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Medication Adherence by Pill Count Method and Changes in Mean Arterial Pressure Among Community Members with Hypertension: A Pre-Experimental Study

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ABSTRACT

Poor medication adherence contributes to inadequate blood pressure control and increases the risk of hypertension-related complications. The pill count method using a pill box is a simple, objective, and low-cost strategy for monitoring medication adherence in community settings. Therefore, this study aimed to evaluate medication adherence using the pill count method and explore the association with short-term changes in mean arterial pressure (MAP). A pre-experimental one-group pretest–posttest study was conducted among 33 hypertensive patients. Medication adherence was monitored for seven consecutive days using a pill box. Systolic blood pressure (SBP), diastolic blood pressure (DBP), and MAP were measured before and after the observation period, then collected data were analyzed with the Wilcoxon Signed-Rank test. A total of 28 participants (84.8%) showed high medication adherence, with a median adherence of 100% (IQR: 86–100). Significant reductions were observed in SBP (median change: −3.0 mmHg, p = 0.014), DBP (−3.0 mmHg, p = 0.006), and MAP (−3.3 mmHg, p = 0.006). However, these reductions were modest over the seven-day observation period. High medication adherence was followed by modest short-term reductions in blood pressure parameters. These findings should be regarded as exploratory rather than confirmatory and should not be interpreted as evidence of a causal relationship because of the pre-experimental design. Nevertheless, the pill count method appears to be a practical, objective, and low-cost approach for monitoring medication adherence in community-based hypertension management.

Keyword: Hypertension, Medication Adherence, Pill Count Method, Mean Arterial Pressure

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1. Introduction

Hypertension is among the global public health problems and often shows no any obvious clinical symptoms until the initiation of a condition known as "The Silent Killer" (World Health Organization [WHO], 2023). Uncontrolled hypertension will cause more serious problems, such as stroke, coronary heart disease, and end-stage renal failure. Systolic blood pressure (SBP) ≥140 mmHg and/or diastolic blood pressure (DBP) ≥90 mmHg that remains constant across two measurements at separate periods is considered hypertension (Whelton et al., 2018).

More than 1.28 billion adults aged 30–79 years are affected by hypertension globally, with the majority living in developing countries. The prevalence is projected to increase further, reaching approximately 29% by 2025 (WHO, 2023). In Indonesia, hypertension remains a major contributor to morbidity and mortality, with a prevalence of 34.1% (Ministry of Health of the Republic of Indonesia, 2018).

Patient adherence to long-term treatment is essential for effective hypertension control. However, medication adherence remains a persistent and unresolved challenge, particularly in developing countries. Previous studies have consistently reported that a substantial proportion of hypertensive patients do not take medication as prescribed, showing that non-adherence continues to be a major barrier to optimal blood pressure control. In clinical practice, non-adherence frequently manifests through missed doses, irregular medication intake, premature treatment discontinuation, and poor compliance with follow-up visits, often leading to uncontrolled blood pressure. In many cases, non-adherence is identified indirectly through discrepancies between prescribed and consumed medications, as well as persistently elevated blood pressure levels. These behaviors may arise from multiple factors, including limited understanding of treatment, concerns about side effects, and low perceived need for medication in asymptomatic conditions. Recent evidence shows that non-adherence is strongly associated with poor blood pressure control, as non-adherent patients have a significantly higher potential of uncontrolled hypertension compared to adherent counterparts (Ernawati et al., 2022).

Various methods have been developed to assess and improve medication adherence, ranging from subjective self-report questionnaires to highly accurate electronic monitoring devices and digital health sensors (Berardinelli et al., 2024; Sholihah, 2024). Monitoring medication adherence with electronic and digital devices provides high accuracy. However, high operational costs limit the use of the devices in routine primary care, making community health centres with insufficient resources depend majorly on self-report questionnaires, which remain highly susceptible to social desirability bias and recall bias (Burger, 2024; Sholihah, 2024). In response to these challenges, recent studies increasingly validate pill-counting methods as a practical, low-cost alternative that provides an objective estimate of medication intake by verifying the remaining doses (Ernawati et al., 2022; Fitria et al., 2023). Current evidence on the clinical utility of objective pill-counting methods is mostly found in formal hospital settings or specialized secondary-care outpatient units (Balahura et al., 2022; Vempati et al., 2025). We have strengthened the Introduction by adding recent international evidence (2024–2025) on objective medication adherence monitoring in primary care and community settings. These additional references further support the study rationale by highlighting the growing interest in objective adherence assessment while emphasizing the need for practical, objective, and low-cost monitoring approaches, such as the pill count method, particularly in resource-limited community settings.

Despite the growing investigations on medication adherence, non-adherence remains a persistent problem that contributes to poor blood pressure control, particularly in community-based and resource-limited settings. Various strategies have been developed to assess adherence, but there is still limited evidence regarding the application of simple and objective methods, such as the pill count, in real-world community settings and the association with clinically relevant outcomes in the form of mean arterial pressure (MAP). Addressing this gap is important to better understand how adherence monitoring can be integrated into routine community-based hypertension management. The existence of various community-based platforms has not led to full realization of the potential for integrating objective, low-cost compliance monitoring tools into existing Posyandu. Non-Communicable Disease Posyandus (Posyandu PTM) serve as a critical gateway to primary health care, yet these services often depend strongly on patients' subjective reports and basic examinations. Integrating an objective pill-counting method into routine Posyandu PTM services represents a novel strategy to achieve continuous patient monitoring. This study will contribute significantly to community nursing interventions by providing a practical framework for community nurses and local health workers to carefully monitor and evaluate hypertension management in resource-limited settings. Although objective methods such as electronic monitoring and medication refills at pharmacies have been studied, many community-based adherence studies still rely heavily on patients' self-reports, which are prone to recall bias. This study integrates pill-counting methods into routine community nursing practice through the Integrated Noncommunicable Disease Counseling Posts (Posbindu PTM), thereby providing a practical, objective, and low-cost strategy for monitoring medication adherence in resource-limited settings. Therefore, this study aimed to evaluate medication adherence as the primary outcome and explore the potential association with short-term changes in MAP as an exploratory clinical indicator among hypertensive patients in a community setting, using pill-counting method. Considering the pre-experimental nature of the investigation conducted, the results are

presented in exploratory rather than confirmatory form, serving as preliminary insights for future community-based clinical trials.

2. Methods

This study was conducted from November 2023 to May 2024 using a pre-experimental one-group pretest-posttest design to evaluate hypertension medication adherence and changes in MAP values based on the pill-counting method observed over seven days. SBP, DBP, and MAP were measured before and after compliance monitoring. The pre-experimental design was selected due to the feasibility in a community-based setting, where implementing a control group may be challenging because of logistical considerations.

The population in this study was all community residents in Kota Rantang Village, Hamparan Perak District, Deli Serdang Regency, North Sumatra Province, Indonesia, who had been clinically diagnosed with hypertension. Approximately 33 participants were recruited by total sampling through a process targeted at all hypertensive patients actively registered and routinely visiting the Posyandu PTM. Prior to data collection, the study team established strong communication and rapport with the participants. Consequently, all 33 eligible patients invited agreed to participate, leading to a 0% refusal rate. This active engagement ensured high data completion. Although total sampling minimized selection bias within the study population, the inclusion of participants from a single community (one Posyandu PTM in one village) may limit the external validity and generalizability of the findings to other community settings or populations with different demographic and healthcare characteristics. Inclusion criteria required that participants were members of the Posyandu Penyakit Tidak Menular/ PTM (a community-based health post focusing on non-communicable disease screening and education in Indonesia) and diagnosed by a physician with hypertension. Additionally, the participants should have taken anti-hypertensive drugs for a minimum of one month, lived in the study area, and shown willingness to be observed for seven consecutive days. The inclusion criteria did not require prior documentation of medication non-adherence. Participants were recruited without considering the baseline adherence status, as this study aimed to objectively assess actual medication-taking behavior using the pill count method during the observation period. Therefore, adherence levels were determined prospectively with pill count measurements rather than pre-classified adherence status.

This study started by identifying eligible participants, then after obtaining consent, baseline blood pressure was measured and recorded prior to antihypertensive medication administration. Each participant was provided with a pill box and received education on the proper use. Medication adherence was monitored for seven consecutive days by counting the remaining doses according to the prescribed regimen. During the seven-day observation period, participants continued to receive standard hypertension care and antihypertensive medications prescribed in accordance with routine clinical practice. There were no changes to antihypertensive therapy, including medication type, dosage, or treatment regimen, during the follow-up period. All medication management remained the responsibility of the treating healthcare providers and was not related to the study procedures. On day 7, blood pressure was remeasured before participants received the next supply of antihypertensive medication for the following week. This timing was standardized to ensure consistency in measurement conditions and minimize the acute effects of medication intake. The seven-day observation period was selected to capture short-term medication-taking behavior while maintaining feasibility in a community-based setting and was adjusted to the routine dispensing cycle. Short-term monitoring periods, such as seven days, have been popularly used in adherence investigations to provide a practical and reasonably accurate estimate of administration patterns without imposing excessive burden (Lam & Fresco, 2015; Fitria et al., 2023). However, changes in blood pressure primarily require longer periods of sustained adherence to become clinically apparent.

Data on participant characteristics were collected using a demographic questionnaire. The percentage of adherence to taking hypertension medication was obtained from the calculation of the remaining medication found during the treatment period. Any result of the adherence calculation ≥ 80% shows high compliance, and < 80% represents low compliance (Grymonpre, 1998), as determined with the following formula:

$$\%\ \text{adherence} = \frac{(\text{quantity dispensed}) - (\text{quantity remaining})}{(\text{prescribed number of tablets/d}) \times (\text{number of days between dispensing date and interview})} \times 100$$

The pill count method may be subject to potential bias, such as overestimation of adherence when participants discard medication without actual consumption. Blood pressure data were obtained by measuring brachial artery blood pressure using a Littmann stethoscope and a manual aneroid sphygmomanometer

(Onemed) calibrated by the Testing and Calibration Laboratory, Health Facility Safety Centre, Medan (certificate number: YK.05.02/E.XI/1034/2024 dated April 5, 2024). To ensure consistency among raters and eliminate inter-rater variability, a trained scientist performed all blood pressure measurements, both at the start of the study and on day 7. This single-rater method helped maintain good relationships and consistent communication with the participants throughout the study. Before participants received the next supply of medication for the following week, blood pressure measurements were conducted at two time points, including at baseline, prior to the administration of antihypertensive medication, and on day 7. This timing was standardized to ensure consistency in measurement conditions and minimize the acute effects of intake. Furthermore, initial and subsequent MAP values were calculated using the formula MAP = DBP + 1/3 (SBP-DBP) (DeMers & Wachs, 2023). A MAP value of 70 to 100 mmHg indicates within the normal range, while over 100 mmHg implies hypertension. The outcomes of this study were data on medication adherence and changes in the SBP, DBP, and MAP pre- and post-pill count method. Prior to statistical analysis, data normality was assessed using the Shapiro–Wilk test. The results showed that the data were not normally distributed, leading to the conduction of a non-parametric test. The Wilcoxon Signed-Rank test was used to compare pre- and post-intervention measurements of SBP, DBP, and MAP.

3. Results

This study included 33 hypertensive patients from Kota Rantang Village, Hamparan Perak District, Deli Serdang Regency, Sumatra Utara Province, Indonesia. All participants met the inclusion criteria, provided informed consent, and were given pill boxes as a medium to observe medication adherence, which was monitored directly for seven consecutive days.

Table 1 presents the characteristics of the 33 participants, with a median age of 58 years. The gender distribution was nearly balanced, with 17 males and 16 females. The majority had completed senior high school and were predominantly self-employed. A small proportion reported having a smoking habit, and only a few reported engaging in between-meal eating. Medication adherence was predominantly high, with a median adherence rate of 100% (86–100%). Regarding hemodynamic measures, the median SBP decreased slightly from 160 mmHg (144–168 mmHg) before the intervention to 155 mmHg (143–166 mmHg) after. The median DBP showed minimal change from 95 mmHg (90–100 mmHg) to 96 mmHg (89–99 mmHg). Similarly, MAP decreased slightly from 117 mmHg (110–123 mmHg) to 116 mmHg (107–120 mmHg) post-intervention.

Table 1 Characteristics of Study Participants

Characteristics	Value
n	33
Age (years)	58 (48–65)*
Gender (male/female)	17/16
Education (elementary/junior/senior high school/college)	5/8/16/4
Occupation (self-employed/homemaker/gov. employer)	25/5/3
Smoking habit (yes/no)	10/23
Between-meal eating (yes/no)	5/28
Adherence Categories (high/low)	28/5
Medication Adherence (%)	100 (86–100)*
SBP (Pre) (mmHg)	160 (144–168)*
SBP (Post) (mmHg)	155 (143–166)*
DBP (Pre) (mmHg)	95 (90–100)*
DBP (Post) (mmHg)	96 (89–99)*
MAP (Pre) (mmHg)	117 (110–123)*
MAP (Post) (mmHg)	116 (107–120)*

*Data are presented as median (IQR: Q1–Q3). SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; IQR, interquartile range; Pre, before intervention; Post, after intervention.

Table 2 presents the comparison of SBP, DBP, and MAP before and after the intervention. The Wilcoxon Signed-Rank test was used due to the non-normal data distribution. The results showed a statistically significant reduction in SBP after the intervention, with a median absolute delta reduction of -3.00 mmHg (IQR: -4.00 to 0.00 mmHg) ($Z = -2.453$, $p = 0.014$, $r = 0.403$, 95% CI:0.07–0.66). Similarly, DBP showed a significant decrease, with a median delta change of -3.00 mmHg (IQR -5.00 to 0.00 mmHg) ($Z = -2.749$, $p = 0.006$, $r = 0.452$, 95% CI: 0.13–0.69). MAP showed a statistically significant reduction following the

intervention, with a median delta change of -3.30 mmHg (IQR: -4.35 to -0.50 mmHg) (Z = -2.774, p = 0.006, r = 0.456, 95% CI: 0.13–0.69). The effect sizes for SBP, DBP, and MAP were in the moderate range, showing that even though the absolute changes in blood pressure values were relatively small, the magnitude of the effect was meaningful from a statistical perspective. Based on the Wilcoxon Signed-Rank analysis, MAP values decreased in 25 participants (75.8%), remained unchanged in 2 participants (6.1%), and increased in 6 participants (18.2%) during the seven-day observation period. Similar trends were observed for SBP and DBP, with reductions occurring in 23 (69.7%) and 24 (72.7%) participants, respectively.

Table 2 Comparison of SBP, DBP, and MAP Before and After the Pill Count Method

Comparison of variables	Δ Median (IQR)	Z	Effect size (r)	95% CI	p-value
SBP (Pre)-SBP (Post)	-3.00 (-4.00–0.00)	-2.453	0.403	0.07–0.66	0.014
DBP (Pre)-DBP (Post)	-3.00 (-5.00–0.00)	-2.749	0.452	0.13–0.69	0.006
MAP (Pre)-MAP (Post)	-3.30 (-4.35–-0.50	-2.774	0.456	0.13–0.69	0.006

*SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; IQR, interquartile range; CI, confidence interval. Δ Median (IQR) represents the median change (Post − Pre); negative values indicate a reduction after the intervention. r, effect size. P-values were obtained using the Wilcoxon Signed-Rank Test.

4. Discussion

This study suggests that the pill count method may be a practical strategy for monitoring medication adherence among hypertensive patients in community settings. The majority of participants showed high adherence during the 7-day observation period, which was followed by small reductions in blood pressure parameters. Although statistically significant changes were observed in SBP, DBP, and MAP, the magnitude of the changes was moderate. These results should be interpreted with caution, considering several methodological limitations, including the short duration of observation, the absence of a control group inherent in the pre-experimental design, and potential measurement bias associated with the pill count method, which limit the ability to attribute the observed changes directly to the intervention. The observed decrease in blood pressure parameters cannot be definitively attributed solely to adherence monitoring, and the preliminary results should be interpreted strictly as exploratory trends.

The use of pill boxes provides several advantages in supporting medication adherence by transforming a passive treatment routine into an active self-management process. Pill boxes help support medication routines, increase patient awareness, and facilitate adherence-related behaviors. Visually dividing daily medication doses into separate compartments allows easy remembrance, facilitates self-monitoring, and reduces the complexity of therapeutic regimens, specifically for long-term treatment (Sholihah, 2024; Whittle & Mansell, 2022). In addition, participants received education on the use of pill boxes, which may enhance self-efficacy by helping patients organize medications, remember doses, and feel more confident in managing treatment (Abhilasha & Bagalkotkar, 2024; Tola et al., 2021). Previous studies have reported that patients find pill boxes useful and education on the administration process supports medication-taking behaviors (Tola et al., 2021). Beyond serving as a simple reminder, the structural design of a pill box functions as a continuous feedback mechanism that enhances a patient's internal awareness. Visually empty or filled compartments triggers cognitive self-evaluation, shifting the responsibility for managing the condition from healthcare professionals directly to the patients. This visual confirmation promotes positive reinforcement and self-efficacy, enabling individuals with hypertension to proactively adjust daily habits and strengthen the self-management of health in primary care settings. Proper education and use of pill boxes may help participants maintain consistent, long-term medication adherence. Our findings are broadly consistent with previous international studies highlighting the value of objective medication adherence monitoring in hypertension management. In contrast to many studies using digital technologies or multidisciplinary interventions, our findings suggest that the pill count method could be feasibly integrated into routine community nursing practice as a practical and low-cost approach for resource-limited primary healthcare settings (Yap et al., 2024).

MAP is an important indicator of tissue perfusion and is strongly associated with cardiovascular risk (DeMers & Wachs, 2023). In this study, statistically significant reductions were observed in SBP, DBP, and MAP following the intervention. Although the statistical analysis showed a significant median delta reduction of 3.30 mmHg in MAP, the clinical meaningfulness of this change remains uncertain over a short-term observation period of only seven days. In cardiovascular medicine, while minor statistical shifts are valuable for trend analysis, sustained blood pressure control over months or years is required to significantly reduce long-term cardiovascular risks, such as stroke or myocardial infarction. Therefore, the observed short-term

reduction should be viewed as a preliminary clinical indicator of trend rather than definitive evidence of treatment success. Further studies with longer follow-up periods are needed to determine whether the changes can translate into clinically relevant outcomes.

Relationship of participant characteristics such as education, occupation, smoking habits, and between-meal eating with blood pressure outcomes in this study appeared limited. For instance, elevated blood pressure levels were still observed among most participants who had completed senior high school or higher education, which was associated with better health awareness and outcomes (Zajacova & Lawrence, 2018). The majority were self-employed, a condition often associated with higher occupational stress, which may contribute to increased blood pressure (Wang et al., 2023). Despite these potential influences, clear differences were not found in SBP, DBP, or MAP across the observed characteristics. The impact of known risk factors for hypertension, such as smoking and between-meal eating, may not have been evident due to the relatively small number of participants showing the behaviors (Poulter et al., 2015; Aljuraiban et al., 2016). The results suggest that, within this sample, participant characteristics tend to not play a dominant role in explaining the observed blood pressure changes.

The results have important implications for community-based hypertension management. Pill boxes are a simple and low-cost tool, and the pill count method is simple and easy to implement by patients, families, and health cadres, enabling highly feasible integration into the routine Posyandu Penyakit Tidak Menular (PTM) service framework. To achieve successful routine integration, a structured collaborative strategy including community nurses and local health cadres is recommended. Under this framework, community nurses assume the primary role of clinical supervisors and educators, responsible for conducting initial clinical screenings, training cadres on standardized pill-counting protocols, and managing patients with persistent non-adherence. Concurrently, local health cadres serve as the frontline operational workforce during monthly Posyandu PTM sessions. Cadres have the liberty to efficiently distribute the pill boxes, perform the physical counting of remaining tablets, and record adherence percentages using standardized logbooks. Patients identified with adherence levels below the 80% threshold can be immediately referred to the community nurse for targeted counseling or home-visit interventions. This simple and low-cost method will increase the active participation of hypertension patients in the community in their treatment. The feasibility of this approach is supported by its minimal equipment requirements and its compatibility with existing Posyandu PTM activities. However, long-term sustainability may require ongoing training for volunteers, supervision by community nurses, and a reliable supply of pill boxes, while implementation in resource-limited settings may face challenges due to limited nursing staff and varying levels of patient participation. The results also imply that monitoring medication adherence can be integrated into community-based hypertension patient care standards, specifically for areas with limited access to health services (World Health Organization, 2023).

This study has several methodological limitations, despite the practical contributions. First, the 7-day observation period was too short to assess long-term adherence or sustained changes in blood pressure. Second, the single-group pre-experimental design lacked a control group, leading to impossibility to establish a cause-and-effect relationship. Consequently, the observed decreases in SBP, DBP, and MAP cannot be definitively attributed to pill-count monitoring. These changes may instead be explained by threats to internal validity, such as the Hawthorne effect (behavioral changes due to monitoring), the maturation effect (natural biological fluctuations over time), or regression to the mean (initially extreme readings naturally shifting toward the mean). Third, the pill count method measures medication possession rather than confirmed medication ingestion, which may overestimate adherence because medication removed from the container is not necessarily consumed. Finally, potential confounding factors such as diet, physical activity, and stress were not controlled in this study. Future studies should use randomized controlled trials with longer follow-up periods.

5. Conclusion

In conclusion, the pill-counting method using pill boxes showed a significant association with adherence to antihypertensive medication and a reduction in blood pressure (SBP, DBP, and MAP) among hypertensive patients at the Kota Rantang Village Health Post. However, due to the pre-experimental design and the short observation period, these results should be considered preliminary and as a basis for hypothesis formation, rather than definitive conclusions. The results provided preliminary evidence requiring further validation and confirmation through more rigorous study designs, such as randomized controlled trials with longer follow-up periods. This method remains highly recommended as an affordable and practical primary-level intervention to support community nursing services and improve patient self-management in primary health care facilities.

Ethics approval and consent to participate

Ethical approval was obtained from the Health Research Ethics Committee of the University of North Sumatra (No. 299/KEPK/USU/2024). Written informed consent was obtained from all participants prior to data collection. Participants were informed about the study objectives, procedures, potential risks and benefits, and their right to withdraw from the study at any time without any consequences.

Consent for publication

Not applicable. This study does not include any identifiable personal data or images requiring publication consent.

Availability of data and materials

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

First Author (Ikhsanuddin Ahmad Harahap): Conceived and designed the study, supervised the research process, interpreted the data, prepared the manuscript, revised the manuscript, and took overall responsibility for the study.

Second Author (Elnika Saragih): Contributed to participant recruitment, data collection, and study implementation.

Third Author (Nur Asnah Sitohang): Critically reviewed the manuscript and contributed to manuscript revision.

Fourth Author (Mula Tarigan): Critically reviewed the manuscript and contributed to manuscript revision.

Fifth Author (Lilis Nuriyanti Tambun): Contributed to data collection, performed the statistical analysis, and assisted in data interpretation.

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Artificial Intelligence (AI) Use Disclosure

AI-powered technology is used solely to support language editing and manuscript preparation. No AI tools were used to generate research data, perform data analysis, or interpret research findings. All scientific content, interpretations, and final decisions regarding the manuscript have been reviewed, verified, and approved by the authors, who bear full responsibility for the accuracy and integrity of this work.

Clinical Trial Registration

Not applicable. This study employed a pre-experimental design and was not registered as a clinical trial

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