their feature profiles were obtained, not on the basis of geographic assumptions.

3.5 Stability Testing

Solution stability was tested by repeating the clustering with 50 different random seeds and with a leave-one-out procedure 33 times, including recomputing the normalisation. Similarity to the main solution was measured with the Adjusted Rand Index (ARI) [25]. In the random seed test, n_init was set to 10 so that the sensitivity of the solution to initialisation remains observable.

3.6 External Validation

Differences in unmet need, mCPR, and CPR between clusters were tested with the Kruskal-Wallis test [26] because the clusters are small. Effect size was calculated as epsilon-squared [27]:

$$\varepsilon^2 = \frac{H - k + 1}{n - k}$$

The three outcomes were treated as one family of tests with Bonferroni correction (α = 0.05/3 = 0.0167); active-user attainment is reported as an exploratory analysis. Pairwise post hoc comparisons used Dunn's test [28] with Holm adjustment [29]. The association of each feature with the outcomes was measured with Spearman correlation. Agreement between cluster membership and regional categories was tested with a Monte Carlo permutation chi-square test (5,000 iterations) and Cramér's V.

3.7 Feature Ablation Study

Clustering was repeated with an identical procedure (K = 3 and K = 4) on five feature configurations: four features (main model), area workload only, couple workload only, field workers only, and facilities only. Each configuration was evaluated by the Silhouette, the DBI, the Kruskal-Wallis p-value, and ε^2 for the three outcomes.

3.8 Data-Source Sensitivity Analysis

External validation and the ablation study were repeated using unmet need, mCPR, and CPR from PK-2025 [20] to assess whether the findings depend on the source and calculation method of the indicators. In addition, CRA in the couples-per-worker and couples-per-facility features was replaced with PPM-PA, the active-user target calculated as projected CRA multiplied by the mCPR target of each regency/city [30], to assess whether target workload yields a segmentation different from couple workload.

3.9 Tools and Limitations

The analysis was conducted in Python 3 (scikit-learn, SciPy, pandas, matplotlib, seaborn). The cross-sectional design with n = 33 allows only associative inference at the aggregate regional level, so the results are not interpreted as causal relationships or generalised to the individual level.

Results and Discussion

4.1 Data Characteristics

Service-workload ratios vary widely across regencies/cities. Couples per field worker range from 358 to 2,824 (mean 1,124), villages per field worker from 1.0 to 12.1 (mean 4.3), couples per facility from 364 to 3,361 (mean 1,218), and villages per facility from 0.5 to 12.1 (mean 5.6). On the outcome side, unmet need ranges from 3.31% to 16.16% (mean 9.30%), mCPR from 45.39% to 76.45% (mean 58.85%), and CPR from 45.66% to 76.63% (mean 59.30%).

4.2 Number of Clusters and Stability

The evaluation of K = 2 to 6 is presented in Table 3 and Figure 1. The highest Silhouette was obtained at K = 3 (0.402), whereas the lowest DBI was obtained at K = 4 (0.774) with an almost equal Silhouette of 0.398. In accordance with the decision rule, K = 4 was selected because it has the smallest DBI, meets the Silhouette ≥ 0.35 requirement, and every cluster has at least four regencies/cities.

Table 3. Evaluation of the number of K-Means clusters

K	WCSS	Silhouette	DBI	Smallest cluster
2	5.797	0.355	1.152	15
3	3.338	0.402	0.885	8
4	**2.540**	**0.398**	**0.774**	**4**
5	1.973	0.382	0.815	4
6	1.677	0.350	0.897	4

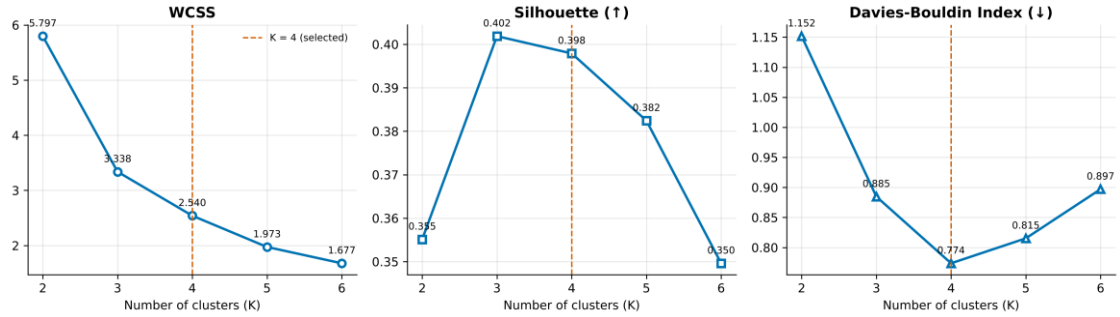


Figure 1. WCSS, Silhouette, and Davies-Bouldin Index for K = 2 to 6

The K = 4 solution is stable. Across 50 random seeds, the mean ARI relative to the main solution is 0.966 (median 1.00), and 86% of the repetitions produce identical membership. In the leave-one-out test, the mean ARI is 0.953 (median 1.00; minimum 0.629). A Silhouette of 0.398 falls within the range of weak structure (0.26–0.50) according to Kaufman and Rousseeuw [31], so the boundaries between clusters are not sharp and several regencies lie close to a cluster boundary, notably Simalungun (individual Silhouette 0.01). Therefore, the adequacy of the segmentation is not based on internal indices alone but also on stability and external validation.

4.3 Cluster Profiles

The mean profiles of the four clusters are presented in Table 4 and Figure 2. Clusters are named after their most distinguishing features.

Table 4. Mean profiles of the K-Means clusters (K = 4)

Cluster	n	Couples/ Worker	Villages/ Worker	Couples /Facility	Villages /Facility	Unmet need (%)	mCPR (%)	CPR (%)
C1 Very high area workload	4	1,459	9.40	1,264	8.36	11.77	52.56	53.12
C2 High facility-based area workload	14	540	4.47	1,028	8.07	10.34	55.49	56.02
C3 High couple workload	7	2,021	3.78	2,151	4.16	9.16	63.03	63.32
C4 Low workload (urban)	8	1,194	1.77	709	1.18	6.36	64.22	64.63

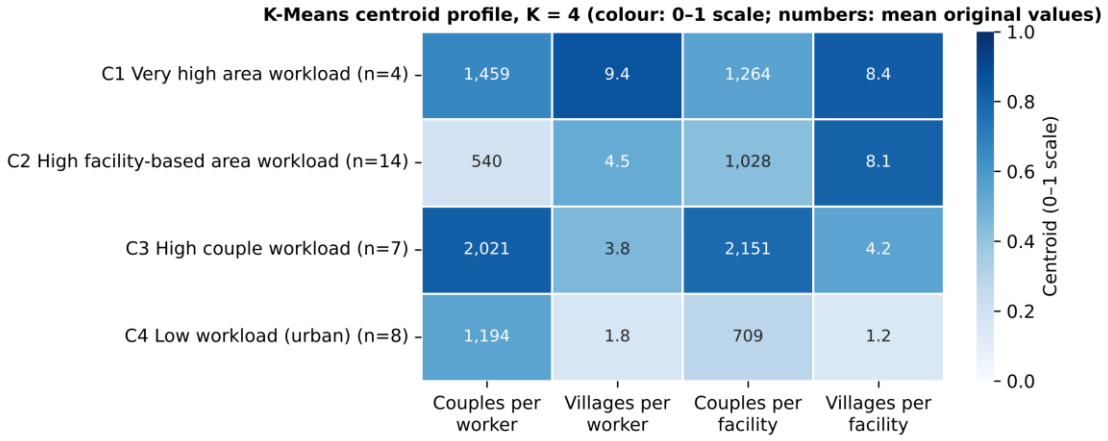


Figure 2. K-Means centroid profile for K = 4 (colour: normalised values; numbers: mean original values)

C1 (Nias, Karo, Dairi, and Gunungsitoli City) has the highest number of villages per field worker, a mean of 9.4 (6.7–12.1), more than twice the regency/city mean (4.3). C2 (14 regencies in the Highlands, the West Coast, and the Nias Islands) has the lowest couples-per-worker ratio, but each facility serves a mean of 8.1 villages. The C2 label reflects that its area workload is driven mainly by health facilities: villages per field worker (4.47) is close to the mean, whereas villages per facility is almost equal to C1 (8.07 and 8.36). C3 (Langkat, Deli Serdang, Asahan, Serdang Bedagai, Batu Bara, South Labuhanbatu, and North Labuhanbatu) has the highest couple workload, both per field worker and per facility, with a moderate area workload. C4 (Labuhanbatu and seven cities) has the lowest area and facility workload.

Cluster membership is strongly associated with the official regional categories (χ^2 = 30.02; Monte Carlo p = 0.0006; Cramér's V = 0.55). All members of C3 are on the East Coast, whereas all members of C1 and C2 are in the Highlands, the West Coast, and the Nias Islands. This agreement shows that a segmentation built solely from service-workload ratios captures the geographic character of the regions without using geographic information as a feature.

4.4 External Validation

The Kruskal-Wallis results are presented in Table 5 and Figure 3. All three outcomes differ between clusters at the 0.05 level, with moderate to large effect sizes (ε^2 0.17–0.24). However, after Bonferroni correction, no outcome reaches significance for the four-feature model. Active-user attainment does not differ between clusters (p = 0.37).

Table 5. External validation of the four-feature model (K = 4)

Outcome	H	p	Bonferroni p	ε^2
Unmet need	8.04	0.045	0.135	0.17
mCPR	10.02	0.018	0.055	0.24
CPR	9.73	0.021	0.063	0.23
Active-user attainment (exploratory)	3.17	0.366	—	0.01

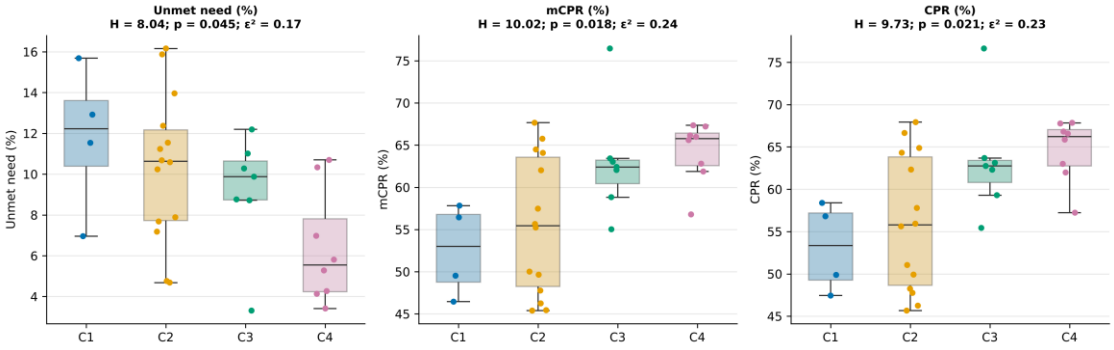


Figure 3. Distribution of unmet need, mCPR, and CPR by cluster

Dunn's test with Holm adjustment shows that the largest differences lie between C1 and C2 on the one hand and C4 on the other (Holm p 0.06–0.09), although no pair is significant at $\alpha = 0.05$. The mean pattern shows a consistent gradient: unmet need decreases and contraceptive use increases from C1 to C4. Importantly, C3, with the highest couple workload, has an mCPR (63.0%) and unmet need (9.2%) close to those of C4, whereas C1, with the highest area workload, has the lowest outcomes.

Feature-level Spearman correlations reinforce this pattern (Table 6). Both area-workload features correlate positively with unmet need and negatively with mCPR and CPR, whereas neither couple-workload feature correlates significantly with any outcome.

Table 6. Spearman correlations between features and outcomes (n = 33)

Feature	Unmet need	mCPR	CPR
Villages/Worker	0.49**	−0.52**	−0.53**
Villages/Facility	0.42*	−0.41*	−0.41*
Couples/Worker	−0.18	0.33	0.31
Couples/Facility	0.10	0.11	0.11

Note: * $p < 0.05$; ** $p < 0.01$.

4.5 Feature Ablation Study

The ablation study tests which workload dimension determines the association between the segmentation and programme outcomes (Table 7 and Figure 4). Segmentation using area workload only yields a Silhouette of 0.426 and a DBI of 0.742, although internal indices of configurations with different feature spaces cannot be compared directly, and is strongly associated with all three outcomes, all of which pass the Bonferroni correction ($p \leq 0.004$; ε^2 0.36–0.42). In contrast, segmentation using couple workload only is not associated with any outcome ($p \geq 0.18$; $\varepsilon^2 \leq 0.06$). The facilities-only configuration is also strongly associated, but its strength stems from the villages-per-facility component, since couples per facility does not correlate with the outcomes (Table 6). The comparison of area workload with couple workload is the main contrast according to the research hypothesis; if all fifteen tests in Table 7 are corrected jointly ($\alpha = 0.0033$), mCPR and CPR for the area-workload configuration remain significant, whereas unmet need ($p = 0.0039$) lies just above the threshold. The same pattern is obtained without the logarithmic transformation: area workload alone is associated with all three outcomes ($p \leq 0.006$), whereas couple workload alone is not ($p \geq 0.13$).

Table 7. Feature ablation study (K = 4)

Configuration	Silhouette	DBI	p unmet need	p mCPR	p CPR
Four features (main model)	0.398	0.774	0.045	0.018	0.021
Area workload only	0.426	0.742	**0.004**	**0.002**	**0.002**
Couple workload only	0.383	0.812	0.433	0.186	0.202
Field workers only	0.406	0.758	0.250	0.039	0.045
Facilities only	0.479	0.622	**0.009**	**0.003**	**0.004**

Note: bold indicates passing the Bonferroni correction ($p < 0.0167$).

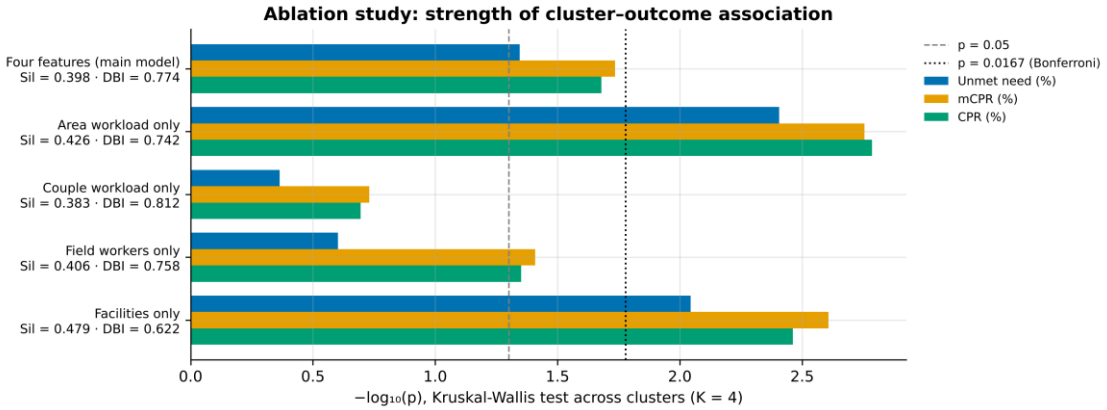


Figure 4. Strength of the cluster–outcome association for each feature configuration ($-\log_{10} p$ of the Kruskal-Wallis test, K = 4)

4.6 Sensitivity to the Data Source

Table 8 presents the re-validation with PK-2025 outcomes. For contraceptive use, the main finding is replicated and even strengthened. The four-feature model is associated with the PK-2025 mCPR and CPR and passes the Bonferroni correction ($p = 0.003$ and 0.004), area workload remains associated ($p \leq 0.007$), and couple workload remains unassociated ($p \geq 0.36$). For unmet need, the association weakens ($p = 0.083$ for the area-workload model) and the ordering of cluster means changes. This is consistent with the only moderate rank correlation between SIGA and PK-2025 unmet need ($\rho = 0.43$).

Table 8. Validation with PK-2025 outcomes (K = 4)

Configuration	p unmet need	p mCPR	p CPR
Four features (main model)	0.044	**0.003**	**0.004**
Area workload only	0.083	**0.006**	**0.007**
Couple workload only	0.621	0.369	0.356

Replacing CRA with PPM-PA produces a segmentation similar to the main model (ARI 0.62; identical cluster sizes of 14/8/7/4) with slightly lower cluster quality (Silhouette 0.368; DBI 0.832), because PPM-PA per field worker correlates very strongly with couples per field worker ($\rho = 0.96$). However, segmentation using PPM-PA target workload alone is associated with mCPR and CPR ($p \leq 0.006$), whereas segmentation using couple workload alone is not ($p \geq 0.18$). This difference more likely reflects outcome information embedded in the target than workload. The mCPR target underlying PPM-PA correlates strongly with the actual 2025 mCPR ($\rho = 0.72$; $p < 0.001$) and with unmet need ($\rho = -0.62$; $p < 0.001$), so target workload carries programme outcome information and introduces circularity when used as a feature. This link is also built into the design, because the target-setting letter directs the distribution of PPM to field workers with attention to unmet need and projected deliveries in each sub-district [30].

Discussion

The main finding of this study is that area workload, not couple workload, is associated with FP programme outcomes. Regions with many villages per field worker and per facility have lower contraceptive use and higher unmet need, whereas the number of couples per field worker is unrelated to outcomes. This pattern is in line with the report that field workers covering several villages at once cannot carry out all monitoring activities [7], and that visits by workers are related to intention to use FP [5]. The presumed mechanism is that when one field worker must reach a mean of 9.4 villages in mountainous and island areas, the likelihood of reaching each couple decreases even though the number of couples served is not large. This mechanism has not been tested directly because the frequency of field worker visits was not measured in this study.

This finding also clarifies seemingly contradictory results in the literature. Proximity to a facility is not associated with contraceptive use in a dense urban setting [8], but this study shows that in regions with high geographic diversity, area coverage per service unit becomes an important differentiator. The positive correlation between couples per field worker and mCPR ($\rho = 0.33$) is not significant and is formed mainly by the East Coast regencies (C3), which have the highest couple workload as well as high mCPR; without the East Coast, the correlation practically disappears ($\rho = 0.03$).

Methodologically, previous studies on clustering in FP programmes evaluated segmentation mainly with internal validity indices [9], [10], [11]. This study shows that external validation and an ablation study provide information that cannot be obtained from internal indices. The four-feature model has adequate internal quality, but its association with outcomes does not survive multiple-comparison correction, whereas the area-workload model has a much stronger external association. The sensitivity analysis adds a layer of caution: the association of area workload with contraceptive use is consistent across two data sources, whereas its association with unmet need depends on the operational definition and data source.

The policy implication is that the deployment of field workers and facilities should take into account the number of villages served, not only the number of couples. Regencies/cities in C1 (Nias, Karo, Dairi, and Gunungsitoli City) are priorities for additional field workers or for restructuring of service areas. C2 requires wider service reach, for example mobile services and stronger facility networks, because the field worker ratio is already relatively adequate but each facility serves many villages. In C3, the high couple workload is not accompanied by low outcomes, so these results provide no basis for prioritising additional personnel there; allocation decisions still require consideration of actual workload.

Active-user attainment relative to PPM-PA does not differ between clusters ($p = 0.37$) and does not correlate with any workload feature ($|\rho| \leq 0.25$; $p \geq 0.17$). It also does not correlate with mCPR ($\rho = 0.17$; $p = 0.35$) or unmet need ($\rho = -0.07$; $p = 0.71$), even though area workload is associated with both indicators. This indicates that target-based performance measures do not yet capture the gaps determined by area workload, because PPM targets are derived from projected CRA and the mCPR target of each regency/city [30] without accounting for the number of villages served. PPM target setting and field worker performance assessment should take the number of villages served into account.

This study has several limitations. The number of villages per service unit is a proxy for area coverage and does not yet reflect land area, travel time, or infrastructure conditions. The cross-sectional design with $n = 33$ limits conclusions to aggregate-level associations. The quality and actual workload of field workers, such as additional duties outside the FP programme, were not measured. PPM-PA was not used as a feature because the underlying mCPR target correlates strongly with the outcomes ($\rho = 0.72$); replacing CRA with PPM-PA produces a similar segmentation (ARI 0.62).

Conclusion

Segmenting the 33 regencies/cities of North Sumatra by four FP service-capacity workload ratios yields four stable clusters consistent with the official geographic categories, namely very high area workload, high facility-based area workload, high couple workload, and low (urban) workload. Unmet need decreases and contraceptive use increases as area workload, not couple workload, decreases. The ablation study confirms this finding: segmentation based on villages per field worker and per facility is strongly associated with unmet need, mCPR, and CPR, whereas segmentation based on couples per field worker and per facility is not. The association of area workload with contraceptive use is consistent across two data sources, whereas its association with unmet need depends on the data source and the operational definition of the indicator.

In practice, the allocation of FP field workers and the strengthening of health facilities should consider the number of villages served as a workload measure alongside the number of couples, with priority given to Nias, Karo, Dairi, and Gunungsitoli City. Methodologically, this study shows that external validation, an ablation study, and a data-source sensitivity analysis strengthen the interpretation of clustering on public programme data. Future research is recommended to use more direct accessibility measures, such as travel time or a geographic difficulty index, to incorporate the actual workload of field workers, and to apply a longitudinal design to assess changes in segments over time.

References

[1] United Nations, "Transforming our world: The 2030 Agenda for Sustainable Development," 2015. Accessed: Oct. 20, 2026. [Online]. Available: https://sdgs.un.org/2030agenda

[2] S. E. K. Bradley, T. N. Croft, J. D. Fishel, and C. F. Westoff, "Revising unmet need for family planning (DHS Analytical Studies No. 25)," Maryland, 2012. [Online]. Available: www.measuredhs.com

[3] D. A. Mukti and A. Prabawa, "Autokorelasi Spasial Unmet Need Keluarga Berencana di Pulau Sumatera Tahun 2022," *Media Publikasi Promosi Kesehatan Indonesia*, vol. 7, no. 5, pp. 1220–1225, May 2024, doi: 10.56338/mppki.v7i5.5060.

[4] W. D. D. Kartika, "Faktor yang Memengaruhi Unmet Need Keluarga Berencana," *Jurnal Biometrika dan Kependudukan*, vol. 4, no. 1, pp. 70–75, 2014.

[5] A. Kumar *et al.*, "Health workers' outreach and intention to use contraceptives among married women in India," *BMC Public Health*, vol. 20, no. 1, Jun. 2020, doi: 10.1186/s12889-020-09061-1.

[6] B. E. Ayuk, B. M. Yankam, F. I. Saah, and L. E. Bain, "Provision of injectable contraceptives by community health workers in sub-Saharan Africa: a systematic review of safety, acceptability and effectiveness," *Hum. Resour. Health*, vol. 20, no. 1, Dec. 2022, doi: 10.1186/s12960-022-00763-8.

[7] S. Sulastri, H. Krisnani, D. Puspita Sari, R. Ekawati, P. K. Penelitian dan Pengembangan dan KS BKKBN, and P. Pelatihan dan Pengembangan Perwakilan BKKBN Provinsi Jawa Barat, "PENANGANAN UNMET NEED KB DI KAMPUNG KB: STUDI KASUS DI DUA KAMPUNG KB DI KABUPATEN CIANJUR (HANDLING UNMET NEED FOR FAMILY PLANNING IN KAMPUNG KB: A CASE STUDY IN TWO KAMPUNG KB IN CIANJUR REGENCY)," *Jurnal Kependudukan Indonesia* |, vol. 14, no. Desember, pp. 119–136, 2019.

[8] S. Babazadeh, J. Hernandez, P. Anglewicz, and J. Bertrand, "The relationship between spatial access and modern contraceptive use: is proximity to a healthcare facility a determinant of use among women in Kinshasa, DRC?," *Gates Open Res.*, vol. 5, p. 80, May 2021, doi: 10.12688/gatesopenres.13229.1.

[9] A. P. Pramudiyanti, M. F. Shafiro, L. A. Salim, and Wasyik, "K-Means Cluster Analysis Related to Unmet Need for Family Planning in Banyuwangi, Indonesia: A Case Study," *Journal of Public Health Research and Community Health Development*, vol. 7, no. 2, pp. 136–142, Mar. 2024, doi: 10.20473/jphrecode.v7i2.39691.

[10] A. E. Sahri, W. D. Utami, and A. Hamid, "Implementasi K-Medoids Clustering Dalam Pengelompokkan Jenis Alat Kontrasepsi Berdasarkan Kecamatan di Kabupaten Sidoarjo," *Jurnal Ilmiah Komputasi*, vol. 23, no. 2, Jun. 2024, doi: 10.32409/jikstik.23.2.3567.

[11] R. Rahmad, S. Defit, and R. Sovia, "Analisis Data Mining dengan Metode K-Means Clustering Dalam Pengelompokan Penggunaan Alat Kontrasepsi," *Bulletin of Computer Science Research*, vol. 5, no. 5, pp. 1174–1181, Aug. 2025, doi: 10.47065/bulletincsr.v5i5.750.

[12] J. Han, M. Kamber, and J. Pei, *Data Mining: Concepts and Techniques*, 3rd ed. Waltham: Morgan Kaufmann Publishers, 2012.

[13] A. K. Jain, "Data Clustering: 50 Years Beyond K-Means," *Pattern Recognit. Lett.*, vol. 31, no. 8, pp. 651–666, 2010, doi: 10.1016/j.patrec.2009.09.011.

[14] D. Arthur and S. Vassilvitskii, "k-means++: The Advantages of Careful Seeding," in *Proceedings of the Eighteenth Annual ACM-SIAM Symposium on Discrete Algorithms*, Society for Industrial and Applied Mathematics (SIAM), 2007, pp. 1027–1035.

[15] Kementerian Kependudukan dan Pembangunan Keluarga/BKKBN, "Sistem Informasi Keluarga (SIGA)," Kementerian Kependudukan dan Pembangunan Keluarga/BKKBN. Accessed: Oct. 11, 2026. [Online]. Available: https://newsiga-siga.kemendukbangga.go.id

[16] Badan Kependudukan dan Keluarga Berencana Nasional, *Buku Metadata Pengelolaan Data Rutin Pelayanan KB Pada SIGA*. 2023.

[17] Badan Pusat Statistik, *Keputusan Kepala Badan Pusat Statistik Nomor 750 Tahun 2025 tentang Kode dan Nama Wilayah Kerja Statistik*. 2025. Accessed: Aug. 11, 2026. [Online]. Available: https://barat.jakarta.go.id/statistik/publikasi/download/54

[18] Badan Pusat Statistik, *Keputusan Kepala Badan Pusat Statistik Nomor 135 Tahun 2026 Tentang Perubahan Atas Keputusan Kepala Badan Pusat Statistik Nomor 750 Tahun 2025 Tentang Kode Dan Nama Willayah Kerja Statistik*. 2026. Accessed: Aug. 10, 2026. [Online]. Available: https://jdih.bps.go.id/public/dokumen-hukum/download/eyJpdiI6Ii9aUTlvNVcwa3hPTjU1eVBCR3NxeWc9PSIsInZhbHVlIjoiSVdPZ2duaE92c3ZyaUVSSEhXb2I0Zz09IiwibWFjIjoiODk3N2IzOGI0ZmM0NzNkZjEyOWFmZTdkMjRiNmYyNWMwZDQzNjQ1NTRhNzFlZmYyNWJjNWE0ZjQ1MzNlOGIwOSIsInRhZyI6IiJ9

[19] United Nations, "World Family Planning 2022 Meeting the changing needs for family planning: Contraceptive use by age and method," 2022. Accessed: Oct. 26, 2026. [Online]. Available: https://www.un.org/development/desa/pd/content/World-Population-Prospects-2022

[20] Kementerian Kependudukan dan Pembangunan Keluarga/BKKBN, "Laporan Indikator Kinerja Utama 2025: Hasil Pemutakhiran Pendataan Keluarga 2025," 2025. Accessed: Jul. 20, 2026. [Online]. Available: https://kkbdrive.bkkbn.go.id/index.php/s/KM3xC4xZwZXTEfF

[21] Dinas Penanaman Modal dan Pelayanan Terpadu Satu Pintu Provinsi Sumatera Utara, "Profil Daerah." Accessed: Jun. 05, 2026. [Online]. Available: https://simponisumut.sumutprov.go.id/profil-kota

[22] C. C. Aggarwal, *Data Mining: The Textbook*. Springer International Publishing, 2015.

[23] P. J. Rousseeuw, "Silhouettes: a graphical aid to the interpretation and validation of cluster analysis," *J. Comput. Appl. Math.*, vol. 20, pp. 53–65, 1987, doi: 10.1016/0377-0427(87)90125-7.

[24] D. L. Davies and D. W. Bouldin, "A Cluster Separation Measure," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 1, no. 2, pp. 224–227, 1979, doi: 10.1109/TPAMI.1979.4766909.

[25] L. Hubert and P. Arabie, "Comparing partitions," *J. Classif.*, vol. 2, no. 1, pp. 193–218, Dec. 1985, doi: 10.1007/BF01908075.

[26] W. H. Kruskal and W. A. Wallis, "Use of ranks in one-criterion variance analysis," *J. Am. Stat. Assoc.*, vol. 47, no. 260, pp. 583–621, 1952, doi: 10.1080/01621459.1952.10483441.

[27] M. Tomczak and E. Tomczak, "The need to report effect size estimates revisited. An overview of some recommended measures of effect size," *Trends Sport Sci.*, vol. 21, no. 1, pp. 19–25, 2014.

[28] O. J. Dunn, "Multiple comparisons using rank sums," *Technometrics*, vol. 6, no. 3, pp. 241–252, 1964, doi: 10.1080/00401706.1964.10490181.

[29] S. Holm, "A simple sequentially rejective multiple test procedure," *Scandinavian Journal of Statistics*, vol. 6, no. 2, 1979, Accessed: Nov. 03, 2026. [Online]. Available: https://www.jstor.org/stable/4615733

[30] Perwakilan BKKBN Provinsi Sumatera Utara, "Target PPM PB dan PPM PA Tahun 2025," Jun. 2025.

[31] L. Kaufman and P. J. Rousseeuw, *Finding Groups in Data: An Introduction to Cluster Analysis*. New York: John Wiley & Sons, Inc., 1990. doi: 10.1002/9780470316801.