

# RMJ

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# Comparing Diagnostic Criteria for Noise-Induced Hearing Loss in Hospital Personnel: Age Adjustments With ISO 7029-2017

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## Abstract

**Background:** Noise-induced hearing loss (NIHL) is a prevalent occupational health concern, especially in high-noise industries. Despite various diagnostic methods, no universally accepted gold standard for diagnosing NIHL exists. Age adjustments, which are an unresolved issue, vary across proposed standards. Comparing diagnostic criteria is vital for improving early detection and prevention strategies.

**Objective:** To compare different NIHL diagnostic methods, assessing the impact of age adjustments on hearing threshold interpretations in hospital personnel.

**Methods:** A retrospective study was conducted, analyzing audiometric data from hospital personnel in a hearing conservation program (HCP) using multiple diagnostic criteria, including the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) threshold shift criteria, the Coles, Lutman, and Buffin (CLB) method with OSHA age-adjustment table, and ISO 7029-2017 values. NIHL quantification was performed using various averages and age-associated hearing loss (AAHL) values.

**Results:** A total of 108 participants (71.30% male; mean age 43.92 years) were included. The mean duration of employment was 12.80 years. Based on OSHA Standard Threshold Shift (OSTS), 9.26% of participants had NIHL, while NIOSH Significant Threshold Shift (NSTS) identified 35.19%. Coles' bulge analysis revealed varied NIHL prevalence of 28.70% using OSHA Table F-1/F-2, and 46.30% with ISO 7029-2017. Mean hearing thresholds (average of 0.5 kHz, 1 kHz, 2 kHz, 3 kHz) were 23.02 dB (OSHA AAHL) and 20.90 dB (ISO 7029-2017), compared to 41.22 dB and 50.56 dB when 4 kHz was included.

**Conclusions:** NIHL diagnosis remains complex due to the lack of a definitive standard. Diagnostic criteria and age adjustment methods influence prevalence estimates, highlighting the need for further research to enhance NIHL assessment for more effective prevention strategies.

**Keywords:** Noise-induced hearing loss, Age-adjustment, Audiogram, ISO 7029-2017

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## Introduction

Current methods for diagnosing noise-induced hearing loss (NIHL) using pure-tone audiograms have been criticized for their inadequacy in diagnosing NIHL resulting from various types of noise exposure, particularly those beyond steady broadband noise or in cases of co-exposure. This limitation arises due to the absence of a universally accepted gold standard for diagnosing NIHL, as well as the fact that certain adverse effects of noise exposure may not be fully captured by the audiogram.<sup>1-4</sup> Various diagnostic methodologies

have been employed worldwide, including those proposed by Coles et al,<sup>5</sup> Niskar et al,<sup>6</sup> and Phillips et al.<sup>7</sup> Among these, the Coles, Lutman, and Buffin (CLB) method, developed over 2 decades ago, has remained the most widely accepted and commonly used approach by clinicians.<sup>5</sup> In specific cases where individuals are exposed to atypical noise, such as intense low-frequency noise, an alternative method proposed by Moore et al<sup>8</sup> has been suggested as a more suitable diagnostic tool. Most of these methods are based on the presence of a “noise notch” or a calculated bulge, which rely on the hearing threshold levels (HTLs) at 3, 4, or 6 kHz being elevated (indicating worse hearing) compared to HTLs at both lower frequencies (1 kHz) and higher frequencies (8 kHz). The specificity of the CLB method — defined as the percentage of individuals without NIHL who are correctly identified as not having NIHL — was estimated to be 87% when each ear was evaluated separately, as reported by Moore et al.<sup>9</sup>

The Health and Safety Executive (HSE) has emphasized the significance of a notch at 4 kHz as a well-established clinical indicator of NIHL, while also noting that a notch at 6 kHz is more variable and of limited diagnostic utility.<sup>10</sup> Additional diagnostic criteria have been introduced by the Occupational Safety and Health Administration (OSHA, 1981), the National Institute for Occupational Safety and Health (NIOSH, 1998), and the US Department of Defense (2019), all of which require serial audiogram comparisons over time. NIOSH defines NIHL based on a standard threshold shift (NSTS) — typically a permanent hearing threshold of 25 dB or greater at 3, 4, or 6 kHz in either ear, confirmed by repeat testing. OSHA uses a similar threshold but defines a standard threshold shift (OSTS) as a change of 10 dB or more at 2, 3, and 4 kHz in either ear, relative to the baseline audiogram. However, occupational audiograms often exhibit considerable variability over short intervals, sometimes differing markedly between tests conducted just 1 or 2 years apart due to multiple factors.<sup>11</sup>

In Thailand, hearing conservation programs adhere to the guidelines established by the Hearing Loss Prevention Program (HLPP) of NIOSH, which are not explicitly referenced in the national regulations.<sup>12</sup> Furthermore, age adjustment or age correction is not mandated in either the diagnosis or quantification of NIHL. Given the lack of a universally recognized gold standard for diagnosing NIHL, significant variability exists in its diagnosis. This inconsistency can be particularly challenging in clinical settings, where a 95% confidence level is required to minimize the likelihood of a diagnosis occurring by chance. In contrast, medico-legal contexts apply a lower threshold, diagnosing NIHL based on a probability exceeding 50%.<sup>11</sup>

Another challenge in NIHL assessment is its quantification. It is well established that aging significantly impacts hearing sensitivity.<sup>2</sup> However, OSHA and NIOSH do not impose strict requirements for routine age correction, which may lead to overestimation of both the prevalence and severity of NIHL among workers. However, OSHA provides age correction tables (F-1 and F-2), which do not include the 8 kHz frequency, a key element in identifying the characteristic “bulge” in Coles’ diagnostic method for NIHL.<sup>13</sup>

ISO 7029-2017 is a more recent and periodically revised standard for age correction, regarded by experts as the most appropriate for quantifying age-associated hearing loss (AAHL) at present.<sup>11</sup> ISO 7029-2017 is an international standard titled: Acoustics — Statistical distribution of hearing thresholds related to age and gender. It provides reference data for the distribution of hearing thresholds in otologically normal people. Previous versions of this standard were published in 1984 and 2000. The AAHL values used by Coles et al<sup>5</sup> were based on the now-outdated ISO 7029-1984. ISO 7029-2017 offers greater

sensitivity in detecting hearing abnormalities than previous versions (1984 and 2000), as it is based on populations carefully screened to exclude conductive hearing loss and noise exposure.<sup>11</sup> To date, no studies have applied ISO 7029-2017 in the context of NIHL assessment in Thailand, particularly within occupational settings, as far as the author is aware. This study is among the first to do so.

## Methods

This retrospective study analyzed a set of data from an annual health examination in year 2024 from 108 hospital personnel aged 20-60 years, all of whom were enrolled in a hearing conservation program (HCP) due to their occupational exposure to noise. Although Thai regulations mandate an HCP for noise exposure levels of 85 dB or higher, workplace regulations in this study required implementation at a lower threshold of 80 dB. In compliance with legal requirements, these personnel underwent regular audiometric testing as part of their hearing monitoring regimen, alongside other HCP measures such as noise monitoring and the provision of personal protective equipment (PPE). Audiometric testing is mandatory for all personnel enrolled; so data were collected from the entire population. Audiograms were performed using an audiometer compliant with ANSI S3.6 – Specifications for Audiometers, within an audiometric booth certified according to the ANSI S3.1-1999 standard for ambient noise levels. The tests were administered by occupational health registered nurses who had completed a specialized training program in Occupational Health Nurse Practitioner Practice, accredited by the Ministry of Public Health (MOPH), Thailand. Data were obtained from medical records and supplemented with responses to annual questionnaires completed by participants during their routine physical examinations.

The diagnosis of NIHL among hospital personnel was conducted based on the CLB method. Given the absence of a universally accepted diagnostic standard, ISO 7029-2017 was incorporated as a reference to define HTL “bulges”, thereby mitigating the confounding effects of AAHL.<sup>5</sup>

After the diagnostic stage, the severity of NIHL was further evaluated by comparing individuals’ hearing thresholds to the median reference values established using ISO 7029-2017 as a way of quantifying NIHL.<sup>14</sup> The median HTL (50th percentile) was chosen for this study, as it is the recommended default threshold unless there is strong evidence of exceptionally good or poor hearing ability, and despite differing opinions, it remains the best approach when occupational audiograms are unavailable or unreliable (Figure 1).<sup>11, 15</sup>

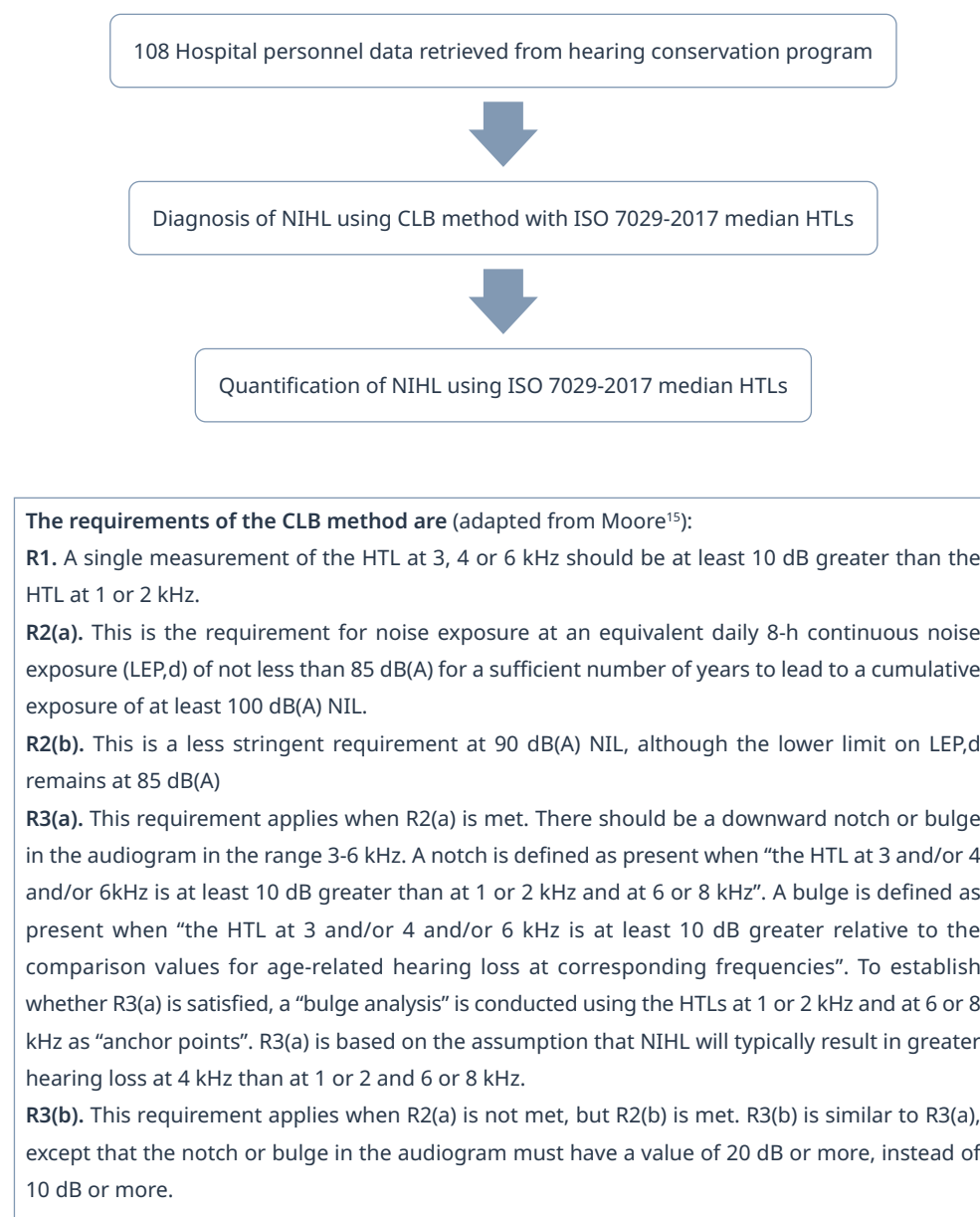
All data were anonymized, ensuring the removal of personally identifiable information such as names and hospital numbers. Data analysis was conducted using Stata version 14.0 (StataCorp. Version 14. College Station, TX: StataCorp LP; 2015). Ethical approval for this study was obtained from the hospital’s ethics committee.

## Results

A total of 108 participants were included in the study, with the majority being male (71.30%) and the remaining female (28.70%). The mean (SD) age of participants was 43.92 (10.27) years. Regarding medical history, 9.26% reported a history of past ear injuries or infections, while 88.89% had no such history. In terms of smoking habits, 11.11% were active smokers, 17.59% were past smokers, and 71.30% had never smoked. The mean (SD) duration of employment at the hospital was 12.80 (10.23) years.

The prevalence of NIHL varied depending on the criteria used for assessment. Based on the OSTS criterion, 9.26% of participants were identified with NIHL (95% CI, 4.53-16.37). The NSTS criterion classified 35.19% of participants as having NIHL (95% CI, 26.24-44.96). The difference in prevalence between these criteria was statistically significant, as indicated by the Pearson chi-square test ( $P < .001$ ) (Table 2).

**Figure 1. Flow of Participant Selection**



Abbreviations: CLB, Coles, Lutman, and Buffin method; HTL, hearing threshold level; NIL, noise immersion level.

**Table 1. Demographic Data**

| Characteristic                          | No. (%)       |
|-----------------------------------------|---------------|
| Sex                                     |               |
| Male                                    | 77 (71.30)    |
| Female                                  | 31 (28.70)    |
| Age, mean (SD), y                       | 43.92 (10.27) |
| History of past ear injuries/infections |               |
| Yes                                     | 10 (9.26)     |
| No                                      | 98 (90.74)    |
| History of smoking                      |               |
| Active smoker                           | 12 (11.11)    |
| Past smoker                             | 19 (17.59)    |
| Never smoke                             | 77 (71.30)    |
| Work at this hospital, mean (SD), y     | 12.80 (10.23) |
| Work department                         |               |
| Laundry unit                            | 24 (22.22)    |
| Central sterile supply unit             | 20 (18.52)    |
| Casting room technicians                | 2 (1.85)      |
| Prosthesis and orthosis                 | 6 (5.56)      |
| Medical device unit                     | 9 (8.33)      |
| Electricians                            | 6 (5.56)      |
| Plumbers                                | 5 (4.63)      |
| Carpenters                              | 8 (7.41)      |
| Air conditioning technicians            | 10 (9.26)     |
| Vehicles                                | 17 (15.74)    |
| Technician office                       | 1 (0.93)      |

**Table 2. Prevalence of NIHL by Different Criteria**

| NIHL by Criterion                                  | No. (%)    | 95% CI      |
|----------------------------------------------------|------------|-------------|
| OSTS                                               | 10 (9.26)  | 4.53-16.37  |
| NSTS                                               | 38 (35.19) | 26.24-44.96 |
| Coles' bulge analysis using OSHA Table F-1 and F-2 | 31 (28.70) | 20.41-38.20 |
| Coles' bulge analysis using ISO 7029-2017          | 50 (46.30) | 36.65-56.15 |

Abbreviations: NIHL, noise-induced hearing loss; NSTS, NIOSH Significant Threshold Shift; OSHA, Occupational Safety and Health Administration; OSTS, OSHA Standard Threshold Shift.

When using Coles' bulge analysis, the prevalence differed based on the reference standard applied. Using OSHA Table F-1 and F-2, 28.70% of participants were identified with NIHL (95% CI, 20.41-38.20), whereas applying the ISO 7029-2017 standard, the prevalence increased to 46.30% (95% CI, 36.65-56.15); the highest proportion of affected workers identified.

An example of a bulge analysis using the CLB method is presented, where 1 kHz and 8 kHz were selected as anchor points. The AAHL values represent those for a 37-year-old man at the 50th percentile with no history of noise exposure. The measured HTL values were then compared to the corresponding AAHL values, with any discrepancies at the anchor points referred to as “misfit values”. These misfit values were subsequently interpolated across frequencies using a logarithmic scale (Table 3).

The AAHL values were then adjusted, ensuring that when an AAHL value exceeded (ie, was worse than) the measured HTL, it was set equal to the measured HTL, while any negative AAHL values were set to zero. The adjusted AAHL was then compared to the measured HTL to estimate NIHL, as shown in the bottom row of the table. According to the bulge criterion, any value exceeding 10 dB at 3 kHz, 4 kHz, or 6 kHz qualifies as a bulge. In this case, the most pronounced NIHL was observed at 6 kHz.

Further analysis of NIHL severity, illustrated the average HTL at specific frequencies according to different standards. Notably, HTL values at 1 kHz, 2 kHz, and 4 kHz and 0.5 kHz, 1 kHz, 2 kHz, 4 kHz, were significantly higher compared to those at 0.5 kHz, 1 kHz, 2 kHz, 3 kHz, and 1 kHz, 2 kHz, 3 kHz. Paired *t* test comparisons between each pair of standards revealed statistically significant differences in mean HTLs, with all comparisons yielding *P* < .001 (Table 4).

The 4 kHz frequency is not only essential in diagnosis the NIHL,<sup>10</sup> it is also particularly relevant for quantifying hearing difficulties, as it plays a crucial role in speech comprehension, especially in environments where background sounds are presented.<sup>16</sup> It is also one of the most reliable predictors of the Speech Reception Threshold (SRT), which determines the level at which an individual can understand 50% of sentences in background noise.<sup>17</sup> Earlier publications suggested using 2 kHz, 3 kHz, and 4 kHz to predict speech comprehension ability. However, more recent research emphasizes that 4 kHz should always be included, and that the average HTL across 1 kHz, 2 kHz, and 4 kHz provides a more accurate measure of the overall magnitude of NIHL.<sup>11</sup> Despite these advancements, current practice still primarily relies on averaging HTL across 0.5 kHz, 1 kHz, 2 kHz, and 3 kHz.

**Table 3. Example of a Bulge Analysis Using the CLB Method With AAHL Values From ISO 7029-2017 for a Man Aged 37 Years at the 50th Percentile (Median)**

| Parameter                             | Frequency, Hz |      |      |      |      |      |
|---------------------------------------|---------------|------|------|------|------|------|
|                                       | 1000          | 2000 | 3000 | 4000 | 6000 | 8000 |
| HTL, dB HL                            | 25            | 20   | 5    | 20   | 30   | 5    |
| HTL at selected anchor points         | 25            | NA   | NA   | NA   | NA   | 5    |
| Selected AAHL                         | 1.09          | 1.85 | 2.57 | 3.20 | 4.13 | 4.80 |
| Misfit values at anchor points, dB    | 23.91         | NA   | NA   | NA   | NA   | 0.20 |
| Interpolated misfit values, dB        | 23.91         | 4.85 | 1.91 | 0.99 | 0.39 | 0.20 |
| Adjusted AAHL                         | 25            | 6.75 | 4.51 | 4.19 | 4.49 | 5    |
| Set AAHL to 0 when AAHL < 0           | 25            | 6.75 | 4.51 | 4.19 | 4.49 | 5    |
| Set AAHL to actual when AAHL > actual | 25            | 6.75 | 4.51 | 4.19 | 4.49 | 5    |
| NIHL, ie, bulge (dB), rounded         | 0             | 13   | 0    | 16   | 26   | 0    |

Abbreviations: AAHL, age-associated hearing loss; CLB, Coles, Lutman, and Buffin method; HL, hearing loss; HTL, hearing threshold limit; NA, not applicable; NIHL, noise-induced hearing loss.

Table 4. NIHL Quantification Using Different AAHL Values

| Average                               | OSHA (F-1/F-2), dB | ISO 7029-2017, dB |
|---------------------------------------|--------------------|-------------------|
| Mean of 0.5 kHz, 1 kHz, 2 kHz, 3 kHz* | 23.02              | 20.90             |
| Mean of 0.5 kHz, 1 kHz, 2 kHz, 4 kHz  | 41.22              | 50.56             |
| Mean of 1 kHz, 2 kHz, 3 kHz**         | 23.81              | 21.37             |
| Mean of 1 kHz, 2 kHz, 4 kHz***        | 51.82              | 41.59             |

Abbreviations: AAHL, age-associated hearing loss; NIHL, noise-induced hearing loss; OSHA (F-1/F-2), Occupational Safety and Health Administration Table F-1 and F-2.

\* Current practice in USA (American Medical Association) and Thailand (Social Security Office; Workmen's Compensation Fund).

\*\* UK standard.

\*\*\* Ireland and Australia standard.

Discussion

As emphasized multiple times throughout this article, there has been no universally accepted gold standard for diagnosing NIHL. The most reliable approach to determine the gold standard is the method proposed by Moore et al<sup>9</sup> which compares the specificity of each diagnostic technique between individuals with noise exposure and a nonexposed control population. Among these methods, the highest overall sensitivity (72.5%) was observed in the Phillips et al<sup>7</sup> method, whereas the Niskar et al<sup>6</sup> method exhibited a significantly lower sensitivity of 27%. The CLB method (2000) demonstrated a sensitivity of 70%.<sup>9</sup>

A study conducted in a population similar to that of the present study found that the prevalence of NIHL, as determined using the NSTS, was 41.5% (95% CI, 37.49-45.54). When assessed using the OSTs, the prevalence was lower at 25.3% (95% CI, 21.81-28.93).<sup>18</sup> Similarly, research conducted among auto parts workers in Thailand reported an NIHL prevalence of 30.72% based on NIOSH criteria and 14.37% based on OSHA criteria, with a substantial discrepancy of 53.22%.<sup>19</sup> Findings from research on workers in the chemical industry revealed that the prevalence of NSTS and OSTs and OSTs with age correction ranged from 22.15% to 31.91%, 4.83% to 14.85%, and 2.34% to 5.29%, respectively.<sup>20</sup>

A large-scale study by Masterson et al<sup>21</sup> further demonstrated a considerable variation in NIHL prevalence depending on the hearing shift criteria used (NSTS, OSTs, and OSTs with age correction). In that study, the prevalence of workers identified with OSTs was 31.64% lower than that of workers diagnosed using NSTS. Comparatively, the present study found an even greater difference of 73.68%.

Healthcare workers have been identified as one of the occupational groups with the highest prevalence of NIHL. In the same study, the Healthcare and Social Assistance sector exhibited a prevalence of 23.9% based on NSTS criteria.<sup>21</sup> In contrast, the prevalence decreased to 16.67% when OSHA criteria were applied. Following age correction, the prevalence was further reduced to 8.02%. Regardless of the diagnostic method used, this occupational sector showed a consistently higher prevalence of NIHL compared to the overall worker population, which exhibited prevalence rates of 20.26%, 13.85%, and 6.41%, by using NSTS, OSTs, and OSTs with age correction, respectively.

One possible explanation for the notably high prevalence of NIHL reported using the ISO 7029-2017 method in this study was the arbitrary selection of the median (50th percentile) as the comparison percentile. Since the choice of percentile significantly impacts NIHL

estimation, Moore et al<sup>11</sup> recommend using the 50th percentile as the default reference for age-related corrections. However, Cole opposes this approach, cautioning against applying a fixed percentile across all frequencies when assessing the severity of NIHL.<sup>5</sup> Instead, he advocates for an alternative calculation method, particularly in medicolegal contexts.

Nevertheless, as there is no definitive method for selecting the most appropriate percentile, a retrospective analysis of past audiograms from some participants could help identify individuals with unusually high or low hearing thresholds. If a participant's hearing thresholds are poorer than expected, a lower (worse) percentile should be applied, and vice versa.

Data collected from 60 dental professionals revealed that 15% to 25% of male and 13% to 18% of female participants had hearing thresholds exceeding the 95th percentile limits when compared to the ISO 7029-2017 normative age- and sex-distributions.<sup>22</sup> Furthermore, clinical hearing loss was observed in 61% of male and 25% of female ears, based on a diagnostic criterion using a 4-frequency air conduction threshold pure-tone average (4F-PTA) of 500, 1000, 2000, and 4000 Hz exceeding 20 dB. The present study did not include dental professionals, as noise exposure in dental settings did not exceed the standard threshold.

Zhang et al<sup>22</sup> reported that male participants in their study had a mean (SD) of 4F-PTA of 25.5 (21.5) dB, while female participants had a mean (SD) of 4F-PTA of 14.2 (10.8) dB. Compared to the present study, where the total population exhibited an average of 4-frequency HTL of 50.56 dB, Zhang's study reported significantly lower thresholds. Notably, Zhang's research did not specify noise exposure levels in their sampling environment, whereas the present study exclusively included individuals exposed to noise levels of 80 dB or higher in their workplace.

Another important aspect of audiogram interpretation is longitudinal analysis. As regulatory requirements increasingly mandate long-term retention of audiometric test results — sometimes extending until an employee's retirement — longitudinal interpretation is becoming increasingly important. Serial audiometric monitoring is essential for detecting changes in HTL that may indicate irreversible conditions such as NIHL. However, a major challenge for interpreters is accounting for the effects of aging. Whether age adjustment should be performed routinely remains a subject of debate. Overestimating the impact of aging could compromise the effectiveness of hearing conservation programs by leading program managers to misattribute NIHL to age-related hearing loss. Conversely, neglecting age correction could result in an underestimation of age-related effects, leading to misallocated resources that target age-related hearing loss rather than NIHL.

Age adjustments are permitted under certain regulations, such as those established by the US Federal Railroad Administration (FRA) (2006), the US Occupational Safety and Health Administration (OSHA) (1983), and the US Mine Safety and Health Administration (MSHA) (1999). However, the US NIOSH (1998) does not mandate or recommend age adjustment.<sup>23</sup> Although NIOSH age adjustment tables are incorporated into OSHA's hearing conservation amendment, NIOSH itself argues that these "corrections" do not accurately reflect true age-related hearing changes.<sup>13</sup> Similarly, the US Department of Defense (2018) does not permit age adjustments when assessing changes in audiometric thresholds. In contrast, Thailand's regulations do not explicitly mention age adjustment. Some organizations may opt to apply age corrections according to OSHA's recommendations to avoid overestimating NIHL prevalence due to age-related hearing loss.

Instead of the standard from ISO 7029-2017, Flamme et al<sup>24</sup> proposed the use of population-based tables derived from the US National Health and Nutrition Examination Survey (NHANES) (2005-2012) to estimate age-related hearing changes. These tables account for work histories spanning up to 30 years and beyond. However, it is important to note that using ISO 7029-2017 for age adjustment may yield distinct results compared to NHANES tables.<sup>25</sup> The population used to develop ISO 7029-2017 was carefully screened to exclude individuals with conductive hearing loss or noise exposure, which may lead to an overestimation of age-related hearing loss compared to NHANES-derived estimates which reflect real-world occupational exposure. A study by Stenklev et al<sup>1</sup> also raised concerns about ISO 7029's reliability, particularly in female subjects, as it appeared to underestimate HTL in even otologically normal samples. Additionally, the study noted that ISO 7029-2017 criteria might be unreliable for individuals over 60 years of age. Further research on this issue would be beneficial for practical applications.

This study had certain limitations. First, the requirements for the CLB method could not be fully met, as occupational noise exposure in this setting did not exceed the 90 dB(A) noise immersion level (NIL). Second, the author deliberately selected the median (50th percentile) as the "anchor point" for all bulge analyses, following experts' recommendations.<sup>11</sup> The choice of percentile may significantly influence NIHL estimations. Future research should explore alternative percentiles tailored to individual participants, such as selecting the percentile based on the HTLs for the frequencies with the best thresholds in the better-hearing ear. Further investigations could also examine the integration of age adjustment methods in longitudinal audiometric analyses.

## Conclusions

This study highlights the challenges of diagnosing NIHL with different methods yielding varying prevalence. The choice of diagnostic criteria significantly impacts NIHL prevalence and quantification. ISO 7029-2017 standard gives a statistically different result when compared to the Table F1-F2 currently recommended by OSHA, highlighting the complexities of age adjustment in audiometric assessments as both overestimation and underestimation can affect the accuracy of NIHL diagnosis.

### Additional Information

**Ethics Approval:** This study was approved by the Ethical Committee of Chonburi Hospital (No. 54/67/S/h3 on 6 August 2024).

**Clinical Trial Consideration:** This study does not report on a clinical trial.

**Financial Support:** No financial support was provided for this study.

**Conflict of Interest:** The author declares no conflict of interest.

**Author Contributions:**

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Formal Analysis: Pitchaya Chevasutho

Methodology: Pitchaya Chevasutho

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# Factors Affecting Melioidosis Prevention Behaviors Among People in the Area of Health Zone 10, Ubon Ratchathani

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## Abstract

**Background:** The number of melioidosis cases in Thailand rose from approximately 3500 in 2022 to more than 4000 in 2023, with provinces in Health Zone 10 experiencing the highest incidence.

**Objective:** To investigate the factors influencing the melioidosis prevention behaviors of the population in the Health Zone 10 area of Ubon Ratchathani province.

**Methods:** This cross-sectional analytic study included 352 adults ( $\geq 45$  years) selected by multistage sampling. Data were collected using a validated questionnaire and analyzed using descriptive statistics and binary logistic regression.

**Results:** Most of the participants were female farmers (65.9%); 66.8% had nonrisk preventive behaviors, whereas 33.2% were in the risk group. Compared with the age group of 45-55 years, it was found that those aged  $\geq 66$  years had a significantly lower chance of having inappropriate disease prevention behaviors (adjusted odds ratio [AOR], 0.10;  $P = .003$ ). Regarding educational level, it was found that the group with completed primary education had a significantly lower chance of having inappropriate disease prevention behaviors (AOR, 0.02;  $P < .001$ ) than the group with less than primary education. The group with secondary education had a significantly lower chance (AOR, 0.02;  $P < .001$ ). Regarding occupation, using agriculture (rice farming and gardening) as the reference group, the animal husbandry group was significantly more likely to engage in inappropriate disease prevention behaviors (AOR, 7.91;  $P = .027$ ). Other occupations also had a significantly higher chance than the reference group (AOR, 13.67;  $P < .001$ ). Regarding knowledge about melioidosis, those with high knowledge were significantly less likely to engage in inappropriate disease prevention behaviors (AOR, 0.10;  $P < .001$ ) than those with low knowledge.

**Conclusions:** Factors associated with disease prevention behaviors included age, education level, occupation, knowledge about melioidosis, and certain health literacy.

**Keywords:** Factors, Behavior, Melioidosis, Health Zone 10

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## Introduction

Melioidosis is an endemic disease found in Southeast Asian countries and northern Australia. Outbreaks have also been reported in Hong Kong, Taiwan, India, New Zealand, Thailand, and other parts of the world.<sup>1</sup> Melioidosis, also known as “soil fever”, is a public health issue in several countries, especially in the northeastern region of Thailand, which has the highest incidence rate in the world. The disease is of great public health importance

because of its high mortality rate and complex diagnosis; it is also a notifiable communicable disease under Thailand's Communicable Disease Act B.E. 2558 (2015).<sup>2</sup> Melioidosis is caused by the gram-negative bacterium *Burkholderia pseudomallei*, which infects humans and animals in tropical climates. These bacteria are commonly found in the environment, including soil, mud, and water sources.<sup>3</sup> Infection usually occurs through direct contact with contaminated soil or water that enters the skin, ingestion, or inhalation. After exposure, there is no vaccine, and even with treatment, the mortality rate from the disease remains at 10%-50%.<sup>4</sup> Symptoms of the disease range from asymptomatic to severe, such as fever, chills, muscle pain, pneumonia, liver and spleen abscesses, or bloodstream infection that spreads to all organs, which can lead to death.<sup>5</sup> Those with comorbidities, those with weakened immune systems, and chronic alcoholics often experience severe symptoms, which are the cause of death. The high-risk groups are farmers or those who have had prolonged contact with soil and water.<sup>6</sup>

Over the past decade, there has been a noticeable increase in the incidence of melioidosis in Thailand. In 2022 and 2023, the incidence rate rose remarkably to 5.33 and 6.4 cases per 100 000 population, respectively. Although the average annual number of cases in the past ranged between 2000 and 3000, in 2022, approximately 3500 cases were reported, and in 2023, the number exceeded 4000. Two significant peaks were observed in January and between July and October 2023. In total, 4108 cases were recorded nationwide in 2023, with an incidence rate of 6.21 per 100 000 people and 101 deaths, corresponding to a case fatality rate of 2.45%.<sup>7</sup> Compared with 2021 and 2022, this represents a 1.86-fold increase in cases. Notably, the number of deaths reported in 2022 increased 22.29 times compared with that in 2021, from 6 deaths in 2021 to 157 in 2022. In 2023, the highest incidence rates were found in Health Zone 10, Health Zone 7, and Health Zone 8, at 27.98, 13.86, and 11.7 per 100 000 population, respectively. Within Health Zone 10, the highest rates were observed in Mukdahan (46.48), Ubon Ratchathani (25.94), Amnat Charoen (24.01), Yasothon (23.94), and Sisaket (21.32). Mukdahan also recorded the highest number of deaths at 27.<sup>8</sup>

Therefore, the researchers are therefore interested in studying the factors that influence preventive behaviors against melioidosis among the population in Health Zone 10, Ubon Ratchathani. This is because the majority of the population in Health Zone 10, Ubon Ratchathani, are engaged in occupations that require prolonged contact with soil and water, such as farmers, fishermen, and gardeners. Farmers working in environments with prolonged exposure to bacteria-contaminated soil, water, and dust are at high risk of contracting melioidosis. This study also examined the health literacy factors that influence the preventive behaviors against melioidosis among the population in Health Zone 10. This study revealed reveal the health literacy factors that affect melioidosis prevention behaviors, leading to changes in prevention methods to reduce the incidence of melioidosis and providing foundational data for projects addressing melioidosis-related issues.

## Methods

### Population and Sample

This study targeted the population aged 45 and above within Health Zone 10 (covering Ubon Ratchathani, Sisaket, Yasothon, Amnat Charoen, and Mukdahan provinces). Participants were selected from districts with the highest average melioidosis incidence rates over the past 3 years (2021-2023), including Wan Yai (Mukdahan), Na Tan (Ubon Ratchathani),

and Chanuman (Amnat Charoen). Sample size was calculated using the following equation:  $n = (Np[1 - p] z_{1-\alpha/2}^2) / (d^2 [N - 1] + p[1 - p] z_{1-\alpha/2}^2)$ ,<sup>9</sup> where  $n$  is the sample size,  $N$  is the population size of 1 925 943 people,<sup>10</sup>  $z_{1-\alpha/2}^2$  is the standard value under the normal curve at a confidence level of 0.05, which is equal to 1.96,  $p$  is the prevalence proportion of melioidosis, obtained from a literature review of 0.29,<sup>11</sup> and  $d$  is the maximum acceptable error value, set to 0.05.

Based on a 95% confidence level and 80% power, the resulting sample size was 317 participants. To ensure normal data distribution and representativeness, a 5% dropout rate was added, bringing the total sample to 352. Sampling employed multistage sampling to the target population in each district, followed by simple random sampling based on the calculated sample size (78 from Wan Yai, 141 from Na Tan, and 132 from Chanuman).

This study received ethical approval from the Ubon Ratchathani Provincial Public Health Office (SSJ.UB 2568-01.005). All participants were fully informed of the study objectives and provided written informed consent before participation. They retained the right to withdraw without consequences. This study adhered to the ethical principles of respect for persons, beneficence, and justice. Potential risks and corresponding preventive measures were clearly communicated to the participants.

The inclusion criteria were as follows: ability to read, write, and communicate effectively; aged 45 or older; occupations with prolonged soil and water exposure, eg, farmers (rice cultivation, gardening, and fishing) and livestock raisers; presence of chronic diseases such as diabetes, hypertension, kidney disease, thalassemia, immunodeficiency, or chronic alcoholism; willingness to participate voluntarily; and cooperation and signed informed consent to join the study.

### Research Instruments

Data were collected using a self-administered quantitative questionnaire assessing knowledge, attitudes, and preventive behaviors regarding melioidosis. The questionnaire was divided into 5 sections: personal characteristics, knowledge of melioidosis, attitudes toward melioidosis prevention, health literacy related to melioidosis, and preventive behaviors against melioidosis.

### Variable Measurement

To ensure content validity, the questionnaire was reviewed by 5 experts, then revised according to their feedback. The item-objective congruence, was 0.93. Reliability testing was conducted through a pilot study with 30 participants from Huai Thap Than district, Amnat Charoen province, who shared demographics similar with the study population. Results were analyzed and used to refine the questionnaire and determine the reliability of the instrument by finding the Cronbach  $\alpha$  coefficient. Knowledge, attitude, awareness, and preventive behavior questionnaires had a reliability value of 0.78, 0.74, 0.91, 0.70, respectively; the entire questionnaire had a reliability value of 0.76. This was considered acceptable; therefore, the questionnaire was used to collect data from the sample group.

### Statistical Analysis

Data from the questionnaires were analyzed using statistical SPSS software version 30.0 (IBM SPSS Statistics for Windows, Version 30.0. Armonk, NY: IBM Corp; 2024) with the following procedures: descriptive statistics to summarize the characteristics of the risk groups; univariate analysis via univariable logistic regression to examine relationships between

independent variables and melioidosis preventive behaviors, reporting odds ratio (OR) with 95% confidence interval (CI); and multivariate analysis using binary logistic regression to identify independent predictors of preventive behaviors, presenting adjusted (AOR) with 95% CI. Variables with *P* values < .25 in the univariate analysis were included.<sup>12</sup> The best-fitting model was determined using backward elimination, removing variables sequentially based on likelihood ratio tests, with *P* < .05 considered statistically significant.

Results

Personal Factors

The majority of respondents were female (65.90%) aged 45-55 years (56.50%), with a mean (SD) age of 55.38 (7.82) years (median [range], 55 [45-87] years). Most had completed only primary education (47.70%) and were married (75.90%). The dominant occupation was agriculture, accounting for 80.10% of participants. Monthly family income was generally low (mean [SD], ₦6276.42 [₦5268.81]), with 37.80% earning less than ₦3000. The minimum income reported was ₦300, and the maximum reached ₦35 000 (Table 1).

| Table 1. General Information |             |
|------------------------------|-------------|
| Variable                     | No. (%)     |
| Gender                       |             |
| Male                         | 120 (34.10) |
| Female                       | 232 (65.90) |
| Age, y                       |             |
| 45-55                        | 199 (56.50) |
| 56-65                        | 120 (34.10) |
| ≥ 66                         | 33 (9.40)   |
| Education level              |             |
| Below primary                | 20 (5.70)   |
| Primary                      | 168 (47.70) |
| Lower secondary/vocational   | 79 (22.40)  |
| Upper secondary/technical    | 72 (20.50)  |
| Bachelor's degree or higher  | 13 (3.70)   |
| Marital status               |             |
| Single                       | 34 (9.70)   |
| Married                      | 267 (75.90) |
| Widowed                      | 34 (9.70)   |
| Divorced                     | 17 (4.80)   |

**Table 1. General Information (Continued)**

| Variable                         | No. (%)     |
|----------------------------------|-------------|
| Current occupation               |             |
| Agriculture (farming/gardening)  | 282 (80.10) |
| Animal husbandry                 | 11 (3.10)   |
| Homemaker                        | 17 (4.80)   |
| Business/sales                   | 12 (3.40)   |
| Government/state enterprise      | 6 (1.70)    |
| Agriculture and animal husbandry | 16 (4.50)   |
| Others                           | 8 (2.30)    |
| Monthly income, ฿                |             |
| ≤ 3000                           | 133 (37.80) |
| 3001-6000                        | 97 (27.60)  |
| > 6000                           | 122 (34.70) |
| Chronic disease                  |             |
| None                             | 238 (67.60) |
| Diabetes                         | 71 (20.20)  |
| Kidney disease                   | 5 (1.40)    |
| Thalassemia                      | 4 (1.10)    |
| Others                           | 34 (9.70)   |
| Residential environment          |             |
| Standing water near house        | 14 (4.00)   |
| Forested area nearby             | 123 (34.90) |
| Nearby ponds or marsh            | 19 (5.40)   |
| Other                            | 196 (55.7)  |

Most respondents showed high knowledge levels, totaling 248 individuals (70.50%). Those with moderate knowledge numbered 63 (17.90%), whereas 41 (11.60%) demonstrated low knowledge levels. The mean (SD) knowledge score was 12.09 (2.81).

Overall attitude scores revealed that majority (223 respondents, 63.40%) held a moderate attitude toward prevention. A notable 129 individuals (36.60%) demonstrated a high preventive attitude, with no participants exhibiting low attitude scores.

Health literacy was predominantly moderate, with 258 respondents (73.30%). High health literacy was observed in 66 individuals (18.80%); only 28 (8.00%) showed low literacy levels (Figure 1).

A total of 117 participants (33.20%) displayed risky behaviors, whereas the majority — 235 participants (66.80%) — demonstrated nonrisky preventive behaviors.

The results of binary logistic regression analysis studying factors related to melioidosis prevention behaviors among the population in Health Zone 10, Ubon Ratchathani province, found that many factors were significantly related to disease prevention behavior at the 0.05 level. Regarding age, it was found that those aged ≥ 66 years had a significantly lower chance of having inappropriate disease prevention behaviors (AOR, 0.10; 95% CI, 0.021-0.454;  $P = .003$ ) than those aged 45-55 years (reference group). Regarding education level,

the group that completed primary school had a significantly lower chance of having inappropriate disease prevention behavior (AOR, 0.02; 95% CI, 0.003-0.075;  $P < .001$ ) compared with the group with education lower than primary school (reference group). The secondary school group had significantly lower chance (AOR, 0.02; 95% CI, 0.004-0.100;  $P < .001$ ). The group with bachelor's degree or higher the least likely and significant difference was observed. Regarding occupation, using agriculture (rice farming and gardening) as the reference group, the animal husbandry group was significantly more likely to engage in inappropriate disease prevention behaviors (AOR, 7.91; 95% CI, 1.258-49.765;  $P = .027$ ). Other occupations were also significantly more likely than the reference group (AOR, 13.67; 95% CI, 3.441-54.271;  $P < .001$ ). Residential environmental factors, such as living near forests, swamps, or other areas, were not significantly associated with disease prevention behaviors ( $P > .05$ ). Regarding knowledge about melioidosis, those with high knowledge were significantly less likely to engage in inappropriate disease prevention behaviors (AOR, 0.10; 95% CI, 0.036-0.263;  $P < .001$ ) than those with low knowledge (the reference group). Those with moderate knowledge showed no significant difference ( $P = .236$ ). Health literacy and access to health information and services, both at moderate and high levels, showed no significant relationship with disease prevention behaviors ( $P > .05$ ). Health literacy and understanding health information and services at either moderate or high levels showed no significant relationship with disease prevention behaviors ( $P > .05$ ) (Table 2).

Figure 1. Percentage of Knowledge, Attitude, and Perception

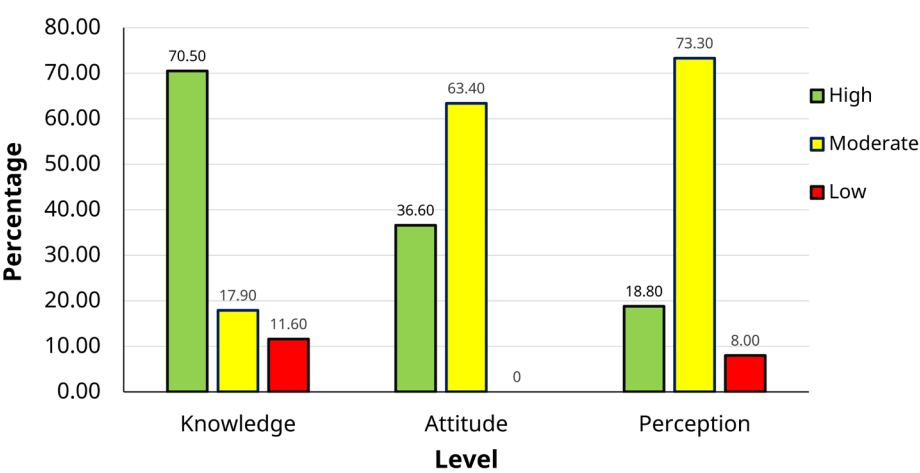


Table 2. Binary Logistic Regression Analysis to Identify Factors Influencing Melioidosis Prevention Behaviors Among the Population in Health Zone 10, Ubon Ratchathani Province

| Variable | No. of Participants<br>(n = 117) | Regression<br>Coefficient | AOR           | 95% CI | P Value |
|----------|----------------------------------|---------------------------|---------------|--------|---------|
| Age, y   |                                  |                           |               |        |         |
| 45-55    | 69                               | 0                         | 1 [Reference] | NA     | NA      |
| 56-65    | 44                               | 0.47                      | 0.847-3.049   | 1.61   | .147    |
| ≥ 66     | 4                                | -2.32                     | 0.021-0.454   | 0.10   | .003    |

**Table 2. Binary Logistic Regression Analysis to Identify Factors Influencing Melioidosis Prevention Behaviors Among the Population in Health Zone 10, Ubon Ratchathani Province (Continued)**

| Variable                                                                | No. of Participants<br>(n = 117) | Regression<br>Coefficient | AOR           | 95% CI | P Value |
|-------------------------------------------------------------------------|----------------------------------|---------------------------|---------------|--------|---------|
| Education level                                                         |                                  |                           |               |        |         |
| Less than primary education                                             | 15                               | 0                         | 1 [Reference] | NA     | NA      |
| Primary education                                                       | 47                               | -4.14                     | 0.003-0.075   | 0.02   | < .001  |
| Secondary education                                                     | 53                               | -3.89                     | 0.004-0.100   | 0.02   | < .001  |
| Bachelor's degree or higher                                             | 2                                | -5.60                     | 0-0.059       | 0      | < .001  |
| Current occupation                                                      |                                  |                           |               |        |         |
| Agriculture (farming and gardening)                                     | 87                               | 0                         | 1 [Reference] | NA     | NA      |
| Animal husbandry (cattle, pig, etc)                                     | 9                                | 2.07                      | 1.258-49.765  | 7.91   | .027    |
| Homemaker                                                               | 4                                | 0.27                      | 0.297-5.749   | 1.31   | .724    |
| Self-employed/trader                                                    | 4                                | 1.52                      | 0.997-21.1    | 4.59   | .050    |
| Government / state enterprise                                           | 1                                | 0.69                      | 0.153-26.178  | 2.00   | .597    |
| Agriculture and animal husbandry                                        | 11                               | -0.84                     | 0.046-4.036   | 0.43   | .461    |
| Others                                                                  | 1                                | 2.62                      | 3.441-54.271  | 13.67  | < .001  |
| Residential environment                                                 |                                  |                           |               |        |         |
| Water stagnation near house                                             | 5                                | 0                         | 1 [Reference] | NA     | NA      |
| Forest near house                                                       | 43                               | -0.86                     | 0.086-2.066   | 0.42   | .287    |
| Pond/lake near house                                                    | 12                               | 1.38                      | 0.615-25.557  | 3.97   | .147    |
| Others                                                                  | 57                               | -0.49                     | 0.135-2.776   | 0.61   | .525    |
| Knowledge about melioidosis                                             |                                  |                           |               |        |         |
| Low                                                                     | 30                               | 0                         | 1 [Reference] | NA     | NA      |
| Moderate                                                                | 31                               | -0.66                     | 0.174-1.539   | 0.52   | .236    |
| High                                                                    | 56                               | -2.33                     | 0.036-0.263   | 0.10   | < .001  |
| Health literacy: accessing health information and services              |                                  |                           |               |        |         |
| Low                                                                     | 35                               | 0                         | 1 [Reference] | NA     | NA      |
| Moderate                                                                | 64                               | -0.62                     | 0.258-1.115   | 0.54   | .095    |
| High                                                                    | 18                               | -0.88                     | 0.157-1.099   | 0.42   | .077    |
| Health literacy: understanding health information and services          |                                  |                           |               |        |         |
| Low                                                                     | 43                               | 0                         | 1 [Reference] | NA     | NA      |
| Moderate                                                                | 49                               | -0.10                     | 0.449-1.833   | 0.91   | .785    |
| High                                                                    | 25                               | 0.41                      | 0.599-3.823   | 1.51   | .381    |
| Health literacy: communication and questioning for better understanding |                                  |                           |               |        |         |
| Low                                                                     | 23                               | 0                         | 1 [Reference] | NA     | NA      |
| Moderate                                                                | 49                               | -1.38                     | 0.072-0.879   | 0.25   | .031    |
| High                                                                    | 45                               | -1.41                     | 0.065-0.923   | 0.25   | .038    |
| Health literacy: health decision-making                                 |                                  |                           |               |        |         |
| Low                                                                     | 21                               | 0                         | 1 [Reference] | NA     | NA      |
| Moderate                                                                | 64                               | 0.94                      | 0.955-6.818   | 2.55   | .062    |
| High                                                                    | 32                               | -0.07                     | 0.28-3.104    | 0.93   | .909    |

**Table 2. Binary Logistic Regression Analysis to Identify Factors Influencing Melioidosis Prevention Behaviors Among the Population in Health Zone 10, Ubon Ratchathani Province (Continued)**

| Variable                                           | No. of Participants<br>(n = 117) | Regression<br>Coefficient | AOR           | 95% CI | P Value |
|----------------------------------------------------|----------------------------------|---------------------------|---------------|--------|---------|
| Health literacy: self-health behavior modification |                                  |                           |               |        |         |
| Low                                                | 16                               | 0                         | 1 [Reference] | NA     | NA      |
| Moderate                                           | 44                               | -1.33                     | 0.062-1.143   | 0.27   | .075    |
| High                                               | 57                               | -1.52                     | 0.05-0.961    | 0.22   | .044    |
| Health literacy: sharing health information        |                                  |                           |               |        |         |
| Low                                                | 19                               | 0                         | 1 [Reference] | NA     | NA      |
| Moderate                                           | 66                               | 0.20                      | 0.439-3.414   | 1.23   | .698    |
| High                                               | 32                               | 0.09                      | 0.341-3.476   | 1.09   | .886    |

Abbreviations: AOR, adjusted odds ratio; NA, not applicable.

The predictive equation can be written as follows:  $\text{Logit}(y) = 2.83 - 1.17\text{Know} + 0.75\text{Atti} - 0.60\text{HL}$ . From the aforementioned equation, the probability of the public's behavior in preventing melioidosis in Health Zone 10, Ubon Ratchathani, can be predicted as follows:  $P(\text{preventive behavior}) = \frac{e^{2.83 - 1.17\text{Know} + 0.75\text{Atti} - 0.60\text{HL}}}{1 + e^{2.83 - 1.17\text{Know} + 0.75\text{Atti} - 0.60\text{HL}}}$ . If  $P < 0.5$ , it is concluded that there is no effect on the preventive behavior against melioidosis. If  $P \geq 0.5$ , it is concluded that there is an effect on the preventive behavior against melioidosis.

The analysis results showed that the variables significantly influencing preventive behavior against melioidosis ( $P < .05$ ) are knowledge about melioidosis and health literacy. Insufficient knowledge is associated with a decrease in preventive behavior (OR, 0.309;  $P < .001$ ), whereas good health literacy tends to increase the likelihood of exhibiting preventive behavior against melioidosis (OR, 2.020;  $P = .030$ ).

Discussion

This study revealed that melioidosis prevention behaviors among the sample in Health Zone 10 were influenced by several key factors, including age, education level, occupation, living environment, disease knowledge, and specific dimensions of health literacy.

Those aged 66 and over had a significantly lower incidence of inappropriate disease prevention behaviors than the reference group, aged 45-55 years. This suggests that older adults are more prone to disease prevention practices. These findings are consistent with existing health behavior models across the lifespan.<sup>13, 14</sup>

Regarding education level, those with primary and secondary education were significantly less likely to engage in inappropriate disease prevention behaviors than those with less than primary education. Those with a bachelor's degree or higher were significantly less likely to engage in inappropriate disease prevention behaviors, and this difference was also significant. These results suggest a relationship between higher education and a greater likelihood of engaging in appropriate disease prevention behaviors.<sup>15</sup>

Regarding occupational factors, using agriculture as the reference group, animal farmers were significantly more likely to engage in inappropriate disease prevention behaviors, as were other occupations not categorized as specific. This suggests that certain

occupations are more likely to engage in inadequate disease prevention behaviors than the reference group.<sup>13, 16, 17</sup>

Regarding living environment No significant relationship was found between living near forests, standing water, swamps, or other areas and disease prevention behaviors. The analysis showed no statistically significant differences across all groups.<sup>3, 11, 16</sup>

Regarding knowledge about melioidosis, those with high knowledge were significantly less likely to engage in inappropriate disease prevention behaviors than those with low knowledge. However, those with moderate knowledge showed no significant differences from the reference group.<sup>8, 16</sup>

Finally, health literacy, including access to health information and services and understanding health information and services, showed no statistically significant relationship with disease prevention behaviors. The values at each health literacy level did not differ significantly from the reference group.

In future studies, the sample population should be expanded to include other areas within Health Zone 10 or different regions with varying contexts. This would allow for comparative analysis, enhance the diversity of influencing factors on melioidosis prevention behavior, and improve the generalizability and applicability of research findings on a broader scale.

Although this study primarily employed a quantitative approach, future research should consider incorporating qualitative methods, such as in-depth interviews or focus group discussions. These methods would provide deeper insights into attitudes, motivations, and constraints affecting individuals' preventive behaviors, thereby contributing to a more comprehensive understanding of the issue.

Such qualitative insights could support the development of community-contextualized health promotion programs aimed at improving melioidosis prevention behaviors. Moreover, future studies should include intervention trials to implement and evaluate the effectiveness of such programs in targeted populations.

## Conclusions

This study demonstrated that melioidosis prevention behaviors among individuals in Health Zone 10 were significantly associated with selected sociodemographic characteristics and disease-related knowledge. Older adults aged  $\geq 66$  years were less likely to exhibit inappropriate prevention behaviors than younger age groups. Higher educational attainment was consistently associated with more appropriate preventive practices. Occupational differences were evident, with animal farmers and other nonagricultural occupations showing a higher likelihood of inappropriate prevention behaviors. Knowledge of melioidosis played an important role, as individuals with high knowledge levels demonstrated better preventive behaviors. In contrast, living environment factors and dimensions of health literacy related to access and understanding of health information were not significantly associated with prevention behaviors. Overall, the findings highlight the importance of demographic characteristics and disease-specific knowledge in shaping melioidosis prevention behaviors.

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Formal Analysis: All authors

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# A Qualitative Study Exploring COVID-19 Vaccine Hesitancy and Refusal Among Unvaccinated Patients Visiting Family Physicians in Bangkok, Thailand

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## Abstract

**Background:** Vaccine hesitancy and refusal are critical barriers to achieving herd immunity against COVID-19. Despite widespread vaccine availability nationwide, some people remain unvaccinated.

**Objective:** To explore reasons for COVID-19 vaccine hesitancy and refusal among unvaccinated patients visiting family physicians at the Department of Family Medicine, Faculty of Medicine Ramathibodi Hospital.

**Methods:** A qualitative study collected data using in-depth semi-structured telephone interviews between 24 March 2022 and 16 June 2022. All recruited participants had never received COVID-19 vaccination and were registered patients at the Family Medicine outpatient clinic, Ramathibodi Hospital. The interviews were conducted in Thai, digitally recorded, and transcribed verbatim. They were reviewed for accuracy and analyzed using thematic analysis.

**Results:** Thirteen participants, aged 55 to 83 years, were interviewed. Four themes were identified: 1) fear of vaccination, particularly concerns about side effects; 2) vaccine safety and effectiveness, safety and efficacy concerns, and perceptions of vaccines as “emergency vaccines”; 3) health information, especially negative vaccine/health content from social media and mainstream news; and 4) personal health beliefs, including reliance on self-care, hygiene, and Thai herbal medicine as alternatives. Most participants (92%) stated they would continue refusing vaccination despite availability.

**Conclusions:** Vaccine hesitancy and refusal were driven by fear of side effects, personal beliefs, and exposure to negative health information. Therefore, it is strongly recommended that health sectors develop a knowledge management platform to disseminate evidence-based health information that is widely accessible. This would enable patients to make well-informed and autonomous decisions.

**Keywords:** COVID-19 vaccine hesitancy and refusal, Infodemic, Qualitative methods, Primary care, Patient-centeredness

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## Introduction

The COVID-19 pandemic was declared by the World Health Organization (WHO) on 11 March 2020.<sup>1</sup> Thailand experienced 5 distinct waves of COVID-19 between January 2020 and March 2022. The first wave began with clusters of cases at Bangkok nightlife venues, boxing stadiums, and returning travelers from overseas, resulting in widespread transmission throughout the country.<sup>2,3</sup> By March 2022, there had been more than 3.2 million COVID-19 cases and over 23 000 deaths reported, which caused a strained healthcare system.<sup>4,6</sup>

At the time of this research, various types of COVID-19 vaccines were readily available nationwide. On 17 December 2021, the WHO Emergency Use Listing (EUL) approved 9 vaccines to combat increasing global infection rates.<sup>7</sup> Each functioned using messenger RNA (mRNA), adenovirus vector, whole inactivated coronavirus, or protein subunit mechanisms.<sup>8</sup> In Thailand, the National Vaccine Institute chose the AstraZeneca COVID-19 vaccine for people over 60, and CoronaVac, an inactivated vaccine, for individuals aged 18 to 60.<sup>9, 10</sup> The allocation of vaccines was done according to WHO guidelines, prioritizing the “608” groups, which include high-risk individuals defined as those aged 60 years or older and those with 1 of 8 preexisting health conditions, such as diabetes mellitus, chronic kidney disease, cardiovascular disease, chronic respiratory disease, obesity, cancer, or pregnancy.<sup>11, 12</sup> Following the COVID-19 vaccine rollout that began in March 2021, as of 28 January 2022, 72.97% of the Thai people had received at least one dose of the vaccine<sup>13</sup> while coverage of older adults aged 60 and above was 75.1%.<sup>14</sup> Vaccination has been hailed as the most significant public health achievement, contributing to the decline in mortality and morbidity rates from various infectious diseases.<sup>15</sup> In particular, during the COVID-19 pandemic, vaccination is the primary measure for controlling the outbreak. However, according to the WHO, vaccine hesitancy has remained one of the top 10 global health problems.<sup>16</sup> This hesitancy refers to the refusal or delay of vaccination despite the availability of vaccine services. It affects the achievement of herd immunity and increases the risk of disease transmission. In the case of COVID-19, the rapid development of vaccines and the political dimensions surrounding vaccination further intensified public reluctance. Vaccine hesitancy is a context-specific phenomenon that varies across time, place, and vaccine type.<sup>17</sup>

Data from previous studies have shown that factors affecting COVID-19 vaccine hesitancy included perceptions of vaccine importance, efficacy, safety, concerns about side effects, low confidence in the vaccine, mistrust in the government, vaccine accessibility, and personal or religious beliefs.<sup>8, 14</sup> Understanding why patients may opt out of COVID-19 vaccination despite the vaccine being readily available and highly effective in controlling the pandemic, providing protection from severe illness, and reducing the mortality rate if infected is essential. This study aimed to investigate the reasons behind vaccine hesitancy among patients visiting the Family Medicine outpatient clinic at the Faculty of Medicine Ramathibodi Hospital. To acknowledge and accept patients’ rights and autonomy in decision making.

## Methods

### Study Design and Participants

The study used a qualitative approach, with in-depth semi-structured telephone interviews to explore vaccine hesitancy. The study was conducted among patients who visited family physicians at the Department of Family Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University, a tertiary university hospital in Bangkok, Thailand. Participants who had opted against vaccination are considered a minority group, and this research study aimed to avoid any prejudice by taking a neutral stance to explore and understand their reasons for refusing COVID-19 vaccination.

The data collection period coincided with Thailand’s fifth wave of the Omicron variant of COVID-19, during which the national vaccination rate was approximately 80%.<sup>13</sup>

All interviews were conducted between 24 March 2022 and 16 June 2022. Data saturation was the criterion used to determine when to conclude data gathering.

Participants were recruited if they were registered at the Department of Family Medicine, Faculty of Medicine Ramathibodi Hospital, and had not previously received a COVID-19 vaccine. Eligible participants were required to be at least 18 years of age and able to read and understand the Thai language.

Participants were excluded if they declined to participate in the study. Participants with diagnosed mental illness or cognitive impairment that substantially impaired informed consent were excluded. If a participant felt uncomfortable or did not wish to respond, they could decline to answer any questions or withdraw from the study at any time.

### Data Collection

A purposive sampling method was used to select participants who met the criteria of being registered patients at the Department of Family Medicine, Faculty of Medicine Ramathibodi Hospital, and who had not received a COVID-19 vaccination. Participants' COVID-19 vaccination histories were verified at the nurse registration counter in the Family Medicine outpatient clinic. Once eligible participants had been identified, they were discreetly approached by the researcher to avoid potential stigma.

The researcher explained the study's objectives and obtained informed consent for participation in the qualitative research, including permission for audio recording of the interviews. The vaccine history interview and subsequent recruitment process were conducted exclusively for research purposes and were not part of routine vaccination screening or counseling. To ensure participant privacy, all recruitment discussions were conducted confidentially by research staff and were separate from the clinical workflow.

Participants were subsequently contacted by the researcher via telephone to provide detailed information about the scheduled date and time of the interview. Verbal consent was obtained from each participant before conducting the interviews, which were carried out in the Thai language and lasted between 30 and 60 minutes. Field notes were taken during the interviews. All interviews were conducted via telephone and audio-recorded in accordance with the guidelines of the Human Research Ethics Committee, Faculty of Medicine Ramathibodi Hospital.

Participants were interviewed one-on-one using an in-depth semi-structured telephone interview approach. They were asked a set of questions compiled by the researchers based on the vaccine hesitancy questionnaire developed by the WHO and adapted for the Thai context (Table 1).

### Data Analysis

All audio recordings were transcribed verbatim in Thai by the researcher. The identities of all participants were removed. Thematic analysis was conducted using the 6-stage comprehensive thematic analysis approach developed by Braun et al.<sup>18</sup> Themes and subthemes were coded using Microsoft Excel, version 2013 (Microsoft Corp). All researchers independently reviewed the transcripts multiple times, identified meaningful quotations, and established relevant themes. The results were validated and agreed upon by all researchers, then translated into English by a bilingual researcher, who subsequently verified them with all members of the research team.

## Results

### Participants Characteristics

Thirteen participants, aged 55 to 83 years, were interviewed. Over 69% of participants were above the age of 60. Most participants (84%) had a preexisting health condition and visited family physicians to manage their health conditions. If given a chance to receive the COVID-19 vaccination of their choice, 12 participants (92%) stated that they would still refuse, while 1 participant expressed hesitancy and may reconsider in the future. More than 60% of the interviewed participants lived in Bangkok, while the remaining lived in rural provinces (Table 2).

**Table 1. Questionnaire for In-Depth Interviews**

#### Questionnaire

- 1) Have you ever registered for COVID-19 vaccination?
- 2) Have you encountered any obstacles or events related to vaccination in the past that may have resulted in a refusal to be vaccinated against COVID-19?
- 3) What is your opinion about the vaccine against COVID-19?
- 4) Do you have a preference for any type of COVID-19 vaccination?
- 5) Have you encountered obstacles or difficulties in registering for the COVID-19 vaccination?
- 6) Have you received any information regarding the COVID-19 vaccine?  
If yes: Where did the source of the information come from?  
Examples: newspapers, news, social media, relatives, friends
- 7) Has anyone advised you to get vaccinated against COVID-19?
- 8) Has anyone prevented you or warned you not to get COVID-19 vaccination?
- 9) If you were given the opportunity to get vaccinated against COVID-19, what would your decision be? Please tell me more about this.
- 10) If a relative or someone you know has been vaccinated against COVID-19, what is your opinion regarding this?

**Table 2. Baseline Characteristics of Participants**

| Characteristic | No. (%)    |
|----------------|------------|
| Age, y         |            |
| 50-59          | 4 (30.77)  |
| 60-69          | 3 (23.08)  |
| 70-79          | 4 (30.77)  |
| 80-89          | 2 (15.38)  |
| Gender         |            |
| Male           | 2 (15.38)  |
| Female         | 11 (84.62) |
| Marital status |            |
| Single         | 3 (23.08)  |
| Married        | 8 (61.54)  |
| Widowed        | 2 (15.38)  |

**Table 2. Baseline Characteristics of Participants (Continued)**

| Characteristic              | No. (%)   |
|-----------------------------|-----------|
| Education                   |           |
| Primary education           | 5 (38.46) |
| Secondary education         | 2 (15.38) |
| Higher education            | 6 (46.15) |
| Underlying diseases         |           |
| None                        | 2 (15.38) |
| Diabetes                    | 4 (30.77) |
| Dyslipidemia                | 7 (53.85) |
| Hypertension                | 8 (61.54) |
| Chronic kidney disease      | 1 (7.69)  |
| Osteoarthritis              | 1 (7.69)  |
| Asthma                      | 1 (7.69)  |
| Hyperthyroidism             | 2 (15.38) |
| Thalassemia                 | 1 (7.69)  |
| Osteoporosis                | 1 (7.69)  |
| Number of diseases          |           |
| 0                           | 2 (15.38) |
| 1                           | 1 (7.69)  |
| 2                           | 7 (53.85) |
| > 2                         | 3 (23.08) |
| Living place                |           |
| Bangkok Metropolitan region | 8 (61.54) |
| Central region              | 2 (15.38) |
| Eastern region              | 1 (7.69)  |
| North eastern region        | 1 (7.69)  |
| Southern region             | 1 (7.69)  |
| Occupation                  |           |
| Unemployed                  | 2 (15.38) |
| Employed                    | 5 (38.46) |
| Retired                     | 6 (46.15) |
| Health entitlements         |           |
| Universal Health Coverage   | 2 (15.38) |
| Social security scheme      | 1 (7.69)  |
| Civil servant               | 6 (46.15) |
| Self-pay                    | 4 (30.77) |

## Themes

This study revealed 4 main themes contributing to COVID-19 vaccine hesitancy and refusal among unvaccinated patients: fear of vaccination, vaccine safety and effectiveness, health information, and personal health beliefs. The details of each theme are described below.

### 1) Fear of Vaccination

Fear of vaccination was apparent among most participants. One of the main concerns voiced by most participants was the potential side effects that could worsen their current health status. For some participants, their hesitancy grew stronger after hearing first-hand negative health information from people around them.

[ID01]: *"I have witnessed friends suffering from strokes and dying after vaccination."*

[ID06]: *"Fear of side effects, I have an underlying disease, so I'm scared."*

[ID09]: *"I have many chronic diseases. So, I was terrified."*

The rapid timeline from the first cases of COVID-19 to vaccine development also led many participants to question the legitimacy of the vaccines.

[ID01]: *"Listen to the news, and this vaccine has been researched for less than one year, only 6 months, and the vaccine was studied for 6 months and developed to be given to the mass population. How come? It seems like using people as a testing tool!"*

[ID02]: *"Because there is no confidence in the vaccine. Which vaccine has been developed in under 2 years? There is no way I would believe in a vaccine fully developed in this timeframe."*

### 2) Vaccine Safety and Effectiveness

Apart from concerns about side effects, the continued rise in COVID-19 infections among the vaccinated population raised doubts about vaccine safety and effectiveness.

[ID05]: *"My reason is that I do not trust the vaccines... Also, if I receive the vaccine, I could still get infected... People who have received 1, 2, 3, or 4 doses still get infected. I don't want to put my life at risk."*

[ID09]: *"When my son got infected with COVID-19, it further made me doubt the vaccine's protection capabilities."*

[ID10]: *"My boyfriend got infected, despite having four doses of vaccination. So, my point of view is that vaccination doesn't help. It's like taking something into our body."*

[ID11]: *"I want more assurance from the general population getting vaccinated. Despite the high infectivity rate and aim to achieve herd immunity, our lives are also essential."*

Two participants noted that the term used to describe all COVID-19 vaccines was emergency vaccines. They pointed out that the manufacturers would be utterly immune to any unforeseen circumstances that may arise.

[ID07]: *"I believe that worldwide vaccines, no matter which country developed them, are all called 'emergency vaccines', and even if anything happens, there will be no accountability."*

[ID13]: *"This vaccine, just like the drugs, is for emergency use, and it's not 100% protective."*

### 3) Health Information

Nine participants reported exposure to negative news about COVID-19 vaccines, including reports of adverse effects and potential future harm. Most of this information was obtained from social media platforms such as the LINE application, YouTube, Facebook, and from mainstream Thai news channels. Such information heightened their fears and further reduced their willingness to get vaccinated.

[ID03]: "I got frightened by the news on television. The news anchor kept on repeating, 'another death'... He would keep on repeating news on people dying from vaccination."

[ID08]: "I watched the news, they kept on saying, 'Have you seen this effect and that effect?' This made me scared."

#### 4) Personal Health Beliefs

Many participants discussed self-care and hygiene, as well as using Thai herbal medicine as a safe and natural method to prevent diseases. These remedies are unique and have cultural significance in Thailand.

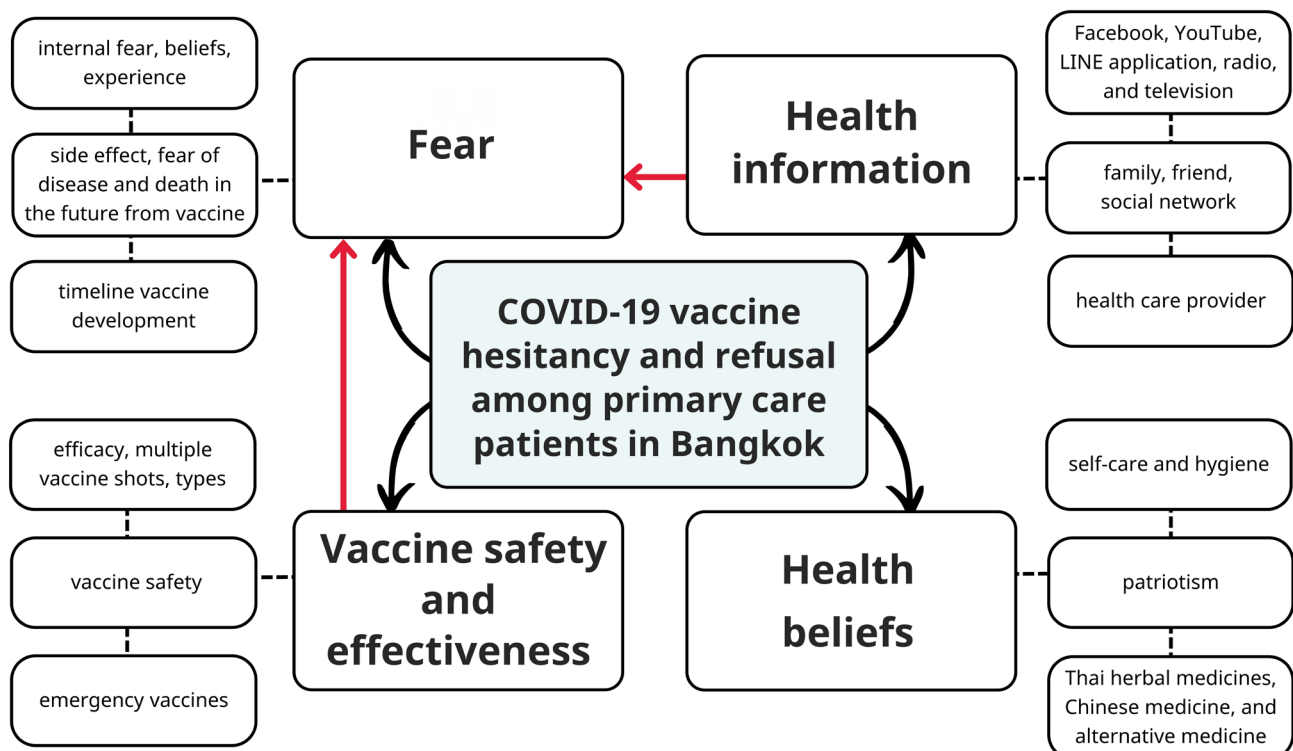
[ID01]: "I eat foods that are spicy, hot, and herbs... I eat basil leaves, kaffir lime leaves, galangal, lemongrass, and Tom Yam condiments."

[ID03]: "When I hear about COVID news, I take ginger water as it has anti-inflammatory properties. When I have nasal congestion, I mix boiled onions with boiling water and inhale to help clear congestion."

[ID07]: "I carry a small bottle of alcohol gel with me and always wear a mask. I have noticed that Japanese people have been wearing masks when they are ill for quite some time. When everyone wears a mask, it helps reduce the transmission of diseases."

The qualitative data showed that vaccine safety concerns, doubts regarding vaccine effectiveness, and negative health information were closely linked to the fear of vaccination (Figure 1).

**Figure 1. Themes of COVID-19 Vaccine Hesitancy and Refusal Among Unvaccinated Patients**



## Discussion

This study revealed 4 themes affecting COVID-19 vaccine hesitancy and refusal among unvaccinated patients in a Family Medicine outpatient clinic at the Faculty of Medicine Ramathibodi Hospital. Fear of vaccination was the most decisive factor among participants in this study. This is in line with previous studies citing fear as a driving factor in decision-making.<sup>19</sup> This study observed that most participants who had opted out of vaccination were older adults over 60. The older adults are considered the most vulnerable group with the highest mortality and morbidity rates from COVID-19 infection, and they also have a high rate of vaccination hesitancy.<sup>20</sup> Many participants expressed concerns that potential side effects could worsen their health. Consistent with previous studies, reported concerns about vaccine side effects played a significant role in vaccine hesitancy.<sup>8, 11</sup> Especially among older adults, the primary concerns were the risk of serious adverse events following immunization, such as complications related to age and existing medical conditions and death.<sup>14</sup> Other studies have reported that vaccine hesitancy and refusal were due to the fear of side effects, concerns of safety and efficacy, and the short duration of clinical trials.<sup>21</sup>

This study found that beliefs/doubts about vaccine safety and effectiveness significantly contributed to hesitancy and refusal among participants. Some data have expressed that vaccination did not reduce the transmission of the virus.<sup>17</sup> Furthermore, some qualitative studies on COVID-19 vaccine hesitancy among unvaccinated Americans have reported factors contributing to hesitancy or refusal, including concerns about the safety of COVID-19 vaccines.<sup>22</sup>

The continued lack of reliable health information concerning COVID-19 vaccine remains a significant public health challenge. Findings from this study indicate that the “infodemic” — an excessive spread of both accurate and inaccurate information — had an impact on patients’ anxiety levels and negative perceptions towards vaccination.<sup>23, 24</sup> This information spreads quickly through digital and physical channels much like a disease, complicating the public’s ability to access reliable information.<sup>25</sup> Some studies have identified social media as a primary source of vaccination information and this trend is contributing to vaccine hesitancy.<sup>10</sup> Consequently, it is imperative that healthcare professionals actively disseminate accurate, evidence-based information to counter misinformation.<sup>26</sup>

Nevertheless, in people who do not receive COVID-19 vaccine, this may be due to their personal beliefs in caring for and protecting their health. Especially in Thailand, where there is a view that “food as herbal medicine”. Previous research has reported that functional medicinal plants may help enhance the immune system and manage respiratory tract infections.<sup>27</sup> Moreover, some studies reported that traditional medicine is being considered a possible treatment for COVID-19, and the WHO is working with some research institutions around the world to select traditional medicine products with potential use for the treatment of COVID-19.<sup>28</sup>

An earlier study on COVID-19 vaccine resistance among Thai seniors highlighted factors contributing to hesitation, including low education, lack of trust in the healthcare system, and questionable vaccine selection by government authorities.<sup>29</sup> Younger citizens may also have had easier access to immunization due to their technological skills, as registration were online. It has been widely reported that many older adults faced difficulties navigating online vaccination platforms and struggled to get vaccinated.<sup>30, 31</sup>

However, many individuals in the working-age population may have been subjected to mandatory vaccinations in the workplace, which can be viewed as paternalistic.<sup>32, 33</sup>

Mandatory vaccination has been shown to increase vaccination rates in some contexts, however ethical concerns regarding vaccine mandates and patient autonomy remain.<sup>8</sup> This study found that media personnel and healthcare workers impacted decision-making. In the future, unbiased and evidence-based information should be provided while respecting an individual's autonomy in making health-related decisions.

Several studies used the "5C Model" to describe major factors of vaccine hesitancy, which are confidence (importance, safety, and efficacy of vaccine); convenience (context-specific access issues related to time and vaccine availability); communication (sources of information); context (ethnicity, religion, occupation, and socioeconomic factors); and complacency (perception of low risk and low disease severity).<sup>24, 25, 34</sup> This study found that the participants' responses aligned with the model in the domains of confidence, communication, convenience, and context. This model is a practical framework for understanding vaccine hesitancy.

### Strengths and Limitations

The study offers insights into vaccine perceptions within specific sociocultural and healthcare contexts in Thailand, enhancing an understanding of beliefs about self-care, herbal medicine, and local attitudes toward vaccination.

Despite achieving data saturation, this study has limitations. The sample size was small and primarily consisted of female participants, which limited representation of the male perspectives. The data collection occurred during the fifth wave of COVID-19, between March 2022 and June 2022, toward the end of the pandemic. This timing may have excluded certain groups, such as individuals subject to mandatory vaccination, from participation.

### Recommendations

This study focused only on patients and did not incorporate the perspectives of healthcare professionals. Including healthcare providers in future studies would enable comparative analysis between patients' and clinicians' views on vaccine hesitancy. Additionally, all participants were adults aged 55 to 83 years, excluding younger populations and children. Future studies should therefore include a wider age range to capture generational differences in vaccine attitudes and behaviors.

## Conclusions

The study found that vaccine hesitancy and refusal among patients were primarily driven by fear of side effects, concerns about vaccine safety and effectiveness, personal beliefs, and exposure to inaccurate information from various sources. Most participants relied on their sense of autonomy to guide decision-making. The study also demonstrated the prevalence of an infodemic, with a relatively high amount of health information, both online and offline, significantly influencing decision-making. Therefore, government agencies should develop a knowledge management platform that disseminates widely-accessible evidence-based health information. Such a platform would enable patients to make well-informed and autonomous decisions.

### Additional Information

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# Factors Associated With Homework Adherence in Cognitive Behavioral Therapy

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## Abstract

**Background:** Homework is a central component of cognitive behavioral therapy (CBT), promoting the application of therapeutic skills in daily life. However, adherence to homework varies and may be influenced by multiple factors, particularly among young people.

**Objectives:** To identify factors associated with homework adherence in CBT, and to examine these factors specifically in young people.

**Methods:** A cross-sectional descriptive study was conducted with 79 clients receiving CBT through the “Therapist Volunteers” project or the outpatient psychiatry clinic at Ramathibodi Hospital, along with 47 therapists. Data were collected from January 2024 to September 2024. Measures included the Working Alliance Inventory - Short Revised, the Situational Motivation Scale, SCORE-15, Homework Rating Scale II, Homework Compliance Scale, and Clinical Global Impression - Improvement Scale. Descriptive and inferential statistics, including multiple regression analysis, were used.

**Results:** The mean age of participants was 26.06 years; 82.3% were female. Therapeutic alliance, intrinsic motivation, and identified regulation were significantly associated with homework adherence ( $P < .05$ ). Among young people, therapeutic alliance, identified regulation, and therapist experience were positively associated with homework adherence. Both self-reported homework adherence and therapist-rated completion were significantly correlated with clinical improvement ( $P < .01$ ).

**Conclusions:** A strong therapeutic alliance, along with intrinsic motivation and identified regulation, play crucial roles in enhancing homework adherence and clinical outcomes in CBT. For young people, therapist experience and tailored support strategies may further strengthen treatment engagement.

**Keywords:** Homework adherence, Cognitive behavioral therapy, Therapeutic alliance, Intrinsic motivation, Identified regulation

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## Introduction

At present, a large number of people are seeking treatment for mental health problems, with available treatment options including pharmacological treatment, environmental modifications, and various forms of psychotherapy. One widely recognized and effective form of psychotherapy is cognitive behavioral therapy (CBT), which emphasizes the interrelationship among thoughts, emotions, behaviors, and physical sensations. The core principle of CBT is that these 4 elements are interrelated and influence one another.

Therefore, changing one aspect can result in changes in the others. CBT has been shown to be effective, particularly in treating depression and anxiety disorders.<sup>1</sup>

CBT is supported by extensive research evidence for its effectiveness. It can be applied to a wide range of psychological problems and promotes long-term self-reliance in clients. However, its effectiveness depends on the client's cooperation, consistency in completing homework assignments, and the therapist's ability to tailor interventions to each individual. CBT is a structured and systematic form of therapy that requires active participation and commitment from both parties. It typically involves 6 steps: 1) checking in; 2) reviewing homework or content from the previous session; 3) setting the agenda; 4) discussing the session content; 5) summarizing and providing feedback; and 6) assigning new homework. Clients usually attend one session per week, each lasting about 45 minutes to 1 hour, with treatment typically lasting 6-12 or 12-20 sessions depending on goals and treatment plans.<sup>2, 3</sup>

Each component of the CBT process plays an important role in effective treatment. Previous studies have shown that homework is an essential component associated with symptom improvement.<sup>4-6</sup> Homework refers to tasks or exercises mutually agreed upon by the therapist and client to be practiced in daily life outside of therapy sessions. The purpose is to help clients apply the knowledge and skills learned in therapy to real-life situations, improve problem-solving abilities, and promote adaptive behaviors and thought patterns.<sup>7</sup>

Homework may take various forms, such as thought records to identify and challenge negative automatic thoughts, relaxation training (eg, deep breathing or mindfulness), exposure to feared or avoided situations, or behavioral activation to increase daily activities. Many studies have found that homework adherence significantly contributes to treatment success. Clients who complete homework regularly tend to have better treatment outcomes. Therapists who build trust, demonstrate consistency, and maintain credibility can help clients transfer learned skills into daily life, thereby supporting sustained improvement and preventing relapse.<sup>8-10</sup> Therefore, therapists and clients should emphasize the collaborative design of homework assignments to increase the likelihood of completion and engagement.

Although homework is an important part of CBT, previous research has identified several factors that influence adherence. These can be categorized into 3 main categories. Therapist-related factors are among the most significant. The therapeutic relationship, built through trust and understanding, creates a foundation that allows clients to feel confident in following recommendations. In addition, the therapist's ability to explain assignments clearly and to design tasks appropriate to the client's needs or capacities can improve adherence. The therapist's own beliefs about the importance of homework may also shape the client's perception of its value.<sup>11-14</sup>

Client-related factors also play a key. Motivation depends on how clients perceive the value and difficulty of the task, as well as their alignment with personal goals. If clients view homework as valuable and feasible, they are more likely to complete it.<sup>15, 16</sup> Motivation can be conceptualized according to self-determination theory<sup>17</sup> and classified into 4 types: 1) intrinsic motivation, where clients engage in homework for inherent interest or enjoyment; 2) identified regulation, reflecting the perceived personal value of assignments; 3) external motivation, driven by rewards or external pressures; and 4) amotivation, indicating a lack of intention or perceived value. These motivational types influence self-regulation and engagement. Attitudes toward therapy (eg, whether homework is viewed as necessary or burdensome),<sup>18, 19</sup> time management, and comprehension of assignment also affect adherence.<sup>20, 21</sup>

Family-related factors are especially relevant for young people. At the end of each session, therapist often provides guidance to family members to support the client. Families with good problem-solving skills and supportive environment are more likely to encourage consistent homework adherence and reduce stress around assignments.<sup>22, 23</sup> Other facilitators include encouragement from friends and having a quiet environment for homework, while barriers include limited time, busy family schedules, or lack of readiness.

Understanding these factors can help tailor support strategies to the needs of individual clients. Nevertheless, many clients do not complete homework regularly. Among adults, nonadherence ranges from 20% to 50%, while among young people it can be as high as 50% and tends to increase over the course of treatment.<sup>24, 25</sup> The World Health Organization (WHO) defines young people as those aged 10-24 years<sup>26</sup> a developmental period marked by changes in emotion regulation, identity, self-control, and social roles. These transitions may make young people respond to therapy differently from adults, potentially leading to greater challenges in self-regulation and homework adherence.<sup>23</sup> Therefore, it is necessary to study this group separately to understand mechanisms specific to this developmental stage and inform age-appropriate approaches.

In addition, previous studies have primarily examined how homework affects treatment outcomes,<sup>4</sup> typically examining associated factors in isolation, with limited research on family influences, despite their potential significance for young people. Moreover, few studies have examined homework adherence in the Thai context. Therefore, this study aimed to identify factors associated with homework adherence in CBT and, as a secondary aim, to explore these factors specifically among young people. The researchers hypothesized that client-related, therapist-related, and family-related factors were associated with CBT homework adherence.

## Methods

### Population and Sample

This study employed a cross-sectional descriptive design involving individuals who received CBT through the “Therapist Volunteers” program and those receiving treatment at the outpatient psychiatry clinic of Ramathibodi Hospital between January 2024 and September 2024.

The inclusion criteria were: 1) clients undergoing CBT, regardless of gender; 2) aged between 13 and 35 years; and 3) who had attended at least 3 therapy sessions. For those whose treatment had already concluded, termination must have occurred no more than 6 months prior. There were no exclusion criteria.

The sample size was determined using G\*Power software version 3.1.9.7, which is widely used for power analysis and is based on Cohen's formula. The statistical test selected was linear multiple regression: fixed model,  $R^2$  deviation from zero. Parameters were set as follows: effect size of 0.15, significance level ( $\alpha$ ) of .05, power ( $1-\beta$ ) of 0.80, and number of predictors of 3. Based on these inputs, the estimated minimum required sample size was 77 participants.

Purposive sampling was used to recruit participants from 2 sources: 1) the “Therapist Volunteers” project, which contributed 76 clients receiving regular therapy services; and 2) the outpatient psychiatry clinic at Ramathibodi Hospital, which enrolled an additional 3 clients through open participation in CBT. In total, 79 clients and 47 therapists participated in the study. Informed consent was obtained from participants aged 18 and older, while parental consent was obtained for those under 18 years of age.

### Research Instruments

The instruments used in this study consisted of the following questionnaires:

1) The Client Demographic Questionnaire, developed by the researcher to collect participants' background information, was a self-administered form including questions on: 1) age (reported in years, later categorized into 2 developmental stages: young adult [13-24 years]<sup>27</sup> and adults [25-35 years]); 2) gender (male, female); 3) marital status (single, married); 4) education level (secondary, bachelor's, postgraduate); 5) occupation (student, vendor, company employee, freelance); 6) living arrangement (alone, with partner/friends, with family); 7) mode of therapy (in-person, online, or both); and 8) decision to seek therapy (self-initiated, recommended by partner/friends, family/doctor, or more than one reason).

2) The Therapist Demographic Questionnaire, also developed by the researcher, was a self-administered form including therapist's age, gender, and years of experience providing CBT.

3) Working Alliance Inventory - Short Revised (WAI-SR):<sup>28</sup> a self-reported instrument completed by clients to assess the overall therapeutic alliance throughout the treatment period. Developed by Hatcher, permission to translate and use the instrument was obtained from the original author. It was translated into Thai by the researcher and back-translated into English by a language expert. Feedback was discussed with 3 experts in CBT, and the instrument was revised accordingly. Content validity was evaluated by 3 CBT experts. The 12-item scale measures 3 dimensions: 1) goals; 2) tasks; and 3) bond (4 items each). Each item is rated on a 5-point Likert scale from "not at all" (0) to "very much" (4). Total scores range from 0 to 60, with higher scores indicating stronger therapeutic alliance. Internal consistency reliability was excellent (Cronbach  $\alpha$  = 0.91). The scale-level content validity index (S-CVI) for the entire scale was 0.97 (Supplementary S1).

4) The Situational Motivation Scale (SIMS):<sup>29</sup> a self-reported measure used to assess clients' motivation to complete therapy homework. Developed by Guay, permission to translate and use the instrument was obtained from the original author. The instrument was translated into Thai by the researcher and back-translated into English by a language expert. The Thai version was then reviewed and validated by 3 CBT experts. The scale includes 16 items across 4 dimensions: 1) intrinsic motivation (items 1, 5, 9, 13); 2) identified regulation (items 2, 6, 10, 14); 3) external regulation (items 3, 7, 11, 15); and 4) amotivation (items 4, 8, 12, 16). Responses are rated on a 7-point Likert scale from 1 (does not correspond at all) to 7 (corresponds exactly). Each subscale has a score range of 4-28, with higher scores indicating greater motivation in that domain. Internal consistency was acceptable (Cronbach  $\alpha$ : intrinsic motivation = 0.77, identified regulation = 0.73, external regulation = 0.71, amotivation = 0.71). The S-CVI for the entire scale was 1.00 (Supplementary S2).

5) 15-item Systemic Clinical Outcome and Routine Evaluation - Thai version (SCORE-15):<sup>30</sup> a self-reported instrument used to assess family functioning. Originally developed by Stratton, and adapted from the SCORE-40, the Thai version was translated and validated by 2 experts. The 15-item scale assesses 3 domains: 1) strengths and adaptability; 2) difficulty in coping; and 3) problematic communication. Permission to use the Thai version was obtained from the original translators, and the instrument was used without modification. Items are rated on a 5-point Likert scale from 1 (describes me very well) to 5 (does not describe me at all). Total scores range from 15 to 75, with lower scores indicating better family functioning. The scale showed high reliability (Cronbach  $\alpha$  = 0.94) and validity (range 0.90-1.85).

6) Homework Compliance Scale (HCS):<sup>31</sup> a single-item therapist-rated measure of clients' overall level of homework adherence. Developed by Primakoff, permission to

translate and use the instrument was obtained from the original author. The instrument was translated into Thai by the researcher and back-translated into English by a language expert. The Thai version was then reviewed and validated by 3 CBT experts. The item asks therapists to rate clients' homework behavior on a scale from 1 to 6: 1) did not do the homework; 2) attempted, but failed due to external factors; 3) completed alternative, but related task; 4) partially completed the assigned homework; 5) completed homework as assigned; and 6) completed more than was assigned. Higher scores reflect higher homework adherence. The S-CVI for the entire scale was 0.83 (Supplementary S3).

7) Homework Rating Scale II (HRS-II);<sup>21</sup> a self-report measure used to assess clients' overall level of adherence with CBT homework. Developed by Kazantzis, based on CBT principles and determinants of adherence, permission to translate and use the instrument was obtained from the original author. The instrument was translated into Thai by the researcher and back-translated into English by a language expert. The Thai version was then reviewed and validated by 3 CBT experts. The 12-item scale consists of 3 domains: 1) engagement (items 1-4) scores 0-16; 2) beliefs (items 5-9) scores 0-20; and 3) consequences (items 10-12) scores 0-12. Items are rated on a 5-point Likert scale from 0 (not at all) to 4 (completely). Negatively worded items (items 3 and 4) were reverse scored. Total scores range from 0-48, with higher scores indicating higher homework adherence. Internal consistency was good (Cronbach  $\alpha$  = 0.82, intraclass correlation [ICC] = 0.83). The S-CVI for the entire scale was 0.94 (Supplementary S4).

In addition to these standard subscales, an exploratory index termed psychological effort was analyzed as supplementary results. This index was introduced by the original instrument developer after this study's data collection. It reflects the balance between clients' engagement and their perceived task difficulty and obstacles. Specifically, engagement is calculated as the mean of all items except those related to difficulty and obstacles, while difficulty and obstacles is the mean of those 2 items (reverse scored). The formula divides engagement by difficulty and obstacles, with a constant of 1 added to both numerator and denominator to avoid division by zero and improve stability. Thus, greater perceived difficulty reduces the denominator, resulting in higher psychological effort scores. Previous psychometric studies have reported that higher psychological effort values are associated with lower symptom severity, supporting its predictive validity.

8) Clinical Global Impression - Improvement Scale (CGI-I);<sup>32</sup> a single-item scale rated by the therapist to assess overall clinical improvement after treatment. Therapists rated the client's progress relative to baseline on a 7-point scale ranging from 1 (very much improved) to 7 (very much worse), with lower scores indicating better clinical outcomes. The CGI-I is a public-domain instrument; therefore, permission for use was not required. For this study, the scale was translated into Thai by the researcher and back-translated into English by a language expert to ensure linguistic and conceptual equivalence. The translation process followed standard forward-backward procedures, and no changes were made to the original structure or meaning of the instrument.

### Statistical Analysis

All data were analyzed using SPSS version 18.0 (PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc; 2009). Descriptive statistics (frequency, percentage, mean [SD]) were used to describe demographic characteristics of clients and therapists, therapy process variables, attitudes toward therapy, and family-related variables. Inferential statistics included the chi-square test for categorical variables, Mann-Whitney *U* test for comparing medians

between 2 independent nonnormally distributed groups, Kruskal-Wallis test for comparing medians across more than 2 groups, Spearman rank correlation for assessing correlations between continuous or ordinal variables, and multiple regression analysis for identifying predictors of homework adherence.

Results

Descriptive Data on Clients, Therapists, Therapy Process, Attitudes Toward Therapy, and Family Factors

Among the 79 total participants, the majority were adults (65.82%) with a mean (SD) age of 26.06 (5.45) years. Most were female (82.27%) and held a bachelor’s degree (64.55%). The majority were single (94.93%) and students (32.91%). Most lived with their families (51.89%) (Table 1).

In the subgroup of 27 young adults, the majority were female (81.48%) with a mean (SD) age of 19.7 (3.03) years. Most were enrolled in bachelor’s degree programs (74.07%) and all were single. Most worked as students (85.18%) and lived with their families (77.77%). Among the 47 participating therapists, most were female (72.34%) with mean (SD) of 2.43 (1.49) years of CBT experience, ranging from 1 to 8 years.

Regarding therapy process factors, 53 participants (67.08%) received therapy online. The mean (SD) therapeutic alliance score (WAI-SR) for young adults was 39.96 (6.2), which was significantly higher than that of adults which was 35.52 (8.36) ( $P = .011$ ).

For attitudes toward therapy, most participants reported seeking therapy on their own (50.63%). The highest mean (SD) motivational score was in the identified regulation dimension was 24.45 (3.54). The mean (SD) score for family functioning (SCORE-15) was 41.51 (9.93).

The overall mean (SD) score for homework adherence (HRS-II) was 34.01 (5.82), and for the HRS-II subscales and psychological effort are presented (Supplementary S5). In the total sample, mean (SD) scores were 9.95 (2.41) for homework engagement, 15.72 (2.81) for homework beliefs, 8.18 (2.09) for homework consequences, and 1.15 (0.29) for psychological effort. Young people and adults showed similar patterns, with a significant difference only in homework beliefs ( $P = .005$ ). The therapist-rated homework compliance score (HCS) had a mean (SD) of 4.1 (1.19). The mean (SD) score for clinical improvement (CGI-I) was 2.14 (0.81).

Table 1. Descriptive Characteristics of Clients, Therapists, Therapy Process, Attitudes Toward Therapy, and Family Factors Among Young People and Adults

| Variable          |                   | Total (N = 79) | Young People (n = 27) |         | Adults (n = 52) |         | P Value |
|-------------------|-------------------|----------------|-----------------------|---------|-----------------|---------|---------|
|                   |                   | No. (%)        | No. (%)               | Min-Max | No. (%)         | Min-Max |         |
| Client factors    |                   |                |                       |         |                 |         |         |
| Age, mean (SD), y |                   | 26.06 (5.45)   | 19.70 (3.03)          | 13-24   | 29.37 (2.87)    | 25-34   |         |
| Gender            | Male              | 14 (17.7)      | 5 (18.5)              | NA      | 9 (17.3)        | NA      | .890    |
|                   | Female            | 65 (82.3)      | 22 (81.5)             | NA      | 43 (82.7)       | NA      |         |
| Education level   | Secondary         | 7 (8.9)        | 7 (25.94)             | NA      | 0               | NA      | < .001  |
|                   | Bachelor’s degree | 51 (64.6)      | 20 (74.1)             | NA      | 31 (59.6)       | NA      |         |
|                   | Graduate degree   | 21 (26.6)      | 0                     | NA      | 21 (40.4)       | NA      |         |

**Table 1. Descriptive Characteristics of Clients, Therapists, Therapy Process, Attitudes Toward Therapy, and Family Factors Among Young People and Adults (Continued)**

| Variable                                                      |                       | Total (N = 79) | Young People (n = 27) |         | Adults (n = 52) |         | P Value |
|---------------------------------------------------------------|-----------------------|----------------|-----------------------|---------|-----------------|---------|---------|
|                                                               |                       | No. (%)        | No. (%)               | Min-Max | No. (%)         | Min-Max |         |
| Marital status                                                | Single                | 75 (94.9)      | 27 (100)              | NA      | 48 (92.3)       | NA      | .139    |
|                                                               | Married               | 4 (5.1)        | 0                     | NA      | 4 (7.7)         | NA      |         |
| Occupation                                                    | Student               | 26 (32.9)      | 23 (85.2)             | NA      | 3 (5.8)         | NA      | < .001  |
|                                                               | Company employee      | 24 (30.4)      | 3 (11.1)              | NA      | 21 (40.4)       | NA      |         |
|                                                               | Freelance             | 12 (15.2)      | 1 (3.7)               | NA      | 11 (21.2)       | NA      |         |
|                                                               | Others                | 17 (21.5)      | 0                     | NA      | 17 (32.7)       | NA      |         |
|                                                               |                       |                |                       |         |                 |         |         |
| Living                                                        | Alone                 | 23 (29.1)      | 4 (14.8)              | NA      | 19 (36.5)       | NA      | .004    |
|                                                               | Partner/ Friends      | 15 (19.0)      | 2 (7.4)               | NA      | 13 (25)         | NA      |         |
|                                                               | Family                | 41 (51.9)      | 21 (77.8)             | NA      | 20 (38.5)       | NA      |         |
| Therapist factors (n = 47)                                    |                       |                |                       |         |                 |         |         |
| Gender                                                        | Male                  | 13 (27.7)      | 2 (12.5)              | NA      | 14 (87.5)       | NA      | .041    |
|                                                               | Female                | 34 (72.3)      | 25 (39.7)             | NA      | 38 (60.3)       | NA      |         |
| Experience, mean (SD), y                                      |                       | 2.43 ( 1.49)   | NA                    | 1-8     | NA              | NA      | NA      |
| Therapy process, attitudes toward therapy, and family factors |                       |                |                       |         |                 |         |         |
| Therapy format                                                | In-person             | 22 (27.8)      | 5 (18.5)              | NA      | 17 (32.7)       | NA      | .116    |
|                                                               | Online                | 53 (67.1)      | 19 (70.4)             | NA      | 34 (65.4)       | NA      |         |
|                                                               | Both                  | 4 (5.1)        | 3 (11.1)              | NA      | 1 (1.9)         | NA      |         |
| WAI-SR, mean (SD)                                             |                       | 37.04 (7.94)   | 39.96 (6.2)           | 18-48   | 35.52 (8.36)    | 9-45    | .011    |
| Decision to seek therapy                                      | Self                  | 40 (50.6)      | 12 (44.4)             | NA      | 28 (53.8)       | NA      | .154    |
|                                                               | Partner/Friends       | 7 (8.9)        | 2 (7.4)               | NA      | 5 (9.6)         | NA      | NA      |
|                                                               | Family/Doctor         | 13 (16.5)      | 8 (29.6)              | NA      | 5 (9.6)         | NA      | NA      |
|                                                               | Multiple reason       | 19 (24.1)      | 5 (18.5)              | NA      | 14 (26.9)       | NA      | NA      |
| SIMS, mean (SD)                                               | Intrinsic motivation  | 19.11 (4.61)   | 19.81 (4.51)          | 11-28   | 18.75 (4.66)    | 9-28    | .367    |
|                                                               | Identified regulation | 24.45 (3.54)   | 24.41 (3.75)          | 17-28   | 24.62 (3.45)    | 13-28   | .971    |
|                                                               | External regulation   | 18.65 (4.78)   | 19.63 (5.9)           | 9-28    | 18.13 (4.06)    | 11-26   | .150    |
|                                                               | Amotivation           | 8.29 (4.22)    | 8 (4.16)              | 4-19    | 8.44 (4.29)     | 4-20    | .571    |
| SCORE-15, mean (SD)                                           |                       | 41.51 (9.93)   | 43.41 (8.63)          | 27-61   | 40.52 (10.48)   | 23-69   | .131    |
| Homework adherence and clinical outcome                       |                       |                |                       |         |                 |         |         |
| HRS-II, mean (SD)                                             |                       | 34.01 (5.82)   | 35.07 (5.95)          | 21-44   | 33.46 (5.74)    | 19-46   | .201    |
| HCS, mean (SD)                                                |                       | 4.1 (1.19)     | 3.89 (1.31)           | 1-6     | 4.21 (1.12)     | 2-6     | .417    |
| CGI-I, mean (SD)                                              |                       | 2.14 (0.81)    | 2.15 (0.77)           | 3-7     | 2.13 (0.84)     | 4-7     | .930    |

Abbreviations: CGI-I, Clinical Global Impression – Improvement Scale; HCS, Homework Compliance Scale; HRS-II, Homework Rating Scale II; NA, not applicable; SIMS, The Situational Motivation Scale; SCORE-15, 15-item Systemic Clinical Outcome and Routine Evaluation - Thai version; WAI-SR, Working Alliance Inventory - Short Revised.

### Analysis of Relationship Between Clients, Therapists, Therapy Process, and Attitudinal Factors and Homework Adherence (HRS-II) and Homework Compliance (HCS)

In the full sample, positive correlations were found between HRS-II and the following variables: therapeutic alliance (WAI-SR) ( $r = 0.629$ ), intrinsic motivation ( $r = 0.440$ ), and identified regulation ( $r = 0.486$ ). Amotivation was negatively correlated with HRS-II ( $r = -0.398$ ), all at  $P < .01$ . Family functioning (SCORE-15) was negatively correlated with HCS ( $r = -0.238$ ,  $P < .05$ ). Additionally, both HRS-II ( $r = -0.305$ ) and HCS ( $r = -0.347$ ) were negatively correlated with CGI-I scores ( $P < .01$ ), indicating that higher homework adherence and compliance were associated with greater clinical improvement (Tables 2 and 3). In the subgroup analyses (Supplementary S6), no significant associations were found between HRS-II subscales or psychological effort and most demographic or therapy-related variables. However, significant differences were observed for age group, therapist gender, and living situation. Younger participants reported higher homework beliefs scores compared with adults ( $P < .01$ ), and participants treated by female therapists also reported higher homework beliefs scores than those treated by male therapists ( $P < .05$ ). In terms of living arrangements, individuals living alone demonstrated greater psychological effort than those living with others ( $P < .05$ ). These findings suggest that younger age, therapist gender, and independent living may be associated with specific aspects of homework adherence in CBT.

WAI-SR was positively correlated with all HRS-II subscales at  $P < .01$ : homework engagement ( $r = 0.329$ ), homework beliefs ( $r = 0.607$ ), and homework consequences ( $r = 0.492$ ). Intrinsic motivation was positively associated with all HRS-II subscales at  $P < .01$  ( $r = 0.392$ ,  $0.333$ , and  $0.315$ , respectively), and identified regulation was positively correlated with all HRS-II subscales at  $P < .01$  ( $r = 0.378$ ,  $0.472$ , and  $0.359$ , respectively). Psychological effort showed a significant positive correlation with homework beliefs ( $r = 0.407$ ,  $P < .01$ ) but was not significantly associated with CGI-I. All HRS-II subscales were negatively correlated with CGI-I: homework engagement ( $r = -0.223$ ,  $P < .05$ ), homework beliefs ( $r = -0.316$ ,  $P < .01$ ), and homework consequences ( $r = -0.223$ ,  $P < .05$ ) (Supplementary S7).

In the young adult subgroup, female participants had significantly higher homework adherence scores than males ( $P = .022$ ) (Table 2). Therapeutic alliance ( $r = 0.670$ ), intrinsic motivation ( $r = 0.440$ ), and identified regulation ( $r = 0.434$ ) were positively associated with homework adherence ( $P < .01$ ) (Table 4). Furthermore, HRS-II scores were negatively correlated with CGI-I scores ( $r = -0.594$ ,  $P < .01$ ), suggesting that greater homework adherence was associated with better clinical outcomes. Significant associations between HRS-II subscales and several key factors ( $P < .01$ ) was found. Specifically, homework engagement was positively correlated with therapeutic alliance ( $r = 0.565$ ), intrinsic motivation ( $r = 0.494$ ), and identified regulation ( $r = 0.468$ ). Homework belief was related to perceived benefit of therapy ( $r = 0.529$ ), while homework consequence showed positive associations with therapeutic alliance ( $r = 0.586$ ) and intrinsic motivation ( $r = 0.439$ ). Psychological effort was associated with perceived benefit of therapy ( $r = 0.496$ ) and identified regulation ( $r = 0.471$ ). Furthermore, HRS-II subscales and psychological effort demonstrated significant associations with clinical outcomes ( $P < .01$ ). Specifically, homework engagement was negatively correlated with CGI-I ( $r = -0.305$ ), homework beliefs with CGI-I ( $r = -.345$ ), homework consequences with CGI-I ( $r = -0.347$ ), and psychological effort with CGI-I ( $r = -0.304$ ), indicating that higher scores on these measures were associated with greater clinical improvement (Supplementary S8).

### Multiple Regression Analysis of Factors Associated With Homework Adherence

In the full sample, therapeutic alliance (WAI-SR) was significantly associated with homework adherence (HRS-II) across all regression models. In Model 1,  $\beta = 0.448$  (95% CI, 0.191-0.466;  $P < .001$ ); in Model 2, which controlled for client age and education level,  $\beta = 0.452$  (95% CI, 0.185-0.478;  $P < .001$ ); and in Model 3, which additionally controlled for therapy format and therapist experience,  $\beta = 0.456$  (95% CI, 0.185-0.484;  $P < .001$ ). This suggests that therapeutic alliance remained a significant predictor of homework adherence across all models (Table 5). WAI-SR was significantly associated with homework beliefs and homework consequences, but not with homework engagement or psychological effort. For homework beliefs, significant associations were observed in Model 1 ( $\beta = 0.406$ ; 95% CI, 0.072-0.216;  $P < .001$ ), Model 2 ( $\beta = 0.317$ ; 95% CI, 0.038-0.187;  $P = .004$ ), and Model 3 ( $\beta = 0.321$ ; 95% CI, 0.038-0.190;  $P = .004$ ). For homework consequences, WAI-SR was significant in Model 1 ( $\beta = 0.476$ ; 95% CI, 0.070-0.181;  $P < .001$ ), Model 2 ( $\beta = 0.544$ ; 95% CI, 0.085-0.201;  $P < .001$ ), and Model 3 ( $\beta = 0.549$ ; 95% CI, 0.086-0.204;  $P < .001$ ) (Supplementary S9).

Intrinsic motivation and identified regulation were significantly associated with homework adherence only in Model 1. For intrinsic motivation,  $\beta = 0.200$ ; 95% CI, 0.009-0.497;  $P = .041$ ); for identified regulation,  $\beta = 0.209$  (95% CI, 0.013-0.674;  $P = .039$ ). These associations were not significant in Models 2 and 3, after controlling for additional factors. Family functioning (SCORE-15) was not significantly associated with HRS-II scores in any model. No significant predictors were found for therapist-rated homework adherence (HCS) across models. Intrinsic motivation was significantly associated with homework engagement, but not with other HRS-II subscales or psychological effort. For homework engagement, significant associations were found in Model 1 ( $\beta = 0.287$ ; 95% CI, 0.027-0.272;  $P = .017$ ), Model 2 ( $\beta = .286$ ; 95% CI, 0.026-0.273;  $P = .018$ ), and Model 3 ( $\beta = 0.273$ ; 95% CI, 0.016-0.269;  $P = .028$ ). Identified regulation was significantly associated with homework beliefs only. The associations were significant in Model 1 ( $\beta = 0.242$ ; 95% CI, 0.019-0.366;  $P = .030$ ), Model 2 ( $\beta = 0.290$ ; 95% CI, 0.055-0.406;  $P = .011$ ), and Model 3 ( $\beta = 0.292$ ; 95% CI, 0.052-0.413;  $P = .012$ ) (Supplementary S9).

In the young people subgroup, therapeutic alliance (WAI-SR) was significantly positively associated with homework adherence ( $\beta = 0.582$ ; 95% CI, 0.135-0.982;  $P = .013$ ), indicating that a stronger therapeutic relationship was associated with higher homework adherence. However, no significant association was found between therapeutic alliance and homework adherence. Identified regulation was significantly associated with homework adherence ( $\beta = 0.588$ ; 95% CI, 0.013-0.397;  $P = .038$ ), suggesting that young people with higher identified regulation were more likely to consistently complete their assignments. Additionally, therapist experience was significantly associated with homework adherence ( $\beta = 0.507$ ; 95% CI, 0.017-0.804;  $P = .042$ ). No other variables were significantly associated with either HRS-II or HCS in the young people subgroup.

WAI-SR was significantly associated with homework beliefs and homework consequences among young adults. For homework beliefs, the association was significant in Model 1 ( $\beta = 0.368$ ; 95% CI, 0.006-0.285;  $P = .041$ ) and Model 3 ( $\beta = 0.624$ ; 95% CI, 0.101-0.393;  $P = .002$ ). For homework consequences, the association was significant in Model 1 ( $\beta = 0.427$ ; 95% CI, 0.009-0.312;  $P = .038$ ) and Model 2 ( $\beta = 0.404$ ; 95% CI, 0.005-0.299;  $P = .044$ ) (Supplementary S10).

Table 2. Relationship Between Client, Therapist, Therapy Process, and Attitudinal Factors With Homework Adherence (HRS-II) and Homework Compliance (HCS)

| Variable                 | Total Sample (N = 79) |           |              |                                 |           |             |       |                                 |              |       | Young People Subgroup (n = 27) |             |           |                                 |       |           |       |                                 |           |       |       |
|--------------------------|-----------------------|-----------|--------------|---------------------------------|-----------|-------------|-------|---------------------------------|--------------|-------|--------------------------------|-------------|-----------|---------------------------------|-------|-----------|-------|---------------------------------|-----------|-------|-------|
|                          | No.                   | HRS-II    |              | U <sup>a</sup> /KW <sup>b</sup> |           | HCS         |       | U <sup>a</sup> /KW <sup>b</sup> |              | P     |                                | HRS-II      |           | U <sup>a</sup> /KW <sup>b</sup> |       | HCS       |       | U <sup>a</sup> /KW <sup>b</sup> |           | P     |       |
|                          |                       | Mean (SD) | Value        | Value                           | Mean (SD) | Mean (SD)   | Value | Value                           | Mean (SD)    | Value | Value                          | Mean (SD)   | Mean (SD) | Value                           | Value | Mean (SD) | Value | Value                           | Mean (SD) | Value | Value |
| Gender                   | Male                  | 14        | 33.64 (7.26) | 417.5                           | .630      | 4.00 (1.35) | 442.0 | .862                            | 29.00 (4.95) | 18.5  | .022                           | 3.40 (1.81) | 45.5      | .536                            |       |           |       |                                 |           |       |       |
|                          | Female                | 65        | 34.09 (5.53) | NA                              | NA        | 4.12 (1.16) | NA    | NA                              | 36.45 (5.33) | NA    | NA                             | 4.00 (1.19) | NA        | NA                              |       |           |       |                                 |           |       |       |
| Age group                | Young people          | 27        | 35.07 (5.95) | 578.5                           | .201      | 3.89 (1.31) | 626.5 | .417                            | NA           | NA    | NA                             | NA          | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          | Adult                 | 52        | 33.46 (5.74) | NA                              | NA        | 4.21 (1.12) | NA    | NA                              | NA           | NA    | NA                             | NA          | NA        | NA                              |       |           |       |                                 |           |       |       |
| Education level          | Secondary             | 7         | 31.43 (6.85) | 1.358                           | .507      | 3.57 (1.61) | 3.062 | .216                            | 31.43 (6.85) | 38.0  | .075                           | 2.43 (0.78) | 61.5      | .623                            |       |           |       |                                 |           |       |       |
|                          | Bachelor's            | 51        | 34.27 (5.40) | NA                              | NA        | 4.02 (1.15) | NA    | NA                              | 36.35 (5.20) | NA    | NA                             | 2.10 (0.78) | NA        | NA                              |       |           |       |                                 |           |       |       |
| Marital status           | Graduate              | 21        | 34.24 (6.54) | NA                              | NA        | 4.48 (1.07) | NA    | NA                              | NA           | NA    | NA                             | NA          | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          | Single                | 75        | 34.07 (5.95) | 121.5                           | .523      | 4.11 (1.19) | 149.0 | .981                            | 35.07 (5.95) | NA    | NA                             | 2.19 (0.78) | NA        | NA                              |       |           |       |                                 |           |       |       |
| Occupation               | Married               | 4         | 33.00 (2.44) | NA                              | NA        | 4.00 (1.41) | NA    | NA                              | NA           | NA    | NA                             | NA          | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          | Student               | 26        | 34.65 (5.76) | 0.809                           | .847      | 3.88 (1.33) | 2.903 | .407                            | 34.78 (6.10) | 0.236 | .627                           | 2.17 (0.83) | 0.065     | .802                            |       |           |       |                                 |           |       |       |
| Occupation               | Employee              | 24        | 33.38 (5.17) | NA                              | NA        | 4.13 (0.99) | NA    | NA                              | 36.67 (6.65) | NA    | NA                             | 2.00 (0.00) | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          | Freelance             | 12        | 33.75 (6.49) | NA                              | NA        | 3.92 (1.16) | NA    | NA                              | 37.00 (0.00) | NA    | NA                             | 3.00 (0.00) | NA        | NA                              |       |           |       |                                 |           |       |       |
| Living                   | Others                | 17        | 34.12 (6.68) | NA                              | NA        | 4.53 (1.23) | NA    | NA                              | NA           | NA    | NA                             | NA          | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          | Alone                 | 23        | 35.43 (5.58) | 2.124                           | .346      | 4.04 (1.22) | 0.254 | .881                            | 36.75 (4.92) | 2.70  | .259                           | 1.50 (0.57) | 2.87      | .237                            |       |           |       |                                 |           |       |       |
| Living                   | Partner/friends       | 15        | 32.80 (4.47) | NA                              | NA        | 4.00 (1.25) | NA    | NA                              | 29.00 (4.24) | NA    | NA                             | 2.00 (1.41) | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          | With family           | 41        | 33.66 (6.34) | NA                              | NA        | 4.17 (1.18) | NA    | NA                              | 35.33 (6.10) | NA    | NA                             | 2.33 (0.73) | NA        | NA                              |       |           |       |                                 |           |       |       |
| Therapist gender         | Male                  | 16        | 32.38 (6.67) | 400.0                           | .204      | 3.88 (1.45) | 0.834 | .361                            | 27.50 (9.19) | 10.5  | .176                           | 1.50 (0.70) | 10.5      | .161                            |       |           |       |                                 |           |       |       |
|                          | Female                | 63        | 34.43 (5.57) | NA                              | NA        | 4.16 (1.12) | NA    | NA                              | 35.68 (5.45) | NA    | NA                             | 2.24 (0.77) | NA        | NA                              |       |           |       |                                 |           |       |       |
| Therapy format           | In-person             | 22        | 33.86 (6.74) | 0.686                           | .710      | 4.36 (1.04) | 2.128 | .345                            | 35.40 (5.27) | 3.35  | .187                           | 2.00 (1.00) | 1.39      | .497                            |       |           |       |                                 |           |       |       |
|                          | Online                | 53        | 34.23 (5.48) | NA                              | NA        | 4.02 (1.24) | NA    | NA                              | 35.89 (6.11) | NA    | NA                             | 2.32 (0.74) | NA        | NA                              |       |           |       |                                 |           |       |       |
| Therapy format           | Both                  | 4         | 32.00 (6.05) | NA                              | NA        | 3.75 (1.25) | NA    | NA                              | 29.33 (3.51) | NA    | NA                             | 1.67 (0.57) | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          | Self                  | 40        | 32.85 (6.01) | 7.275                           | .064      | 4.08 (1.18) | 0.169 | .982                            | 34.17 (5.25) | 1.62  | .655                           | 2.25 (0.86) | 1.01      | .798                            |       |           |       |                                 |           |       |       |
| Decision to seek therapy | Partner/friends       | 7         | 31.57 (3.91) | NA                              | NA        | 4.14 (1.06) | NA    | NA                              | 35.00 (2.82) | NA    | NA                             | 2.50 (0.70) | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          | Family/doctor         | 13        | 36.46 (7.38) | NA                              | NA        | 4.15 (1.46) | NA    | NA                              | 35.00 (8.24) | NA    | NA                             | 2.13 (0.83) | NA        | NA                              |       |           |       |                                 |           |       |       |
| Decision to seek therapy | Multiple reason       | 19        | 35.68 (3.84) | NA                              | NA        | 4.11 (1.15) | NA    | NA                              | 37.40 (4.93) | NA    | NA                             | 2.00 (0.70) | NA        | NA                              |       |           |       |                                 |           |       |       |
|                          |                       |           |              |                                 |           |             |       |                                 |              |       |                                |             |           |                                 |       |           |       |                                 |           |       |       |

Abbreviations: HCS, Homework Compliance Scale; HRS-II, Homework Rating Scale II; NA, not applicable.

<sup>a</sup> Mann-Whitney *U* test (U).

<sup>b</sup> Kruskal-Wallis test (KW).

Table 3. Spearman Rank Correlation Among Client Factors, Therapy Process, Attitudes Toward Therapy, Family Functioning, and HRS-II, HCS, CGI-I of Total Sample

| Variable                 | 1        | 2       | 3      | 4        | 5       | 6        | 7       | 8        | 9       | 10       | 11       | 12 |
|--------------------------|----------|---------|--------|----------|---------|----------|---------|----------|---------|----------|----------|----|
| 1) Client age            | 1        |         |        |          |         |          |         |          |         |          |          |    |
| 2) Therapist age         | 0.052    | 1       |        |          |         |          |         |          |         |          |          |    |
| 3) Therapist experience  | -0.185   | -0.040  | 1      |          |         |          |         |          |         |          |          |    |
| 4) WAI-SR                | -0.326** | 0.042   | -0.098 | 1        |         |          |         |          |         |          |          |    |
| 5) Intrinsic motivation  | -0.123   | -0.272* | 0.124  | 0.320**  | 1       |          |         |          |         |          |          |    |
| 6) Identified regulation | -0.031   | -0.137  | -0.093 | 0.436**  | 0.476** | 1        |         |          |         |          |          |    |
| 7) External regulation   | -0.176   | 0.089   | 0.087  | 0.118    | 0.151   | 0.218    | 1       |          |         |          |          |    |
| 8) Amotivation           | 0.079    | -0.030  | 0.178  | -0.444** | -0.268* | -0.452** | -0.081  | 1        |         |          |          |    |
| 9) SCORE-15              | -0.162   | -0.124  | 0.066  | -0.126   | -0.048  | -0.021   | 0.098   | 0.234*   | 1       |          |          |    |
| 10) HRS-II               | -0.194   | 0.104   | -0.043 | 0.629**  | 0.440** | 0.486**  | 0.205   | -0.398** | -0.107  | 1        |          |    |
| 11) HCS                  | 0.104    | 0.180   | 0.178  | 0.051    | 0.114   | 0.090    | 0.136   | -0.190   | -0.238* | 0.266*   | 1        |    |
| 12) CGI-I                | -0.104   | -0.246* | 0.192  | -0.189   | -0.049  | -0.145   | -0.222* | 0.216    | 0.222*  | -0.305** | -0.347** | 1  |

Abbreviations: CGI-I, Clinical Global Impression - Improvement Scale; HCS, Homework Compliance Scale; HRS-II, Homework Rating Scale II; SCORE-15, 15-item Systemic Clinical Outcome and Routine Evaluation - Thai version; WAI-SR, Working Alliance Inventory - Short Revised.

\*  $P < .05$

\*\*  $P < .01$

Table 4. Spearman Rank Correlation Among Client Factors, Therapy Process, Attitudes Toward Therapy, Family Functioning, and HRS-II, HCS, CGI-I of Young People

| Variable                 | 1        | 2       | 3       | 4       | 5      | 6       | 7       | 8      | 9      | 10       | 11       | 12 |
|--------------------------|----------|---------|---------|---------|--------|---------|---------|--------|--------|----------|----------|----|
| 1) Client age            | 0.394*   | 1       |         |         |        |         |         |        |        |          |          |    |
| 2) Therapist age         | -0.37    | -0.127  | 1       |         |        |         |         |        |        |          |          |    |
| 3) Therapist experience  | 0.402*   | 0.17    | -0.169  | 1       |        |         |         |        |        |          |          |    |
| 4) WAI-SR                | 0.111    | -0.313  | -0.06   | 0.433*  | 1      |         |         |        |        |          |          |    |
| 5) Intrinsic motivation  | 0.198    | -0.115  | -0.216  | 0.413*  | 0.461* | 1       |         |        |        |          |          |    |
| 6) Identified regulation | -0.136   | .387*   | 0.109   | -0.13   | -0.092 | -0.043  | 1       |        |        |          |          |    |
| 7) External regulation   | -0.480*  | 0.032   | 0.218   | -0.268  | -0.145 | -0.457* | 0.056   | 1      |        |          |          |    |
| 8) Amotivation           | 0.071    | -0.1    | -0.178  | -0.042  | -0.098 | 0.016   | -0.028  | 0.202  | 1      |          |          |    |
| 9) SCORE-15              | 0.356    | 0.137   | -0.251  | 0.670** | 0.434* | 0.440*  | 0.235   | -0.243 | -0.068 | 1        |          |    |
| 10) HRS-II               | 0.106    | 0.147   | 0.266   | 0.058   | 0.227  | 0.171   | 0.187   | -0.257 | -0.125 | 0.282    | 1        |    |
| 11) HCS                  | -0.648** | -0.475* | 0.524** | -0.433* | -0.186 | -0.251  | -0.271  | 0.404* | -0.013 | -0.594** | -0.23    | 1  |
| 12) CGI-I                | -0.104   | -0.246* | 0.192   | -0.189  | -0.049 | -0.145  | -0.222* | 0.216  | 0.222* | -0.305** | -0.347** | 1  |

Abbreviations: CGI-I, Clinical Global Impression - Improvement Scale; HCS, Homework Compliance Scale; HRS-II, Homework Rating Scale II; SCORE-15, 15-item Systemic Clinical Outcome and Routine Evaluation - Thai version; WAI-SR, Working Alliance Inventory - Short Revised.

\*  $P < .05$   
\*\*  $P < .01$

Table 5. Multiple Regression Analysis of Factors Associated With Homework Adherence (HRS-II) and Homework Adherence (HCS)

| Model* |                       | Total Sample (N = 79)    |        |         |                          |        |         |                          |        |                  |                          |         |      |  |                  |   |         |
|--------|-----------------------|--------------------------|--------|---------|--------------------------|--------|---------|--------------------------|--------|------------------|--------------------------|---------|------|--|------------------|---|---------|
|        |                       | HRS-II                   |        |         |                          |        |         | HCS                      |        |                  |                          |         |      |  |                  |   |         |
|        |                       | HRS-II                   |        |         | HCS                      |        |         | HRS-II                   |        |                  | HCS                      |         |      |  |                  |   |         |
|        |                       | $\beta$ (95% CI)         | t      | P Value | $\beta$ (95% CI)         | t      | P Value |                          |        | $\beta$ (95% CI) | t                        | P Value |      |  | $\beta$ (95% CI) | t | P Value |
| 1      | WAI-SR                | 0.448 (0.191 to 0.466)   | 4.77   | < .001  | -0.07 (-0.048 to 0.027)  | -0.562 | .576    | 0.377 (-0.002 to 0.724)  | 2.065  | .051             | -0.221 (-0.145 to 0.052) | -0.986  | .335 |  |                  |   |         |
|        | Intrinsic motivation  | 0.2 (0.009 to 0.497)     | 2.069  | .042    | 0.026 (-0.060 to 0.073)  | 0.204  | .839    | 0.154 (-0.283 to 0.688)  | 0.865  | .396             | 0.031 (-0.123 to 0.140)  | 0.141   | .889 |  |                  |   |         |
|        | Identified regulation | 0.209 (0.013 to 0.674)   | 2.073  | .042    | 0.171 (-0.032 to 0.148)  | 1.276  | .206    | 0.291 (-0.154 to 1.078)  | 1.556  | .134             | 0.421 (-0.020 to 0.314)  | 1.828   | .081 |  |                  |   |         |
|        | SCORE-15              | -0.082 (-0.147 to 0.051) | -0.964 | .338    | -0.196 (-0.051 to 0.003) | -1.743 | .086    | -0.144 (-0.328 to 0.129) | -0.904 | .376             | -0.129 (-0.081 to 0.042) | -0.655  | .519 |  |                  |   |         |
|        | WAI-SR                | 0.452 (0.185 to 0.478)   | 4.501  | < .001  | -0.025 (-0.044 to 0.036) | -0.188 | .851    | 0.361 (-0.016 to 0.709)  | 1.995  | .060             | -0.246 (-0.155 to 0.051) | -1.05   | .306 |  |                  |   |         |
| 2      | Intrinsic motivation  | 0.191 (-0.006 to 0.488)  | 1.948  | .055    | 0.03 (-0.059 to 0.075)   | 0.231  | .818    | 0.164 (-0.273 to 0.704)  | 0.921  | .368             | 0.008 (-0.137 to 0.142)  | 0.036   | .972 |  |                  |   |         |
|        | Identified regulation | 0.185 (-0.041 to 0.649)  | 1.757  | .083    | 0.12 (-0.053 to 0.134)   | 0.861  | .392    | 0.224 (-0.280 to 0.991)  | 1.168  | .257             | 0.426 (-0.033 to 0.330)  | 1.711   | .103 |  |                  |   |         |
|        | SCORE-15              | -0.071 (-0.143 to 0.059) | -0.821 | .414    | -0.169 (-0.048 to 0.007) | -1.472 | .146    | -0.151 (-0.332 to 0.123) | -0.956 | .351             | -0.148 (-0.087 to 0.042) | -0.72   | .480 |  |                  |   |         |
|        | Client age            | -0.101 (-0.381 to 0.166) | -0.785 | .435    | 0.017 (-0.071 to 0.078)  | 0.098  | .922    | 0.139 (-0.882 to 1.427)  | 0.492  | .628             | 0.264 (-0.215 to 0.443)  | 0.721   | .479 |  |                  |   |         |
|        | Education level       | 0.154 (-0.994 to 4.131)  | 1.220  | .226    | 0.147 (-0.390 to 1.006)  | 0.88   | .382    | 0.145 (-5.993 to 9.853)  | 0.508  | .617             | -0.157 (-2.718 to 1.799) | -0.424  | .676 |  |                  |   |         |
| 3      | WAI-SR                | 0.456 (0.185 to 0.484)   | 4.473  | < .001  | -0.004 (-0.040 to 0.039) | -0.027 | .979    | 0.582 (0.135 to 0.982)   | 2.768  | .013             | -0.255 (-0.171 to 0.063) | -0.965  | .347 |  |                  |   |         |
|        | Intrinsic motivation  | 0.185 (-0.02 to 0.488)   | 1.839  | .070    | -0.015 (-0.071 to 0.064) | -0.112 | .911    | 0.097 (-0.358 to 0.615)  | 0.554  | .586             | -0.045 (-0.148 to 0.121) | -0.203  | .841 |  |                  |   |         |
|        | Identified regulation | 0.184 (-0.051 to 0.657)  | 1.707  | .092    | 0.162 (-0.040 to 0.149)  | 1.154  | .252    | 0.084 (-0.563 - 0.828)   | 0.401  | .693             | 0.588 (0.013 to 0.397)   | 2.24    | .038 |  |                  |   |         |
|        | SCORE-15              | -0.072 (-0.145 to 0.06)  | -0.821 | .415    | -0.183 (-0.049 to 0.005) | -1.61  | .112    | -0.055 (-0.272 to 0.196) | -0.342 | .736             | -0.102 (-0.080 to 0.049) | -0.502  | .622 |  |                  |   |         |
|        | Client age            | -0.111 (-0.406 to 0.169) | -0.819 | .416    | 0.074 (-0.060 to 0.093)  | 0.424  | .673    | 0.179 (-0.877 to 1.577)  | 0.6    | .556             | 0.599 (-0.081 to 0.598)  | 1.601   | .127 |  |                  |   |         |
|        | Education level       | 0.15 (-1.128 to 4.178)   | 1.147  | .255    | 0.079 (-0.541 to 0.869)  | 0.464  | .644    | 0.099 (-6.927 to 9.567)  | 0.336  | .741             | -0.448 (-3.596 to 0.966) | -1.211  | .241 |  |                  |   |         |
|        | Therapy format        | -0.049 (-2.517 to 1.434) | -0.546 | .586    | -0.114 (-0.781 to 0.269) | -0.973 | .334    | -0.384 (-8.880 to 0.549) | -1.856 | .080             | -0.124 (-1.599 to 1.009) | -0.475  | .640 |  |                  |   |         |
|        | Therapist experience  | -0.003 (-0.715 to 0.693) | -0.031 | .975    | 0.206 (-0.023 to 0.351)  | 1.748  | .085    | 0.062 (-1.193 to 1.653)  | 0.339  | .738             | 0.507 (0.017 to 0.804)   | 2.192   | .042 |  |                  |   |         |

Abbreviations: HCS, Homework Compliance Scale; HRS-II, Homework Rating Scale II; SCORE-15, 15-item Systemic Clinical Outcome and Routine Evaluation - Thai version; WAI-SR, Working Alliance Inventory - Short Revised.

\* Model 1 includes only the main variables, Model 2 adds client-related variables, and Model 3 adds therapist-related variables.

## Discussion

This study aimed to investigate the factors associated with homework adherence in CBT. The results indicated that therapeutic alliance, intrinsic motivation, and identified regulation were positively associated with clients' homework adherence. Specifically, among young people, therapeutic alliance, identified regulation, and therapist experience were found to be positively associated with homework adherence. Moreover, both client-reported homework adherence and therapist-rated homework adherence showed significant associations with better clinical outcomes, as measured by the CGI-I. These findings are consistent with prior research highlighting the potential role of homework in CBT and its potential role in enhancing treatment outcomes.<sup>4, 6, 7</sup>

This study found that the therapeutic alliance was associated with homework adherence. Bordin<sup>33</sup> explained that the therapeutic alliance consists of 3 main components: bond (trust and attachment), goal (mutual agreement on treatment goals), and task (agreement on therapeutic methods). Clearly defined goals and agreements may contribute to strengthening the bond and facilitating cooperation in completing homework. Several studies support this notion. For instance, Safran et al<sup>34</sup> reported that a strong relationship with the therapist was linked to greater acceptance of guidance and participation in therapy-related activities, including homework assignments. Therefore, building a safe and trusting relationship between therapist and client is essential in the early phase of therapy and should occur alongside an effective treatment plan that promotes participation and teamwork while fostering understanding and confidence in clients.<sup>35</sup>

Additionally, the therapist's response to initial nonadherence to homework can influence future homework adherence. Expressing concern, discussing barriers to homework adherence, and collaboratively identifying adjustments may facilitate greater homework adherence in subsequent sessions. Kazantzis et al<sup>21</sup> emphasized that a strong therapeutic alliance has been associated with higher rates of homework completion. Establishing this alliance requires the therapist's skill and experience in creating a sense of safety and trust, and in designing an effective treatment process.<sup>11, 12, 36</sup> This collaborative foundation may enhance engagement of clients with homework tasks and contributes to greater homework adherence, which has been associated with improved clinical outcomes<sup>5, 23</sup> and lower dropout rates.<sup>37</sup>

Fostering motivation for clients to engage in homework may differ between young people and adults.<sup>23</sup> Young people are often motivated by rewards or praise, whereas adults tend to be motivated by perceived value, benefits, and alignment with personal goals. Therefore, therapists must be knowledgeable and able to design personalized interventions that maximize client cooperation, taking into account both professional experience and individual differences.

The analysis also revealed that identified regulation was associated with therapist-rated homework compliance (HCS), but not with self-reported homework adherence (HRS-II). This may reflect characteristics of emerging adulthood, a stage involving the development of self-awareness and self-appraisal. According to Erikson's theory,<sup>38</sup> individuals at this stage face the developmental task of identity versus role confusion, often questioning themselves and their social roles. This may lead to discrepancies in self-evaluation, whereas therapists, who observe behavior directly and over time, may provide more accurate assessments.

Furthermore, the finding that therapist experience was associated with homework adherence among young adults suggests that more experienced therapists may better

tailor techniques to this developmental context. Examples include using motivational interviewing, offering autonomy-supportive feedback, and highlighting the importance and value of assignments. According to Deci and Ryan's self-determination theory,<sup>17, 39</sup> identified regulation is a type of motivation in which recognizing the significance and value of an activity fosters self-regulation in completing assigned tasks. Yew et al<sup>40</sup> explained that when clients believe in and value what they are asked to do, they are more likely to engage consistently. This aligned with findings from McEvoy et al<sup>18</sup> and Malik et al<sup>20</sup> who also described client motivation as a key factor influencing homework adherence in therapy.

The findings of this study indicated that family functioning was not associated with either homework adherence or the level of homework adherence, both in the overall sample and in the young adult subgroup. This contrasts with the findings of Essoe et al<sup>23</sup> who investigated homework adherence in behavioral therapy for patients with Tourette's disorder (TD) and found that family functioning and family stress were associated with homework adherence. Specifically, families with higher stress levels demonstrated lower homework adherence than those with lower stress. However, in the present study, the sample consisted of individuals aged 13 to 35 years, with a mean age of 19.7 leaning toward late adolescence and early adulthood during which the influence of family may be less prominent compared to internal factors such as motivation. This interpretation aligns with Arnett's theory,<sup>41</sup> which describes emerging adulthood as a transitional stage marked by increasing independence and detachment from the family of origin. Additionally, homework in the context of psychological therapy is a highly personal, and family influence may be limited, especially for individuals with high autonomy or independent living.

Moreover, these findings should also be considered within the Thai cultural context. Thailand is traditionally a collectivist society where family involvement in healthcare is emphasized.<sup>42</sup> The lack of association between family functioning and homework adherence in this study may reflect developmental changes in adolescence and emerging adulthood, during which young people seek greater independence even within collectivist cultures. The rapid adoption of online therapy formats in Thailand, as seen in this sample, may also influence how young clients perceive and engage with homework compared with adults.<sup>43</sup> These cultural factors highlight the importance of tailoring CBT interventions in Thailand to balance family engagement with support for individual autonomy.

In the supplemental analyses, psychological effort, though conceptually relevant as a measure of mental exertion, showed no clear relationship with treatment outcomes, suggesting that its role may be more complex than captured here. It is also possible that the absence of significant associations with psychological effort may partly reflect the way this coefficient was calculated, which produced values within a relatively narrow range and thereby limited sensitivity due to restriction of range. While the HRS-II total score was strongly associated with therapeutic alliance, intrinsic motivation, and identified regulation, subscale analyses revealed more nuanced patterns. Therapeutic alliance related to homework beliefs and consequences, but not engagement, intrinsic motivation was linked to homework engagement, and identified regulation was associated with homework beliefs. These findings were consistent with prior evidence on the importance of motivation and alliance in CBT homework<sup>4</sup> and suggested that different motivational processes may shape distinct dimensions of homework behavior, while the overall adherence score remains the most clinically meaningful indicator.

A key strength of this study lies in its assessment of homework adherence from both the client's and therapist's perspectives, providing a broader understanding of client behavior.

This study also considered a wide range of relevant factors including individual traits, therapy process variables, attitudes toward therapy, and family context which contributed to a more balanced analysis of homework-related influences. However, several limitations should be acknowledged. The cross-sectional design limited the ability to draw causal inferences. The sample largely consisted of young people and adults and was drawn from only 2 clinical sites located in Bangkok, which may, to some extent, limit the generalizability of findings to other populations. In addition, although the translated instruments were reviewed by CBT and language experts, the absence of a pilot study or construct validity testing is a limitation, as most participants were students without formal psychiatric diagnoses. This may have affected participants' understanding, willingness to respond, or accuracy of responses. Additionally, data on other potentially relevant factors such as psychiatric diagnoses, types of homework assigned, concurrent treatments were not collected. Studies may also benefit from including more diverse populations, focusing on specific age groups, and incorporating additional variables relevant to homework behavior.

### Future Research Directions

Future studies should employ longitudinal or prospective designs to better clarify the causal relationships between therapeutic alliance, motivation, and homework adherence. Such designs could help determine whether stronger alliance and higher identified regulation lead to better adherence, or whether adherence itself strengthens the therapeutic relationship. In addition, research should examine the role of therapist variables in greater depth, including specific skills, supervision quality, and training background, to understand how these factors influence adherence, especially in younger populations. Expanding the scope to include diverse clinical populations, such as individuals with specific psychiatric diagnoses or different cultural contexts, would enhance the generalizability of findings. Moreover, exploring family involvement and peer support as potential facilitators of homework adherence among adolescents may yield valuable insights, particularly in collectivist cultures. Finally, integrating technology-based strategies, such as mobile health applications and digital reminders, may provide innovative methods to improve homework adherence and should be systematically investigated in future work.

### Implications

The findings of this study provide practical guidance for psychiatrists, psychotherapists, and clinical psychologists in designing therapist training programs. Key skills include building a strong therapeutic alliance by establishing trust and a safe environment, and collaboratively designing homework with clients to address real-life problems. Explaining the purpose and benefits of homework enhances identified regulation, supporting self-regulation and consistent engagement. Structuring treatment plans to promote collaboration and goal-setting, along with providing feedback and reinforcement, further strengthens motivation. Developing these competencies can improve client adherence and ultimately lead to better treatment outcomes in CBT.

### Conclusions

This study found that the strong therapeutic alliance, along with intrinsic motivation and identified regulation, were positively associated with homework adherence in CBT. Among young adults, therapist experience also associated with homework adherence.

Moreover, both client-reported and therapist-rated homework adherence were linked to clinical improvement. These findings underscore the importance of building a strong therapeutic alliance, fostering emotional connection, and creating a safe space within the therapeutic relationship.

### Additional Information

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**Ethics Approval:** This study was reviewed and approved by the Ethics Committee of the Faculty of Medicine Ramathibodi Hospital, Mahidol University (MURA2023/923 on 13 December 2023). All participants provided informed consent prior to participation. For participants under the age of 18, written informed consent was obtained from a parent or legal guardian, along with assent from the participant. The study was conducted in accordance with the Declaration of Helsinki and ethical standards for research involving human participants.

**Clinical Trial Consideration:** This study does not report on a clinical trial.

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**Supplementary Material:** Download Supplementary S1-S10 from the following link:

<https://he02.tci-thaijo.org/index.php/ramajournal/article/view/275833/188730>

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# Surgeon Satisfaction With Anesthesia Services at Srinagarind Hospital: A Comparison With Data From 7 Years Ago

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## Abstract

**Background:** Surgeon satisfaction with anesthesia services is a critical quality indicator that drives multidisciplinary improvement in perioperative care.

**Objectives:** To assess current satisfaction levels and compare improvements over a 7-year period.

**Methods:** This prospective, descriptive study was conducted between May 2024 and July 2024 at Srinagarind Hospital. This study surveyed 41 surgeons (faculty physicians, residents, and staff physicians) across multiple departments using a validated questionnaire covering preoperative, intraoperative, postoperative recovery room, and ward-based anesthesia services. Satisfaction was measured using a 4-point Likert scale and compared with the 2016-2017 baseline data from 102 surgeons.

**Results:** Response rate was 100% (41/41). Overall satisfaction scores ranged from 3.56 to 3.98 (very high satisfaction). The highest satisfaction areas included: fasting guidelines, anesthesia initiation timing, and postoperative patient visits (mean [SD], 3.95 [0.22], 3.98 [0.16], and 3.97 [0.16], respectively). Compared with 2016-2017, significant improvements were observed in coordination systems (mean [SD], 3.46 [0.57] to 3.95 [0.22];  $P < .001$ ), emergency scheduling (mean [SD], 3.42 [0.64] to 3.88 [0.33];  $P < .01$ ), and sign-in cooperation (mean [SD], 3.53 [0.59] to 3.90 [0.30];  $P < .01$ ). Areas for improvement included preoperative coordination communication and glucose loading protocols (mean [SD], 3.63 [0.49] and 3.60 [0.59], respectively).

**Conclusions:** Surgeon satisfaction with anesthesia services at Srinagarind Hospital consistently demonstrated high levels, with marked improvements over 7 years, particularly in coordination systems and safety protocols. A continued focus on communication and evidence-based preoperative protocols will further improve multidisciplinary collaboration.

**Keywords:** Surgeon satisfaction, Anesthesia services, Perioperative care, Patient safety, Quality improvement

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## Introduction

Surgeon satisfaction with anesthesia services represents a fundamental quality metric in modern healthcare systems, serving as an indicator of service excellence and a driver for continuous improvement in perioperative care delivery.<sup>1,2</sup> As internal customers of anesthesia departments, surgeons maintain intimate working relationships with anesthesia providers throughout the perioperative continuum, making their perspectives

invaluable for identifying opportunities for improvement and ensuring optimal patient outcomes.<sup>3,4</sup>

The measurement of surgeon satisfaction has evolved beyond simple customer service metrics to encompass complex assessments of clinical competency, communication effectiveness, workflow efficiency, and safety culture implementation.<sup>5,6</sup> Modern healthcare institutions recognize that surgeon satisfaction directly correlates with team cohesion, reduced medical errors, improved patient safety outcomes, and overall institutional performance in accreditation processes.<sup>7,8</sup>

As a tertiary care academic medical center, Srinagarind Hospital serves as a regional referral center with complex surgical caseloads requiring sophisticated anesthesia services across multiple subspecialties. The hospital's commitment to quality improvement necessitates regular assessment of service delivery from key stakeholder perspectives, particularly surgeons who depend on anesthesia services for successful patient outcomes. Previous research conducted at Srinagarind Hospital in 2016-2017 by Chaikree et al<sup>9</sup> demonstrated overall good satisfaction levels (mean [SD] satisfaction score, 3.06 [0.20]) among 102 surveyed surgeons, while identifying specific areas requiring improvement, including communication protocols, scheduling coordination, and after-hours service delivery. After that baseline assessment, the anesthesia department has implemented several quality improvement initiatives, standardized protocols, and enhanced communication systems.

The dynamic nature of healthcare delivery, evolving surgical techniques, changing patient demographics, and implementation of new safety standards require periodic reassessment of satisfaction levels to ensure continuous alignment between service delivery and surgeon expectations.<sup>10,11</sup> Furthermore, the COVID-19 pandemic has introduced new challenges and adaptations in perioperative care that may have influenced satisfaction parameters.<sup>12</sup>

Contemporary literature emphasizes the importance of multidisciplinary collaboration in achieving optimal surgical outcomes, with anesthesia-surgery team dynamics playing a crucial role in patient safety, operational efficiency, and staff satisfaction.<sup>13,14</sup> Studies from other institutions have shown that high surgeon satisfaction with anesthesia services correlates with reduced case delays, improved communication, enhanced safety culture, and better patient outcomes.<sup>15,16</sup>

This study aimed to provide a comprehensive assessment of current surgeon satisfaction levels with anesthesia services at Srinagarind Hospital in 2023, compare these findings with baseline 2016-2017 data to identify trends and improvements, and establish evidence-based recommendations for further service enhancement. This study addresses critical gaps in understanding how systematic quality improvement initiatives affect surgeon satisfaction over time and provides valuable insights for other academic medical centers seeking to optimize perioperative care delivery.

## Methods

### Study Design, Setting, and Participants

This prospective, descriptive study was conducted at Srinagarind Hospital, a 1500-bed tertiary care academic medical center affiliated with Khon Kaen University, between May 2024 and July 2024. The study protocol was approved by the Khon Kaen University Ethics Committee for Human Research (HE661282).

The study population comprised surgeons actively using anesthesia services at Srinagarind Hospital. Inclusion criteria were as follows: 1) faculty physicians, staff physicians, or residents (years 1-4) from surgical departments; 2) minimum 1 year of experience working with anesthesia services at Srinagarind Hospital; 3) active involvement in surgical procedures requiring anesthesia services during the study period; and 4) voluntary consent to participate. Exclusion criteria were as follows: 1) visiting physicians from external institutions, 2) physicians on extended leave during the study period, and 3) incomplete survey responses.

Sample size was calculated using the formula for descriptive studies:  $n = 4(Z_{\alpha/2})^2\sigma^2/d^2$ , where  $n$  = required sample size,  $\sigma$  = standard deviation from previous literature<sup>9</sup> (0.36 based on 2016-2017 baseline study),  $d$  = total width of expected confidence interval (CI) (0.08), and  $Z_{\alpha/2} = 1.96$  for 95% CI. Calculated sample size:  $n = 4(1.96)^2(0.36)^2/(0.08)^2$ , was 32 participants. Accounting for a 20% nonresponse rate, the final target was 41 participants.

### Survey Instrument

A comprehensive questionnaire was developed based on the validated instrument used in the 2016-2017 baseline study, with modifications to reflect current practice standards and emerging quality metrics. The instrument underwent content validation by 2 senior anesthesiologists and pilot testing with 5 surgeons, with a Cronbach  $\alpha$  of 0.85.

The questionnaire comprised the following: 1) demographic data, including age, gender, position, and department affiliation; 2) preoperative phase satisfaction (11 items), including patient evaluation, coordination, communication, and scheduling systems; 3) intraoperative phase satisfaction (9 items), including service delivery, responsiveness, competency, and safety protocols; 4) postoperative recovery room satisfaction (3 items), including care quality, communication, and discharge management; 5) ward-based postoperative satisfaction (2 items), including patient visits and pain management; 6) service consultation satisfaction (10 items), including various procedural locations and electronic systems; and 7) preoperative preparation knowledge assessment (11 items), including surgeon's understanding of evidence-based protocols.

Satisfaction was measured using a 4-point Likert scale (4 = very satisfied [3.51-4.00], 3 = satisfied [2.51-3.50], 2 = dissatisfied [1.51-2.50], 1 = very dissatisfied [1.00-1.50])

### Data Collection

The survey distribution was distributed through department heads with sealed envelopes containing study information and questionnaires. Follow-up collection occurred at 2-week intervals over 8 weeks to maximize response rates. Electronic and paper-based options were provided to accommodate preferences.

### Comparative Framework

Results were systematically compared with the 2016-2017 baseline data ( $n = 102$ ) to assess changes in the overall satisfaction trend, specific domain improvements or deteriorations, ranking shifts in satisfaction priorities, and emerging areas of concern or excellence.

### Statistical Analysis

Data analysis was performed using SPSS version 26.0 (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp; 2019). Descriptive statistics included frequencies, percentages, and mean (SD). Comparative analysis with the 2016-2017

baseline data used independent *t* tests for continuous variables and chi-square tests for categorical variables. Statistical significance was set at  $P < .05$ .

## Results

### Demographic Characteristics

A total of 41 surgeons participated in the study, achieving a 100% response rate. The demographic distribution showed balanced gender representation with 21 females (51.2%) and 20 males (48.8%). Age distribution was predominantly young professionals, with 23 participants (56.1%) aged 21-30 years, 17 participants (41.5%) aged 31-40 years, and 1 participant (2.4%) aged 41-50 years (Table 1).

Professional status distribution showed 39 residents/staff physicians (95.1%) and 2 faculty physicians (4.9%). Department representation was diverse, with surgery having the highest participation (29.3%), followed by otolaryngology and orthopedics (17.1% each), internal medicine (12.2%), and other specialties including pediatrics, ophthalmology, obstetrics-gynecology, vascular surgery, and radiology, each accounting for 4.8% to 4.9% (Table 1).

### Preoperative Satisfaction Results

Preoperative satisfaction scores showed consistently high levels across all assessed domains (Table 2). The highest satisfaction scores were achieved in coordination systems for regular scheduling within 4:30 PM (mean [SD], 3.95 [0.22]; rank 1), sign-in cooperation (mean [SD], 3.90 [0.30]; rank 2), and emergency scheduling coordination using mobile phones (mean [SD], 3.88 [0.33]; rank 3).

Standard preoperative services, including patient visits and preparation (mean [SD], 3.85 [0.36]) and laboratory test protocols (mean [SD], 3.85 [0.36]), both ranked fourth with identical scores. Areas with relatively lower satisfaction included preoperative coordination communication (mean [SD], 3.63 [0.49]; rank 9), appropriateness of preoperative case cancellations (mean [SD], 3.61 [0.54]; rank 10), and opportunity for opinion expression during consultations (mean [SD], 3.56 [0.50]; rank 11).

### Intraoperative Satisfaction Results

Intraoperative satisfaction obtained the highest overall scores in the study (Table 3). Anesthesia initiation timing when physicians and equipment were ready scored highest (mean [SD], 3.98 [0.16]; rank 1), followed by time-out cooperation (mean [SD], 3.95 [0.22]; rank 2). Multiple domains tied for rank 3 with mean (SD) scores of 3.93 (0.26), including smooth service delivery, anesthesia team knowledge and competency, team facilitation and assistance, and sign-out cooperation.

Lower-ranked areas included appropriateness in service cancellation decisions (mean [SD], 3.78 [0.47]; rank 9) and team responsiveness to abnormal events and emergency situation control (both mean [SD], 3.88 [0.33]; rank 7).

**Table 1. Surgeons' Demographic Data of Using Anesthesia Services at Srinagarind Hospital**

| Variable                 | No. (%)   |
|--------------------------|-----------|
| Gender                   |           |
| Male                     | 20 (48.8) |
| Female                   | 21 (51.2) |
| Age, y                   |           |
| 21-30                    | 23 (56.1) |
| 31-40                    | 17 (41.5) |
| 41-50                    | 1 (2.4)   |
| Status                   |           |
| Faculty physician        | 2 (4.9)   |
| Resident/staff physician | 39 (95.1) |
| Department affiliation   |           |
| Pediatrics               | 2 (4.9)   |
| Ophthalmology            | 2 (4.9)   |
| Surgery                  | 12 (29.3) |
| Obstetrics-gynecology    | 2 (4.9)   |
| Otolaryngology           | 7 (17.1)  |
| Orthopedics              | 7 (17.1)  |
| Internal medicine        | 5 (12.2)  |
| Vascular                 | 2 (4.8)   |
| Radiology                | 2 (4.8)   |

**Table 2. Satisfaction Level of Surgeons With Preoperative Anesthesia Services at Srinagarind Hospital**

| Assessment Item*                                                                                                                        | Mean (SD)   | No. (%)    |           | Satisfaction Rank |
|-----------------------------------------------------------------------------------------------------------------------------------------|-------------|------------|-----------|-------------------|
|                                                                                                                                         |             | Level 3-4  | Level 1-2 |                   |
| 1) The anesthesia team provides preoperative patient visit and preparation                                                              | 3.85 (0.36) | 41 (100.0) | 0         | 4                 |
| 2) The anesthesia team follows standard preoperative patient preparation for appropriate laboratory tests                               | 3.85 (0.36) | 41 (100.0) | 0         | 4                 |
| 3) The anesthesia team coordinates with you before surgery                                                                              | 3.63 (0.49) | 41 (100.0) | 0         | 9                 |
| 4) Opportunity and willingness to listen to opinions during consultation                                                                | 3.56 (0.50) | 41 (100.0) | 0         | 11                |
| 5) Implementation of patient care recommendations into practice                                                                         | 3.76 (0.43) | 41 (100.0) | 0         | 8                 |
| 6) Courtesy and interpersonal relationships                                                                                             | 3.78 (0.42) | 41 (100.0) | 0         | 7                 |
| 7) System for coordination and scheduling elective surgery patients daily according to a regular surgery schedule within 4:30 PM        | 3.95 (0.22) | 41 (100.0) | 0         | 1                 |
| 8) System for coordination and scheduling additional surgery patients after 4:30 PM by contacting the attending physician until 7:00 PM | 3.85 (0.37) | 41 (100.0) | 0         | 6                 |
| 9) System for coordination and scheduling emergency surgery patients outside office hours using mobile phones                           | 3.88 (0.33) | 41 (100.0) | 0         | 3                 |

**Table 2. Satisfaction Level of Surgeons With Preoperative Anesthesia Services at Srinagarind Hospital (Continued)**

| Assessment Item*                                                                                                 | Mean (SD)   | No. (%)    |           | Satisfaction Rank |
|------------------------------------------------------------------------------------------------------------------|-------------|------------|-----------|-------------------|
|                                                                                                                  |             | Level 3-4  | Level 1-2 |                   |
| 10) Appropriateness in deciding to cancel patient services according to schedule before coming to operating room | 3.61 (0.54) | 40 (97.6)  | 1 (2.4)   | 10                |
| 11) Cooperation in performing sign-in                                                                            | 3.90 (0.30) | 41 (100.0) | 0         | 2                 |

\* Feedback from physicians regarding after-hours surgery cases where patients have additional personal expenses: anesthesiologists should see patients at least 1 day before surgery, similar to general elective cases (disagree with some anesthesiologists who come for preoperation when the patient already arrives at the operating room and think it is unfair to after-hours patients).

**Table 3. Satisfaction Level of Surgeons With Intraoperative Anesthesia Services at Srinagarind Hospital**

| Assessment Item                                                                                          | Mean (SD)   | No. (%)    |           | Satisfaction Rank |
|----------------------------------------------------------------------------------------------------------|-------------|------------|-----------|-------------------|
|                                                                                                          |             | Level 3-4  | Level 1-2 |                   |
| 1) The anesthesia team initiates anesthesia service when physician is in the room and equipment is ready | 3.98 (0.16) | 41 (100.0) | 0         | 1                 |
| 2) Smooth and efficient anesthesia service delivery                                                      | 3.93 (0.26) | 41 (100.0) | 0         | 3                 |
| 3) The anesthesia team responds to notification of abnormal events during surgery                        | 3.88 (0.33) | 41 (100.0) | 0         | 7                 |
| 4) The anesthesia team controls situations when emergencies occur during surgery                         | 3.88 (0.33) | 41 (100.0) | 0         | 7                 |
| 5) The anesthesia team has knowledge and ability to provide appropriate anesthesia services              | 3.93 (0.26) | 41 (100.0) | 0         | 3                 |
| 6) The anesthesia team facilitates and assists during surgery                                            | 3.93 (0.26) | 41 (100.0) | 0         | 3                 |
| 7) Appropriateness in deciding to cancel scheduled patient services                                      | 3.78 (0.47) | 40 (97.6)  | 1 (2.4)   | 9                 |
| 8) Cooperation in performing time-out                                                                    | 3.95 (0.22) | 41 (100.0) | 0         | 2                 |
| 9) Cooperation in performing sign-out                                                                    | 3.93 (0.26) | 41 (100.0) | 0         | 3                 |

### Postoperative Recovery Room Satisfaction

All 3 assessed domains in the recovery room achieved very high satisfaction levels (Table 4). Anesthesia team knowledge and competency in postoperative care ranked highest (mean [SD], 3.93 [0.26]), whereas appropriateness in reporting abnormal symptoms and discharge management had a mean (SD) score of 3.83 (0.38), sharing rank 2.

### Ward-Based Postoperative Satisfaction

Ward-based satisfaction measures achieved very high scores (Table 5). Patient visits within 24 hours and continued follow-up for cases with anesthesia problems scored the highest (mean [SD], 3.97 [0.16]; rank 1), whereas mean (SD) postoperative pain management scored 3.85 (0.36), rank 2.

### Seven-Year Comparative Analysis (2016-2023)

Comparative analysis revealed remarkable improvements across multiple domains (Table 6). The most dramatic improvements were observed.

In the preoperative phase, the satisfaction scores of regular scheduling coordination was mean (SD) of 3.46 (0.57) to 3.95 (0.22) (rank improvement from 7 to 1), after-hours scheduling coordination was mean (SD) of 3.35 (0.70) to 3.85 (0.37) (rank improvement from 10 to 6), emergency scheduling coordination was mean (SD) of 3.42 (0.64) to 3.88 (0.33) (rank improvement from 8 to 3), and sign-in cooperation was mean (SD) of 3.53 (0.59) to 3.90 (0.30) (rank improvement from 6 to 2).

In the intraoperative phase, the satisfaction scores of anesthesia initiation timing was mean (SD) of 3.75 (0.48) to 3.98 (0.16) (rank improvement from 4 to 1), service delivery smoothness was mean (SD) of 3.59 (0.61) to 3.93 (0.26) (rank improvement from 8 to 3), and time-out cooperation was mean (SD) of 3.61 (0.57) to 3.95 (0.22) (rank improvement from 6 to 2).

In the postoperative phase, recovery room and ward-based satisfaction was consistently maintained at high levels with modest improvements across all measured domains.

Service Consultation Satisfaction

Consultation satisfaction across various hospital locations demonstrated uniformly high scores (Table 7). Elective operating room consultations ranked highest (mean [SD], 3.87 [0.34]), followed by intubation services (mean [SD], 3.86 [0.35]) and acupuncture room services (mean [SD], 3.79 [0.41]). The electronic consultation system scored moderately (mean [SD], 3.72 [0.51]; rank 7).

Preoperative Preparation Knowledge Assessment

The surgeons’ understanding of evidence-based preoperative protocols was excellent (Table 8). The fasting guidelines obtained the highest score (mean [SD], 3.95 [0.22]), followed by the PONV prevention guidelines (mean [SD], 3.93 [0.27]). Areas with lower scores included glucose loading protocols (mean [SD], 3.60 [0.59]; rank 11) and thromboembolism prevention (mean [SD], 3.65 [0.53]; rank 10).

Table 4. Satisfaction Level of Surgeons With Postoperative Anesthesia Services in Recovery Room at Srinagarind Hospital

| Assessment Item                                                                                       | Mean (SD)   | No. (%)    |           | Satisfaction Rank |
|-------------------------------------------------------------------------------------------------------|-------------|------------|-----------|-------------------|
|                                                                                                       |             | Level 3-4  | Level 1-2 |                   |
| 1) The anesthesia team has knowledge and ability in postoperative patient care and various procedures | 3.93 (0.26) | 41 (100.0) | 0         | 1                 |
| 2) Appropriateness in reporting the patient’s abnormal symptoms                                       | 3.83 (0.38) | 41 (100.0) | 0         | 2                 |
| 3) Appropriateness in managing patient discharge                                                      | 3.83 (0.38) | 41 (100.0) | 0         | 2                 |

**Table 5. Satisfaction Level of Surgeons With Postoperative Anesthesia Services in Patient Ward at Srinagarind Hospital**

| Assessment Item                                                                                                                                        | Mean (SD)   | No. (%)    |           | Satisfaction Rank |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|------------|-----------|-------------------|
|                                                                                                                                                        |             | Level 3-4  | Level 1-2 |                   |
| 1) The anesthesia team visits patients within 24 hours after anesthesia service and continues follow-up to 72 hours for cases with anesthesia problems | 3.97 (0.16) | 41 (100.0) | 0         | 1                 |
| 2) Postoperative pain management in the patient ward                                                                                                   | 3.85 (0.36) | 41 (100.0) | 0         | 2                 |

**Table 6. Comparison of Surgeon Satisfaction With Anesthesia Services Between 2016-2017 and 2023-2024**

| Assessment Item                                                                                                                                   | Mean (SD)   | Satisfaction Level | Rank |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------|------|
| <b>Preoperative phase</b>                                                                                                                         |             |                    |      |
| 1) The anesthesia team provides preoperative patient visit and preparation                                                                        |             |                    |      |
| 2016-2017                                                                                                                                         | 3.63 (0.49) | Very high          | 2    |
| 2023-2024                                                                                                                                         | 3.85 (0.36) | Very high          | 4    |
| 2) The anesthesia team follows standard preoperative patient preparation for appropriate laboratory tests                                         |             |                    |      |
| 2016-2017                                                                                                                                         | 3.72 (0.47) | Very high          | 1    |
| 2023-2024                                                                                                                                         | 3.85 (0.36) | Very high          | 4    |
| 3) The anesthesia team coordinates with you before surgery                                                                                        |             |                    |      |
| 2016-2017                                                                                                                                         | 3.33 (0.66) | High               | 11   |
| 2023-2024                                                                                                                                         | 3.63 (0.49) | Very high          | 9    |
| 4) Opportunity and willingness to listen to opinions during consultation                                                                          |             |                    |      |
| 2016-2017                                                                                                                                         | 3.55 (0.59) | Very high          | 5    |
| 2023-2024                                                                                                                                         | 3.56 (0.50) | Very high          | 11   |
| 5) Implementation of patient care recommendations into practice                                                                                   |             |                    |      |
| 2016-2017                                                                                                                                         | 3.62 (0.53) | Very high          | 3    |
| 2023-2024                                                                                                                                         | 3.76 (0.43) | Very high          | 8    |
| 6) Courtesy and interpersonal relationships                                                                                                       |             |                    |      |
| 2016-2017                                                                                                                                         | 3.60 (0.57) | Very high          | 3    |
| 2023-2024                                                                                                                                         | 3.78 (0.42) | Very high          | 7    |
| 7) System for coordination and scheduling elective surgery patients daily according to regular surgery schedule within 4:30 PM                    |             |                    |      |
| 2016-2017                                                                                                                                         | 3.46 (0.57) | High               | 7    |
| 2023-2024                                                                                                                                         | 3.95 (0.22) | Very high          | 1    |
| 8) System for coordinating and contacting to schedule additional surgical patients after 4:30 PM by calling the attending physician until 7:00 PM |             |                    |      |
| 2016-2017                                                                                                                                         | 3.35 (0.70) | High               | 10   |
| 2023-2024                                                                                                                                         | 3.85 (0.37) | Very high          | 6    |
| 9) System for coordination and scheduling emergency surgery patients outside office hours using mobile phones                                     |             |                    |      |
| 2016-2017                                                                                                                                         | 3.42 (0.64) | High               | 8    |
| 2023-2024                                                                                                                                         | 3.88 (0.33) | Very high          | 3    |

**Table 6. Comparison of Surgeon Satisfaction With Anesthesia Services Between 2016-2017 and 2023-2024 (Continued)**

| Assessment Item                                                                                                  | Mean (SD)   | Satisfaction Level | Rank |
|------------------------------------------------------------------------------------------------------------------|-------------|--------------------|------|
| 10) Appropriateness in deciding to cancel patient services according to schedule before coming to operating room |             |                    |      |
| 2016-2017                                                                                                        | 3.38 (0.66) | High               | 9    |
| 2023-2024                                                                                                        | 3.61 (0.54) | Very high          | 10   |
| 11) Cooperation in performing sign-in                                                                            |             |                    |      |
| 2016-2017                                                                                                        | 3.53 (0.59) | High               | 6    |
| 2023-2024                                                                                                        | 3.90 (0.30) | Very high          | 2    |
| <b>Intraoperative phase</b>                                                                                      |             |                    |      |
| 1) The anesthesia team initiates anesthesia service when physician is in room and equipment is ready             |             |                    |      |
| 2016-2017                                                                                                        | 3.75 (0.48) | Very high          | 4    |
| 2023-2024                                                                                                        | 3.98 (0.16) | Very high          | 1    |
| 2) Smooth and efficient anesthesia service delivery                                                              |             |                    |      |
| 2016-2017                                                                                                        | 3.59 (0.61) | Very high          | 8    |
| 2023-2024                                                                                                        | 3.93 (0.26) | Very high          | 3    |
| 3) The anesthesia team responds to notification of abnormal events during surgery                                |             |                    |      |
| 2016-2017                                                                                                        | 3.75 (0.44) | Very high          | 3    |
| 2023-2024                                                                                                        | 3.88 (0.33) | Very high          | 7    |
| 4) The anesthesia team controls situations when emergencies occur during surgery                                 |             |                    |      |
| 2016-2017                                                                                                        | 3.73 (0.47) | Very high          | 5    |
| 2023-2024                                                                                                        | 3.88 (0.33) | Very high          | 7    |
| 5) The anesthesia team has knowledge and ability to provide appropriate anesthesia services                      |             |                    |      |
| 2016-2017                                                                                                        | 3.78 (0.42) | Very high          | 1    |
| 2023-2024                                                                                                        | 3.93 (0.26) | Very high          | 3    |
| 6) The anesthesia team facilitates and assists during surgery                                                    |             |                    |      |
| 2016-2017                                                                                                        | 3.76 (0.43) | Very high          | 2    |
| 2023-2024                                                                                                        | 3.93 (0.26) | Very high          | 3    |
| 7) Appropriateness in deciding to cancel scheduled patient services                                              |             |                    |      |
| 2016-2017                                                                                                        | 3.60 (0.60) | Very high          | 7    |
| 2023-2024                                                                                                        | 3.78 (0.47) | Very high          | 9    |
| 8) Cooperation in performing time-out                                                                            |             |                    |      |
| 2016-2017                                                                                                        | 3.61 (0.57) | Very high          | 6    |
| 2023-2024                                                                                                        | 3.95 (0.22) | Very high          | 2    |
| 9) Cooperation in performing sign-out                                                                            |             |                    |      |
| 2016-2017                                                                                                        | NA          | NA                 | NA   |
| 2023-2024                                                                                                        | 3.93 (0.26) | Very high          | 3    |
| <b>Postoperative phase at the recovery room</b>                                                                  |             |                    |      |
| 1) The anesthesia team has knowledge and ability in postoperative patient care and various procedures            |             |                    |      |
| 2016-2017                                                                                                        | 3.71 (0.52) | Very high          | 2    |
| 2023-2024                                                                                                        | 3.93 (0.26) | Very high          | 1    |

**Table 6. Comparison of Surgeon Satisfaction With Anesthesia Services Between 2016-2017 and 2023-2024 (Continued)**

| Assessment Item                                                                                                                                        | Mean (SD)   | Satisfaction Level | Rank |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------|------|
| 2) Appropriateness in reporting patient abnormal symptoms                                                                                              |             |                    |      |
| 2016-2017                                                                                                                                              | 3.72 (0.45) | Very high          | 1    |
| 2023-2024                                                                                                                                              | 3.83 (0.38) | Very high          | 2    |
| 3) Appropriateness in managing patient discharge                                                                                                       |             |                    |      |
| 2016-2017                                                                                                                                              | 3.65 (0.50) | Very high          | 3    |
| 2023-2024                                                                                                                                              | 3.83 (0.38) | Very high          | 2    |
| <b>Postoperative phase at the ward</b>                                                                                                                 |             |                    |      |
| 1) The anesthesia team visits patients within 24 hours after anesthesia service and continues follow-up to 72 hours for cases with anesthesia problems |             |                    |      |
| 2016-2017                                                                                                                                              | 3.71 (0.46) | Very high          | 1    |
| 2023-2024                                                                                                                                              | 3.97 (0.16) | Very high          | 1    |
| 2) Postoperative pain management at the ward                                                                                                           |             |                    |      |
| 2016-2017                                                                                                                                              | 3.66 (0.52) | Very high          | 2    |
| 2023-2024                                                                                                                                              | 3.85 (0.36) | Very high          | 2    |

Abbreviation: NA, not applicable.

**Table 7. Satisfaction Level of Surgeons With Anesthesia Service Consultation at Various Points in Srinagarind Hospital**

| Assessment Item                                                               | Mean (SD)   | No. (%)    |           | Satisfaction Rank |
|-------------------------------------------------------------------------------|-------------|------------|-----------|-------------------|
|                                                                               |             | Level 3-4  | Level 1-2 |                   |
| 1) Consultation for anesthesia services in the elective operating room        | 3.87 (0.34) | 41 (100.0) | 0         | 1                 |
| 2) Consultation for anesthesia services in the emergency operating room       | 3.74 (0.44) | 41 (100.0) | 0         | 6                 |
| 3) Consultation for anesthesia services in the delivery room                  | 3.77 (0.43) | 41 (100.0) | 0         | 4                 |
| 4) Consultation for anesthesia services in the x-ray/radiation therapy room   | 3.70 (0.46) | 41 (100.0) | 0         | 8                 |
| 5) Consultation for anesthesia services in the OPD examination room (ECT)     | 3.76 (0.43) | 41 (100.0) | 0         | 5                 |
| 6) Consultation for anesthesia services for central venous catheter insertion | 3.69 (0.47) | 41 (100.0) | 0         | 9                 |
| 7) Consultation for anesthesia services for intubation                        | 3.86 (0.35) | 41 (100.0) | 0         | 2                 |
| 8) Electronic consultation system of the anesthesia department                | 3.72 (0.51) | 40 (97.6)  | 1 (2.4)   | 7                 |
| 9) Consultation for anesthesia services in the acupuncture room               | 3.79 (0.41) | 41 (100.0) | 0         | 3                 |
| 10) Consultation for other anesthesia services: not specified                 | 3.88 (0.35) | 41 (100.0) | 0         | NA                |

Abbreviations: ECT, electroconvulsive therapy; NA, not applicable; OPD, outpatient department.

**Table 8. Basic Understanding of Surgeons in Preoperative Patient Preparation at Srinagarind Hospital**

| Assessment Item*                                                                    | Mean (SD)   | No. (%)    |           | Satisfaction Rank |
|-------------------------------------------------------------------------------------|-------------|------------|-----------|-------------------|
|                                                                                     |             | Level 3-4  | Level 1-2 |                   |
| 1) Acknowledge and understand basic information about anesthesia/surgery beforehand | 3.85 (0.36) | 41 (100.0) | 0         | 3                 |
| 2) Provide exercise/physical rehabilitation to strengthen the body before surgery   | 3.68 (0.53) | 40 (97.6)  | 1 (2.4)   | 8                 |
| 3) Control/treat existing chronic diseases well before surgery                      | 3.80 (0.41) | 41 (100.0) | 0         | 5                 |

**Table 8. Basic Understanding of Surgeons in Preoperative Patient Preparation at Srinagarind Hospital (Continued)**

| Assessment Item*                                                                         | Mean (SD)   | No. (%)    |           | Satisfaction Rank |
|------------------------------------------------------------------------------------------|-------------|------------|-----------|-------------------|
|                                                                                          |             | Level 3-4  | Level 1-2 |                   |
| 4) Stop smoking/drinking alcohol at least 2-4 weeks before surgery                       | 3.66 (0.63) | 40 (97.6)  | 1 (2.4)   | 9                 |
| 5) Practice breathing exercises before surgery                                           | 3.73 (0.45) | 41 (100.0) | 0         | 7                 |
| 6) Fast for at least 6 hours for solid food/2 hours for water before surgery             | 3.95 (0.22) | 39 (95.1)  | 2 (4.9)   | 1                 |
| 7) Drink glucose/sugar-containing fluids 2 hours before surgery                          | 3.60 (0.59) | 41 (100.0) | 0         | 11                |
| 8) Receive information/methods for postoperative pain management                         | 3.85 (0.36) | 41 (100.0) | 0         | 3                 |
| 9) Know guidelines for preventing postoperative nausea/vomiting                          | 3.93 (0.27) | 41 (100.0) | 0         | 2                 |
| 10) Know guidelines for preventing postoperative thromboembolism                         | 3.65 (0.53) | 40 (97.6)  | 1 (2.4)   | 10                |
| 11) Know guidelines for postoperative behavior such as early ambulation and mobilization | 3.75 (0.44) | 41 (100.0) | 0         | 6                 |

\* Surgeon feedback on anesthesia services included the following: 1) anesthesiologists care very well for patients, especially during surgery, 2) have good knowledge and ability in patient care, 3) demonstrate professionalism and safety standards, and 4) are punctual.

## Discussion

### Overall Satisfaction Trends

The findings of this study show sustained high levels of surgeon satisfaction with anesthesia services at Srinagarind Hospital, with notable improvements across multiple domains compared with the 2016-2017 baseline assessment. The overall satisfaction scores ranging from 3.56 to 3.98 indicate consistent "very high" satisfaction levels, reflecting successful implementation of quality improvement initiatives over the 7-year period.

### Remarkable Quality Improvements

The most remarkable improvements were observed in the coordination and scheduling systems, which addressed the primary concerns identified in the 2016-2017 study. The dramatic improvement in regular scheduling coordination (from rank 7 to rank 1) and emergency scheduling systems (from rank 8 to rank 3) demonstrates successful implementation of systematic communication protocols and technology integration.

These improvements align with contemporary literature emphasizing the importance of structured communication systems in perioperative settings.<sup>17, 18</sup> The implementation of standardized scheduling protocols, mobile communication systems, and dedicated coordination personnel likely contributed to these remarkable gains, consistent with findings from other academic medical centers.<sup>19, 20</sup>

### Safety Protocol Implementation

The substantial improvements in safety protocol cooperation, particularly sign-in procedures (rank improvement from 6 to 2) and time-out processes (rank improvement from 6 to 2), reflect the successful adoption of the World Health Organization (WHO) Surgical Safety Checklist principles and enhanced team communication training.<sup>21, 22</sup> Given the growing emphasis on perioperative safety culture and systematic error prevention strategies, these improvements are particularly important.

### Service Delivery Excellence

The consistently high scores in intraoperative service delivery, with anesthesia

initiation timing achieving near-perfect satisfaction (mean [SD], 3.98 [0.16]), demonstrate the anesthesia team's commitment to operational efficiency and professional excellence. This finding supports research indicating that prompt, professional service delivery remarkably affects surgeon satisfaction and overall team dynamics.<sup>23, 24</sup>

### Areas for Continued Improvement

Despite the overall excellent performance, several areas warrant continued attention. Although improved, preoperative coordination communication remains the lowest-ranked preoperative domain. This finding suggests that interpersonal communication aspects require ongoing focus, despite systematic improvements; this is consistent with literature emphasizing the complexity of multidisciplinary communication in healthcare settings.<sup>25, 26</sup> The relatively lower satisfaction with glucose loading protocols (rank 11) may reflect ongoing debates in the literature regarding enhanced recovery after surgery (ERAS) protocols and varying evidence for preoperative carbohydrate loading across different surgical populations.<sup>27, 28</sup> This presents an opportunity for evidence-based protocol development and education.

### Comparative Context

When compared with international literature, the satisfaction scores obtained at Srinagarind Hospital compare favorably with those of other academic medical centers. Le May et al<sup>29</sup> reported similar satisfaction patterns in Canadian teaching hospitals, with a particular emphasis on the importance of technical competency and communication quality. Studies from European institutions have demonstrated comparable satisfaction levels in well-established academic centers with structured quality improvement programs.<sup>30, 31</sup>

### Impact of Quality Improvement Initiatives

The 7-year comparison provides compelling evidence that systematic quality improvement initiatives can substantially enhance surgeon satisfaction. The improvements observed likely resulted from multiple factors including technology integration (implementation of electronic consultation systems and mobile communication protocols), process standardization (development of standardized scheduling and coordination procedures), safety culture enhancement (systematic implementation of safety protocols and team training), continuous monitoring (regular assessment and feedback mechanisms), and multidisciplinary collaboration (enhanced team-based approaches to perioperative care).

### Limitations

Several limitations should be considered when interpreting these results. The single-center design may limit the generalizability to other institutional settings. The relatively small sample size in 2024 (n = 41) compared with that in 2016-2017 (n = 102) may affect statistical comparisons, although the high response rate strengthens the validity of findings.

The voluntary nature of participation may introduce selection bias, potentially favoring responses from surgeons with stronger opinions about anesthesia services. Because most participants were below 40 years of age, the generalizability of the results to the broader population may be limited. Furthermore, the 4-point Likert scale did not provide a neutral option, potentially limiting respondents and forcing them to take a positive or negative position. Additionally, the study design does not capture patient outcome correlations with satisfaction scores, representing an area for future investigation.

### Future Directions

Based on these findings, several recommendations for continued improvement were communication enhancement (develop structured preoperative communication protocols to address remaining satisfaction gaps), evidence-based protocol updates (review and update preoperative preparation guidelines based on current ERAS evidence), technology optimization (further improve electronic consultation systems based on user feedback), outcome correlation studies (investigate relationships between satisfaction scores and patient safety outcomes), and regular monitoring (establish routine satisfaction assessment cycles to maintain quality improvements).

### Conclusions

This 7-year comparative study demonstrates that surgeon satisfaction with anesthesia services at Srinagarind Hospital has achieved consistently high levels with remarkable improvements in coordination systems, safety protocols, and service delivery. Notable improvements include scheduling coordination (rank improvement from 7 to 1), emergency response systems (rank improvement from 8 to 3), and safety protocol implementation.

The key strengths identified include anesthesia team competency, service timing, patient follow-up care, and safety protocol adherence. Areas for continued focus include preoperative communication enhancement and evidence-based protocol standardization.

These findings establish Srinagarind Hospital as a model for sustained quality improvement in anesthesia services and provide valuable benchmarks for other academic medical centers. The results demonstrate that systematic quality initiatives can substantially enhance surgeon satisfaction and support excellence in multidisciplinary perioperative care.

### Additional Information

**Ethics Approval:** This study was approved by the Khon Kaen University Ethics Committee in Human Research (HE661282) on 12 July 2023.

**Clinical Trial Consideration:** This study does not report on a clinical trial.

**Financial Support:** No financial support was provided for this study.

**Conflict of Interest:** The authors declare no conflict of interest.

**Author Contributions:**

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Methodology: All authors

Visualization: All authors

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# Integrated Training Program in Lifestyle Medicine and Health Literacy for Diabetes Coaches: A Research and Development Study in Community-Based Prediabetes Management

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## Abstract

**Background:** Prediabetes significantly increases risk for type 2 diabetes mellitus (DM) and cardiovascular disease. Lifestyle modification represents the most effective preventive approach but requires strong health literacy and self-management skills for sustainable implementation in community settings.

**Objectives:** To develop and evaluate an integrated training program combining lifestyle medicine and health literacy for DM coaches in managing prediabetes within Thai communities. This evaluated whether intensive coach training could produce superior outcomes and assessed peer coaches' effectiveness in delivering lifestyle interventions.

**Methods:** This 12-month research and development study following the ADDIE framework was conducted across 7 provinces in northeastern Thailand. A total of 4998 participants with prediabetes were enrolled: 1127 trained as DM coaches through an intensive 2-day training which integrated lifestyle medicine, health literacy, and coaching techniques while implementing personal lifestyle modifications. The other 3871 received peer coaching from trained coaches. Primary outcomes included fasting blood glucose (FBG), blood pressure (BP), anthropometrics, body composition, knowledge, and lifestyle medicine scores. Linear mixed model (LMM) analysis assessed within-group changes and between-group differences as rates of change over time.

**Results:** Both groups demonstrated significant improvements in all parameters ( $P < .001$ ). The DM coach group achieved substantial reductions in FBG (-8.4 mg/dL), body weight (-0.8 kg), systolic BP (-1.5 mmHg), and diastolic BP (-2.0 mmHg). LMM analysis revealed superior daily improvements in diastolic BP (-0.012 mmHg/day,  $P = .020$ ) in the coach group. Knowledge scores improved by 4.5 points and coaching skills by 1.6 points in the coach group.

**Conclusions:** The integrated DM coach training program effectively improved clinical outcomes, knowledge, and lifestyle practices. This community-based approach offers a promising, scalable strategy for DM prevention in resource-limited settings.

**Keywords:** Prediabetes, Lifestyle medicine, Health literacy, Community health coach, Diabetes prevention

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## Introduction

Prediabetes is defined by impaired fasting glucose (100-125 mg/dL) or elevated hemoglobin A<sub>1c</sub> (HbA<sub>1c</sub>) (5.7%-6.4%).<sup>1, 2</sup> It is a critical health concern globally. Individuals with prediabetes face a substantially elevated risk of progressing to overt type 2 diabetes mellitus (DM) and heightened risks for cardiovascular disease (CVD) and all-cause mortality.<sup>2</sup>

DM is a major global health concern, with its prevalence steadily increasing in both developed and developing countries. In Thailand, the prevalence of diabetes among adults aged 20-79 years has risen from 7.5% in 2011 to 10.2% in 2024, and it is projected to reach 11.6% by 2050.<sup>3</sup> Additionally, approximately 7.6% of the population is estimated to have prediabetes, a condition characterized by impaired fasting glucose that significantly elevates the risk of progression to type 2 DM and associated complications.<sup>4</sup> Health Region 8, 1 of 13 administrative health regions established by the Ministry of Public Health, comprises 7 provinces in northeastern Thailand: Udon Thani, Sakon Nakhon, Nakhon Phanom, Loei, Nong Khai, Nong Bua Lamphu, and Bueng Kan. In 2024, data from Thailand's Health Data Center reported that in Health Region 8 the prevalence of prediabetes was 2.5% and DM was 7.1%, highlighting a substantial and growing burden of glycemic disorders in the region.<sup>5</sup> Currently, routine prediabetes management in Health Region 8 follows Thailand's national guidelines, which include annual screening, and brief lifestyle counseling at primary care facilities. However, limited healthcare personnel, and geographic barriers result in suboptimal engagement and behavior change.

Lifestyle modification (LSM) is universally recognized as the cornerstone intervention for preventing type 2 DM. LSM, achieved through controlling diet and increasing physical activity, which is supported by the strongest evidence of effectiveness for reversing prediabetes.<sup>6</sup> LSM programs, which are derived from major clinical trials, such as the Diabetes Prevention Program (DPP), often target a reduction in body weight and an increase in physical activity to at least 150 minutes per week.<sup>7, 8</sup> Such an intensive LSM can significantly reduce type 2 DM incidence by up to 58% during active intervention periods, with long-term benefits sustained for years after program completion.<sup>8, 9</sup> LSM is considered part of lifestyle medicine, a specialized field emphasizing evidence-based behavioral and lifestyle adjustments as the primary methods for preventing and treating noncommunicable diseases (NCDs).<sup>10, 11</sup> The lifestyle medicine for DM-Coach curriculum developed for this study adapted DPP and Finnish Diabetes Prevention Study methodologies to integrate 6 lifestyle medicine pillars: nutrition, physical activity, stress management, sleep optimization, substance cessation, and positive relationships.<sup>8, 9</sup>

While LSM programs have demonstrated efficacy in controlled research settings, their translation to under-resourced communities faces significant barriers: limited specialized personnel, geographic distance to healthcare facilities, and low health literacy hampering comprehension and self-management, as well as cultural-linguistic mismatch in standard educational materials. Furthermore, existing programs often deliver lifestyle education without adequately addressing health literacy-the fundamental capacity to understand and act on health information. This gap is critical because low health literacy predicts poor diabetes self-management independent of disease knowledge.<sup>12-14</sup>

Effective LSM requires strong self-management skills, which are underpinned by health literacy.<sup>15</sup> Health literacy refers to the capacity to obtain, process, and understand health information to make appropriate decisions.<sup>16</sup> Low health literacy is a significant obstacle to controlling blood glucose and successful diabetes self-management. Conversely, adequate health literacy is positively correlated with improved diabetes knowledge.<sup>17</sup> Therefore, interventions should incorporate health literacy strategies, such as providing information in easily comprehensible language, encouraging "teach-back" to confirm understanding.<sup>15, 18</sup> Additionally, motivational interviewing techniques are integrated into the coaching methodology to enhance behavior change.<sup>19</sup>

This study aimed to: 1) develop an integrated training program combining lifestyle medicine and health literacy for DM coaches through a systematic research and development (R&D) process; 2) evaluate the program's effectiveness on clinical outcomes — specifically fasting blood glucose (FBG), blood pressure (BP), body weight, body mass index (BMI), waist circumference, and body composition (muscle and fat mass percentages); 3) assess behavioral outcomes including diabetes knowledge scores, lifestyle medicine practice scores, and coaching skill development; and 4) compare the rate of change in these outcomes between the DM coach group (who received intensive training and delivered interventions) and the pre-DM group (who received coaching from trained coaches). The hypothesis posited that both the coaching and coached groups would demonstrate significant improvements in clinical parameters, knowledge, and self-management capabilities compared to controls, with potential differences based on their respective roles in the program. This approach allowed for evaluation of the program's effectiveness on cardiometabolic and behavioral outcomes in high-risk individuals while simultaneously assessing the impact of the training experience on the coaches themselves.

## Methods

### Study Design

This research utilized a R&D design. The R&D process followed the ADDIE framework: analysis (situation analysis and literature review), design (curriculum development), development (training materials and protocols), implementation (coach training and intervention delivery), and evaluation (outcome assessment). The study was conducted in Health Region 8, Thailand, over a 12-month period (September 2024 to August 2025) with the following timeline, Phase 1 (months 1-2): situational analysis and literature review; Phase 2 (months 3-4): program development and curriculum design; Phase 3 (months 5-10): implementation and coaching delivery; and Phase 4 (months 11-12): outcome evaluation and analysis.

### Setting

The study was conducted within upper northeast Thai community. The intervention was delivered in community-based settings that were familiar and convenient for participants, including local health promotion centers, community halls, and primary care clinics. The community-based approach involved: 1) partnership with provincial health offices and local health promotion centers; 2) recruitment through existing village health volunteer networks; 3) intervention delivery in familiar community venues (health centers, temples, village halls) rather than clinical settings; 4) peer-to-peer learning model where DM coaches from the same communities supported their neighbors; 5) incorporation of culturally appropriate examples and local foods in nutritional education; and 6) ongoing support through existing community social structures for between-session communication. This community-centered approach was chosen to maximize participation rates and ensure the sustainability of the lifestyle medicine coaching model within the existing Thai healthcare system. The setting facilitated peer-to-peer learning and community engagement, which are essential components of effective health behavior change interventions in collectivist cultures.

### Participants

The study population consisted of 2 comparative groups: individuals with prediabetes who were trained as DM coaches (DM coach group), and individuals with prediabetes who received coaching from the trained DM coaches (pre-DM group). This represented a comprehensive community-based intervention where both groups participated in the prediabetes management program, but with different roles and levels of training.

Participants were purposively selected based on their roles in the community health system. Village health volunteers and primary care staff with prediabetes were invited to become DM coaches and received the intensive training delivered by a multidisciplinary team. Community members with prediabetes were recruited as the pre-DM group and received lifestyle coaching from the trained DM coaches through monthly group sessions and individual consultations.

Participants were included in the study if they were diagnosed with prediabetes, aged between 35-40 years, had the ability to read and write Thai, and demonstrated willingness to participate throughout the study period. The age range was chosen to capture the pre-aging population, early to mid-adulthood individuals at elevated risk for prediabetes progression yet physiologically capable of lifestyle modification. This group represented a critical window for preventive intervention before metabolic decline and comorbidities complicated diabetes management. Exclusion criteria included individuals with a history of severe chronic illness or those who had received previous specialized training in prediabetes management within 6 months prior to the study.

The study flow diagram shows participant recruitment, allocation, follow-up, and analysis (Figure 1). A total of 4998 participants were enrolled, including 1127 in the DM coach group and 3871 in the pre-DM group.

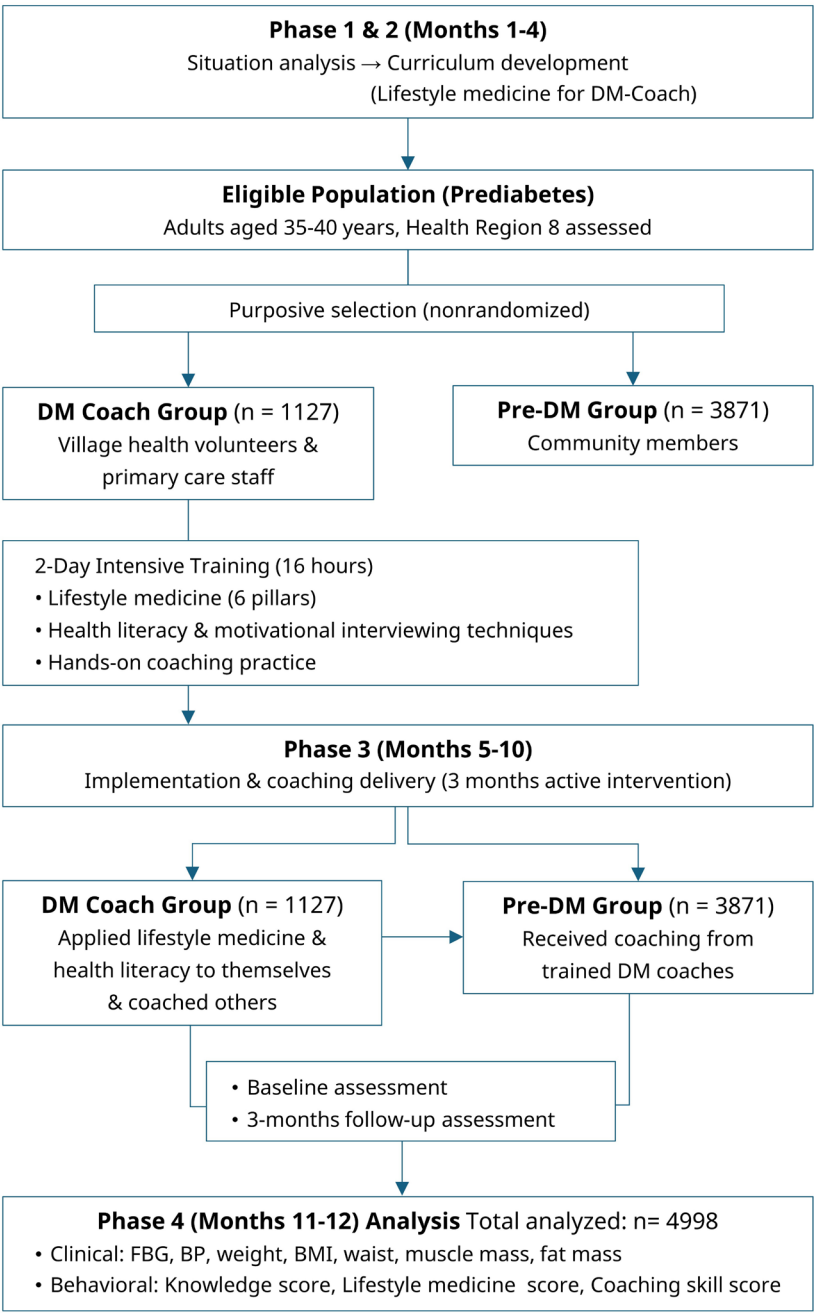
### Intervention

The intervention involved an integrated training program for DM coaches that combined lifestyle medicine principles with health literacy enhancement. The integrated training program referred to the overall intervention model (training DM coaches plus delivering coaching to community members), while the lifestyle medicine for DM-Coach curriculum represented the specific training content delivered to DM coaches. The lifestyle medicine for DM-Coach curriculum was a locally developed, evidence-based training program created during Phase 1. The curriculum integrated lifestyle medicine principles adapted to Thai cultural context, and incorporated health literacy strategies validated in low-resource settings.

The training program was delivered over 2 consecutive days (approximately 16 contact hours) to the DM coach group. The curriculum encompassed 7 key components: 1) lifestyle medicine fundamentals (1 hour: diabetes pathophysiology and 6 lifestyle medicine pillars); 2) nutrition and dietary management (5 hours: plant-based diets, carbohydrate counting, and meal planning with hands-on food preparation); 3) physical activity and exercise prescription (1.5 hours: FITT principles, and safety protocols); 4) stress management and sleep optimization (2 hours: mental health assessment, and relaxation techniques); 5) substance use cessation strategies (1 hour); 6) positive relationships and environmental health (1 hour: social support, and Blue Zones principles); and 7) health literacy and motivational interviewing (4.5 hours: V-SHAPE model, stages of change theory, and motivational interviewing techniques with extensive practical training).

This intensive 2-day approach aimed to equip coaches with the necessary knowledge and skills to effectively support individuals with prediabetes in making sustainable lifestyle modifications. Following training, coaches implemented their learned techniques with assigned pre-DM participants over a 3-month period, providing individual counseling, facilitating group support, and receiving ongoing professional mentorship.

Figure 1. Study Flow Diagram



Abbreviations: BMI, body mass index; BP, blood pressure; DM, diabetes mellitus; FBG, fasting blood glucose.

### Outcome Measures

The study's primary outcomes, measured at 3 months follow-up, encompassed clinical parameters including FBG, systolic and diastolic BP, body weight, BMI, and waist circumference, along with body composition measures of muscle mass percentage and fat mass percentage. Additionally, the research evaluated participants' knowledge scores, lifestyle medicine scores, and coaching skills scores using the following instruments.

Knowledge score (0-30 points): assessed using a 30-item multiple-choice questionnaire covering diabetes pathophysiology, risk factors, complications, prevention strategies, self-management principles, lifestyle medicine concepts, nutrition and dietary practices, physical activity, stress management, sleep health, substance avoidance, positive relationships, health literacy, and behavior change theories (1 point per correct answer).

Lifestyle medicine score (0-50 points): measured using a self-assessment questionnaire evaluating 6 domains: nutrition practices (fruit/vegetable intake, whole grains, portion control, and sugar consumption), physical activity (frequency, duration, and intensity of exercise), stress management (relaxation practices, coping strategies), sleep quality (duration, consistency), substance use avoidance (smoking status, and alcohol consumption), and positive relationships (social connections, and support from others). Responses were based on frequency scales, with points assigned per item (totaling up to 50 points across domains). Higher scores indicate better lifestyle practices, categorized as: 0-20 (poor), 21-30 (fair), 31-40 (good), and 41-50 (excellent).

Coaching skills scores (0-10 points, assessed only in DM coach group): evaluated using a 10-item multiple-choice questionnaire testing competencies in motivational interviewing techniques, stages of change (precontemplation, contemplation, preparation, action, maintenance, and termination), reflective listening, goal-setting facilitation, and follow-up strategies.

### Statistical Analysis

Sample size was determined based on prior lifestyle intervention studies reporting effect sizes of 0.3-0.4 for FBG reduction. To detect a between-group difference of 5 mg/dL in FBG change (80% power,  $\alpha = 0.05$ ), assuming a standard deviation of 15 mg/dL and an intraclass correlation coefficient (ICC) of 0.05 for clustering, which indicated approximately 284 participants per group were required. The actual enrolled sample ( $n = 1127$  DM coaches;  $n = 3871$  pre-DM participants) substantially exceeded this requirement. Recruitment of a larger sample size was undertaken to ensure robustness against attrition (estimated at 15%) and to meet the data requirements of the linear mixed model (LMM) analysis. The substantial sample size provided sufficient degrees of freedom to control for baseline covariates and socioeconomic differences inherent in the purposive selection design, while enabling accurate estimation of random effects across the study's hierarchical structure.

Data were analyzed using R version 4.5.1 (R Project for Statistical Computing). Descriptive statistics included mean (SD) for continuous variables and frequencies (percentages) for categorical variables. Baseline comparisons between DM coach and pre-DM groups used independent sample *t* test for normally distributed continuous variables, Mann-Whitney *U* test for nonnormally distributed variables, and chi-square test for categorical variables.

Within-group changes from baseline to postintervention were assessed using paired *t* test for normally distributed data and Wilcoxon signed rank test for nonnormally distributed data. Between-group differences in change over time were analyzed using LMM

with fixed effects for group, time, and group × time interaction, plus random intercepts for participants and clusters to account for hierarchical data structure and repeated measures. Statistical significance was set at  $P < .05$  with 95% CI reported for effect estimates.

Results

Baseline Characteristics

A total of 4998 participants were enrolled, including 1127 in the DM coach group and 3871 in the pre-DM group. Significant baseline differences were observed between groups (Table 1). While both groups consisted of individuals with prediabetes, they were distinguished by their roles in the intervention delivery model. The baseline differences reflect the purposive selection strategy: individuals with higher education and government employment were preferentially recruited as DM coaches due to their potential for sustained community leadership and health promotion activities. The DM coach group was slightly younger (mean [SD], 39.9 [2.91] vs 40.2 [2.72] years;  $P = .002$ ), had a higher proportion of females (83.6% vs 81.2%;  $P = .033$ ), and demonstrated higher educational attainment with 36.1% holding bachelor's degrees compared to 8.9% in the pre-DM group ( $P < .001$ ).

Occupational distribution differed significantly, with the DM coach group having more government employees (38.2% vs 6.4%) and fewer agricultural occupation (39.3% vs 59.2%) compared to the pre-DM group. Health insurance coverage also varied, with the pre-DM group having higher universal coverage scheme enrollment (82.4% vs 49.2%). The intervention was implemented across 7 provinces in northeastern Thailand, with Udon Thani contributing the largest proportion of participants (26.3% in DM coach group, and 31.3% in pre-DM group), followed by Sakon Nakhon (21.9% and 21.0%, respectively).

Baseline clinical parameters were generally similar between groups, although the DM coach group had slightly higher body weight (mean [SD], 65.18 [13.57] vs 64.25 [12.30] kg;  $P = .029$ ), lower FBG (mean [SD], 105.85 [6.10] vs 106.80 [6.59] mg/dL;  $P < .001$ ), and higher baseline knowledge scores (mean [SD], 21.21 [5.52] vs 19.03 [4.68];  $P < .001$ ).

Table 1. Baseline Characteristics

| Characteristic                | No. (%)                |                      | P Value |
|-------------------------------|------------------------|----------------------|---------|
|                               | DM Coach<br>(n = 1127) | Pre-DM<br>(n = 3871) |         |
| Age, mean (SD), y             | 39.90 (2.91)           | 40.2 (2.72)          | .002    |
| Female                        | 942 (83.6)             | 3145 (81.2)          | .033    |
| Education                     |                        |                      |         |
| Primary education             | 50 (4.4)               | 424 (11.0)           | < .001  |
| Lower secondary education     | 131 (11.6)             | 891 (23.0)           |         |
| Upper secondary/diploma       | 517 (45.9)             | 2188 (56.5)          |         |
| Bachelor's degree             | 407 (36.1)             | 343 (8.9)            |         |
| Higher than bachelor's degree | 22 (2.0)               | 25 (0.6)             |         |

Table 1. Baseline Characteristics (Continued)

| Characteristic                            | No. (%)                |                      | P Value |
|-------------------------------------------|------------------------|----------------------|---------|
|                                           | DM Coach<br>(n = 1127) | Pre-DM<br>(n = 3871) |         |
| Occupation                                |                        |                      |         |
| Agricultural occupation                   | 443 (39.3)             | 2292 (59.2)          | < .001  |
| Self-employed/small business owner        | 76 (6.7)               | 390 (10.1)           |         |
| Private sector employee                   | 72 (6.4)               | 202 (5.2)            |         |
| Government officer/public sector employee | 431 (38.2)             | 249 (6.4)            |         |
| Daily wage laborer/general laborer        | 101 (9.0)              | 694 (17.9)           |         |
| Unemployed                                | 4 (0.4)                | 44 (1.2)             |         |
| Health insurance                          |                        |                      |         |
| Universal coverage scheme                 | 554 (49.2)             | 3190 (82.4)          | < .001  |
| Civil servant medical benefit scheme      | 331 (29.4)             | 167 (4.3)            |         |
| Social security scheme                    | 163 (14.5)             | 394 (10.2)           |         |
| Local government health scheme            | 19 (1.7)               | 20 (0.5)             |         |
| Other                                     | 60 (5.3)               | 100 (2.6)            |         |
| Body weight, mean (SD), kg                | 65.18 (13.57)          | 64.25 (12.30)        | .029    |
| BMI, mean (SD), kg/m <sup>2</sup>         | 25.68 (4.91)           | 25.54 (5.13)         | .413    |
| SBP, mean (SD), mmHg                      | 119.32 (12.54)         | 120.34 (12.68)       | .017    |
| DBP, mean (SD), mmHg                      | 75.41 (9.60)           | 76.00 (9.35)         | .066    |
| Waist circumference, mean (SD), cm        | 84.04 (10.83)          | 84.37 (10.14)        | .334    |
| FBG, mean (SD), mg/dL                     | 105.85 (6.10)          | 106.80 (6.59)        | < .001  |
| Muscle mass, %                            | 35.72 (101.29)         | 30.49 (9.77)         | .002    |
| Fat mass, %                               | 31.22 (7.58)           | 31.00 (7.92)         | .394    |
| Knowledge score, mean (SD)                | 21.21 (5.52)           | 19.03 (4.68)         | < .001  |
| Lifestyle medicine score, mean (SD)       | 33.82 (6.61)           | 32.77 (6.46)         | < .001  |
| Coaching skill score, mean (SD)           | 6.61 (2.03)            | NA                   | NA      |
| Province                                  |                        |                      |         |
| Udon Thani                                | 296 (26.3)             | 1211 (31.3)          | .001    |
| Sakon Nakhon                              | 247 (21.9)             | 811 (21.0)           |         |
| Nakhon Phanom                             | 140 (12.4)             | 486 (12.6)           |         |
| Loei                                      | 140 (12.4)             | 400 (10.3)           |         |
| Nong Khai                                 | 107 (9.5)              | 336 (8.7)            |         |
| Nong Bua Lamphu                           | 88 (7.8)               | 343 (8.9)            |         |
| Bueng Kan                                 | 109 (9.7)              | 274 (7.1)            |         |

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FBG, fasting blood sugar; NA, not applicable; SBP, systolic blood pressure.

### Intervention Outcomes

Both groups demonstrated significant improvements in all measured parameters from baseline to postintervention (Table 2). The DM coach group achieved substantial reductions in FBG (-8.4 mg/dL), body weight (-0.8 kg), BMI (-0.3 kg/m<sup>2</sup>), and BP (systolic: -1.5 mmHg, diastolic: -2.0 mmHg), all with  $P < .001$ .

Knowledge scores improved markedly in both groups, with the DM coach group increasing by 4.5 points (from 21.2 to 25.7,  $P < .001$ ) and the pre-DM group by 5.5 points (from 19.0 to 24.5,  $P < .001$ ). Lifestyle medicine scores increased by 4.3 points in both groups ( $P < .001$ ). The coaching skills score in the DM coach group improved from 6.6 to 8.2 (change of 1.6 points,  $P < .001$ ).

The magnitude and direction of change scores across all measured outcomes for both study groups were determined (Figure 2). The horizontal bar chart indicated that negative values indicated beneficial decreases in clinical and anthropometric parameters, while positive values indicated improvements in knowledge-based assessments. Notable patterns emerged in the comparative effectiveness between groups, with the coach group demonstrating more pronounced reductions in certain cardiovascular risk markers, particularly diastolic BP, while showing similar performance in metabolic parameters such as FBG. The visualization highlights the differential impact of the 2 intervention approaches, with knowledge acquisition outcomes (lifestyle medicine scores and knowledge scores) showing the largest effect sizes among all measured variables. Body composition changes appeared relatively modest in both groups, suggesting that the intervention period may have been insufficient to produce substantial shifts in muscle and fat mass percentages, despite improvements in other anthropometric measures such as waist circumference and overall body weight.

LMM analysis revealed differential rates of change between groups (Table 3). The intervention demonstrated significant daily improvements in several key outcomes: -0.012 mmHg/day of diastolic BP (95% CI, -0.021 to -0.002;  $P = .020$ ); -0.009%/day of muscle mass percentage (95% CI, -0.016 to -0.002;  $P = .008$ ); and -0.014 points/day of knowledge score (95% CI, -0.019 to -0.010;  $P < .001$ )

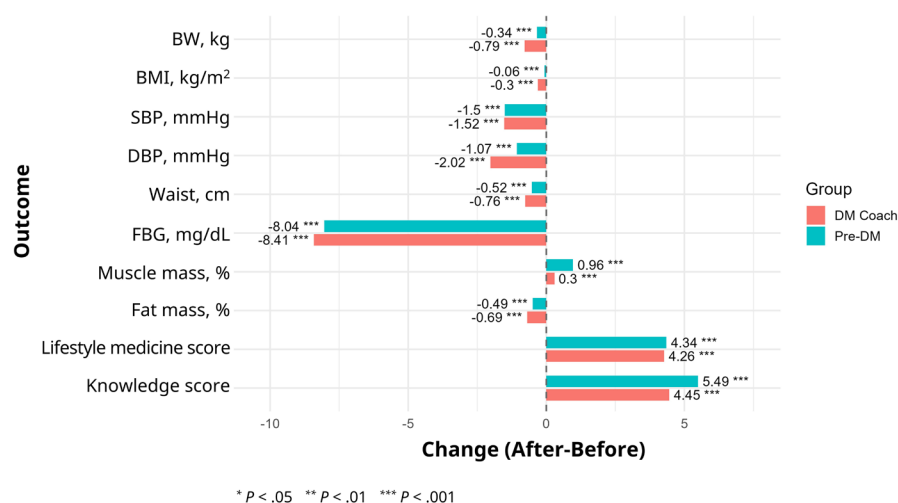
Trends toward improvement were observed for body weight (-0.028 kg/day,  $P = .054$ ) and BMI (-0.005 kg/m<sup>2</sup>/day,  $P = .067$ ), although these did not reach statistical significance.

Table 2. Comparison of Pre- and Postintervention Outcomes in DM Coach and Pre-DM Groups

| Outcome                  | DM Coach |       |              |         | Pre-DM |       |              |         |
|--------------------------|----------|-------|--------------|---------|--------|-------|--------------|---------|
|                          | Pre      | Post  | Δ (Post-Pre) | P Value | Pre    | Post  | Δ (Post-Pre) | P Value |
| Body weight, kg          | 65.2     | 64.4  | -0.8         | < .001  | 64.3   | 63.9  | -0.3         | < .001  |
| BMI, kg/m <sup>2</sup>   | 25.7     | 25.4  | -0.3         | < .001  | 25.6   | 25.5  | -0.1         | < .001  |
| SBP, mmHg                | 119.3    | 117.8 | -1.5         | < .001  | 120.3  | 118.8 | -1.5         | < .001  |
| DBP, mmHg                | 75.4     | 73.4  | -2.0         | < .001  | 76.0   | 74.9  | -1.1         | < .001  |
| Waist, cm                | 84.0     | 83.3  | -0.8         | < .001  | 84.4   | 83.9  | -0.5         | < .001  |
| FBG, mg/dL               | 105.9    | 97.4  | -8.4         | < .001  | 106.8  | 98.8  | -8.0         | < .001  |
| Muscle mass, %           | 35.7     | 36.0  | 0.3          | < .001  | 30.5   | 31.5  | 1.0          | < .001  |
| Fat mass, %              | 31.2     | 30.5  | -0.7         | < .001  | 31.0   | 30.5  | -0.5         | < .001  |
| Knowledge score          | 21.2     | 25.7  | 4.5          | < .001  | 19.0   | 24.5  | 5.5          | < .001  |
| Lifestyle medicine score | 33.8     | 38.1  | 4.3          | < .001  | 32.8   | 37.1  | 4.3          | < .001  |
| Coaching Skill score     | 6.6      | 8.2   | 1.6          | < .001  | NA     | NA    | NA           | NA      |

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FBG, fasting blood sugar; NA, not applicable; SBP, systolic blood pressure.

**Figure 2. Pre-Post Changes in Clinical, Anthropometric, and Knowledge Outcomes by Group**



Abbreviations: BMI, body mass index; BW, body weight; DBP, diastolic blood pressure; DM, diabetes mellitus; FBG, fasting blood sugar; SBP, systolic blood pressure.

**Table 3. Estimated Daily Change in Outcomes From Linear Mixed Models**

| Outcome                  | Estimate (95% CI)*        | SE    | P Value |
|--------------------------|---------------------------|-------|---------|
| Body weight, kg          | -0.028 (-0.056 to 0.000)  | 0.014 | .054    |
| BMI, kg/m <sup>2</sup>   | -0.005 (-0.011 to 0.000)  | 0.003 | .067    |
| SBP, mmHg                | -0.001 (-0.009 to 0.007)  | 0.004 | .753    |
| DBP, mmHg                | -0.012 (-0.021 to -0.002) | 0.005 | .020    |
| Waist circumference, cm  | -0.002 (-0.005 to 0.001)  | 0.002 | .143    |
| FBG, mg/dL               | 0.003 (-0.008 to 0.013)   | 0.005 | .582    |
| Muscle mass, %           | -0.009 (-0.016 to -0.002) | 0.004 | .008    |
| Fat mass, %              | -0.001 (-0.006 to 0.004)  | 0.003 | .670    |
| Knowledge score          | -0.014 (-0.019 to -0.010) | 0.002 | < .001  |
| Lifestyle medicine score | -0.004 (-0.008 to 0.001)  | 0.002 | .087    |

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FBG, fasting blood sugar; SBP, systolic blood pressure.

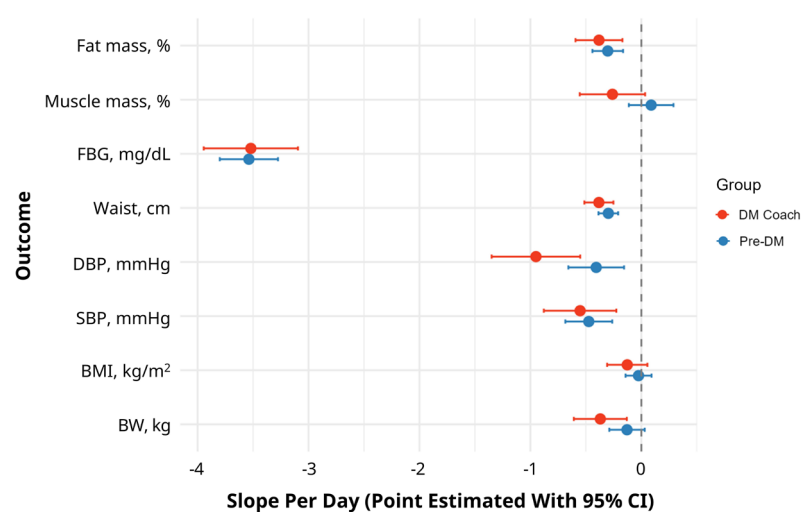
\* Adjusted between-group differences in daily change rates (DM coach - pre-DM) from baseline through 3-month follow-up. Models included fixed effects (group, time, group  $\times$  time interaction) and random intercepts for participants and clusters. Estimate represents the differential daily change rate between groups.

The estimated daily slopes with 95% CI for clinical and anthropometric outcomes, which compared the DM coach (intervention) group and pre-DM (control) group across the study period, were presented (Figure 3). The forest plot visualization demonstrated the rate of daily change for each outcome measure, with negative slopes indicating favorable improvements over time. The figure revealed distinct patterns between groups, with the DM coach group showing more pronounced daily improvements in diastolic BP and waist circumference compared to the pre-DM group. Both groups exhibited similar

trajectories for FBG, with overlapping confidence intervals suggesting comparable rates of change. For body composition measures, the confidence intervals for muscle mass percentage and fat mass percentage showed minimal separation between groups, indicating similar rates of change in both interventions. The visualization also highlighted that systolic BP, BMI, and body weight demonstrated relatively narrow confidence intervals for both groups, with the DM coach group consistently showing slightly more favorable trends. Notably, the figure illustrates that most confidence intervals for anthropometric measures do not cross zero, suggesting consistent directional changes across the intervention period for both study groups.

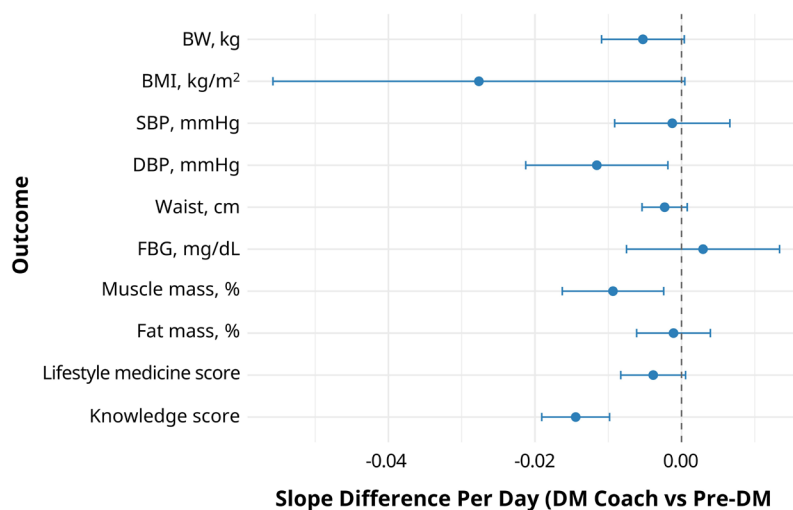
The group  $\times$  time interaction effects displayed the differences in estimated daily slopes between the DM coach and pre-DM groups across all measured outcomes (Figure 4). The forest plot showed slope differences with 95% CI, where negative values indicated that the DM coach group had greater daily improvements compared to the pre-DM group. The vertical dashed line at zero represents no difference between groups. Notable findings included that the knowledge score showed the largest negative slope difference, indicating substantially greater daily improvement in the DM coach group compared to the pre-DM group, with a narrow confidence interval that did not cross zero. Muscle mass percentage also demonstrated a significant negative slope difference, suggesting the DM coach group achieved better daily gains in muscle mass. Most clinical parameters, including body weight, BMI, systolic BP, diastolic BP, and waist circumference, showed confidence intervals that crossed or closely approached the zero line, indicating minimal differences in daily improvement rates between groups. FBG displayed the widest confidence interval and crossed zero, suggesting no significant difference in glycemic control improvement between groups. The lifestyle medicine score showed a slight negative slope difference with a confidence interval approaching zero, indicating marginally better performance in the DM coach group.

**Figure 3. Estimated Daily Slopes ( $\pm$ 95% CI) for Clinical and Anthropometric Outcomes in DM Coach and Pre-DM Groups**



Abbreviations: BMI, body mass index; BW, body weight; DBP, diastolic blood pressure; DM, diabetes mellitus; FBG, fasting blood sugar; SBP, systolic blood pressure.

**Figure 4. Differences in Estimated Daily Slopes Between DM Coach and Pre-DM Groups From Linear Mixed Models**



Abbreviations: BMI, body mass index; BW, body weight; DBP, diastolic blood pressure; DM, diabetes mellitus; FBG, fasting blood sugar; SBP, systolic blood pressure.

## Discussion

This study has demonstrated the effectiveness of an integrated training program for DM coaches in improving prediabetes management outcomes within Thai communities. The program achieved significant improvements across all measured health indices from baseline to postintervention in both groups. These overall favorable changes likely reflected the intensive nature of the lifestyle medicine and health literacy intervention, and they aligned with successful global prevention strategies.

### Clinical Significance and Comprehensive Cardiometabolic Improvement

The magnitude of the improvements observed in the DM coach represented clinically meaningful progress toward prediabetes reversal and type 2 DM prevention.

**Metabolic control:** The DM coach group achieved a substantial reduction in FBG (-8.4 mg/dL), which was highly statistically significant ( $P < .001$ ). This reduction was consistent with previous successful lifestyle intervention studies and has suggested a strong potential for preventing progression to type 2 DM.<sup>2, 20</sup> Prediabetes is a reversible state, and regression to normoglycemia is a key goal, often resulting in a lower risk for diabetes incidence and microvascular complications.<sup>6, 21</sup>

**Anthropometric and body composition gains:** The program successfully promoted weight management, resulting in a significant reduction in body weight (-0.8 kg) and BMI (-0.3 kg/m<sup>2</sup>) ( $P < .001$  for both). The DM coach group also achieved a reduction in waist circumference (-0.8 cm) and fat mass (-0.7%) ( $P < .001$ ). Furthermore, the DM coach group successfully achieved an increase in muscle mass (0.3%) ( $P < .001$ ). Maintaining lean mass is vital for metabolic health, and the overall body composition profile suggested beneficial adaptation to the lifestyle changes. The superior outcomes observed in the DM coach group specifically achieving greater overall weight loss (-0.8 kg vs -0.3 kg) and substantially higher

fat mass reduction (-0.7 kg vs -0.5 kg) indicated a desirable quality of weight loss crucial for enhancing metabolic health and insulin sensitivity in prediabetes management.<sup>22</sup>

Interestingly, the pre-DM group experienced a greater percentage increase in muscle mass (+1.0% vs +0.3%), despite both groups achieving significant gains ( $P < .001$ ). This differential response warrants interpretation. Several mechanisms may explain this pattern including: 1) regression to the mean: the pre-DM group started with substantially lower baseline muscle mass (30.5% vs 35.7%), providing greater potential for muscle gain in individuals further from physiologic ceiling effects; 2) activity patterns: the pre-DM group's higher proportion of agricultural workers (59.2% vs 39.3%) may have engaged in more physically demanding occupational activities which combined with the resistance training recommendations, promoted muscle development; and 3) quality of weight loss: the DM coach group's success in achieving significant weight reduction primarily through fat loss while maintaining relatively stable muscle mass reflected an effective body composition trajectory.

The superior fat mass reduction in coaches, despite smaller absolute muscle gains, suggested more favorable metabolic adaptation. This resilience against muscle loss during weight reduction might be partially supported by the coaches' higher baseline muscle mass and their deeper understanding of resistance training principles gained through intensive training. This emphasis on strategic fat loss through intensive behavior change, including structured physical activity programming, aligned with substantial evidence that lifestyle modification remains the first-line therapy providing the strongest evidence for reversing prediabetes and reducing type 2 DM risk.<sup>2, 6</sup>

**Cardiovascular risk reduction:** The program demonstrated a dual benefit on BP in the DM coach, achieving raw reductions in both systolic BP (-1.5 mmHg) and diastolic BP (-2.0 mmHg) ( $P < .001$ ). Crucially, the LMM analysis, which compared the rate of change between groups, revealed that the DM coach group achieved a significantly superior reduction in diastolic BP (adjusted difference, -0.012 mmHg/day;  $P = .020$ ). This LMM result has provided evidence of the comparative strength of the integrated approach in mitigating cardiovascular risk, consistent with literature showing that lifestyle medicine programs reduce CVD mortality risk.<sup>23</sup>

Both systolic and diastolic BPs declined, but only diastolic BP showed significant differences between groups. This may reflect: 1) systolic BP's greater responsiveness to weight loss and sodium reduction, achieved similarly in both groups; and 2) the greater diastolic BP reduction might reflect improved peripheral vascular function and reduced arterial stiffness resulting from lifestyle modifications, weight loss, and improved insulin sensitivity. Research has demonstrated that insulin resistance is significantly associated with both systolic and diastolic BPs, with particularly strong associations observed in individuals with prediabetes and metabolic dysfunction. A large study of over 10 000 Hispanic/Latino adults without diabetes found positive linear associations between insulin resistance (measured by the homeostatic model assessment of insulin resistance [HOMA-IR]) and both systolic and diastolic BPs, with the association being independent of obesity and antihypertensive medication use.<sup>24</sup> This pronounced diastolic BP improvement, confirmed by a significant daily improvement detected via LMM analysis (-0.012 mmHg/day), suggested that the lifestyle intervention effectively improved peripheral vascular function and reduced arterial stiffness. This effect is particularly crucial for younger, metabolically compromised populations, as studies indicate that diastolic BP levels exceeding 80 mmHg significantly increase the risk of cardiovascular disease events in adults younger than 60 years.<sup>25</sup>

Therefore, the sustained diastolic BP reduction achieved through the intensive coaching program has underscored its efficacy in delivering a multifactorial intervention that targets critical cardiovascular risk factors, which is considered the cornerstone of comprehensive prediabetes management.<sup>1, 2</sup>

### **Knowledge and Skills Enhancement for Sustainable Change**

The intervention successfully achieved significant improvements in all behavioral and skills-based outcomes, supporting the program's foundation in health literacy and community coaching.

**Knowledge and self-management:** Participants in the DM coach group showed substantial improvements in knowledge score (increase of 4.5 points) and lifestyle medicine score (increase of 4.3 points) ( $P < .001$  for both). This indicated successful knowledge transfer and increased adoption of healthy practices. Although the LMM showed a differential rate of change in knowledge favoring the pre-DM group, the absolute success in increasing patient knowledge within the DM coach group was evident and aligned with studies showing that health literacy interventions improve diabetes knowledge and self-care adherence.<sup>26</sup> Such knowledge enhancement is critical, as health literacy plays a substantial role in diabetes knowledge.<sup>17</sup>

**Coaching capacity development:** A key success specific to the intervention was the development of local leadership skills. The coaching skill score improved significantly by 1.6 points in the DM coach group ( $P < .001$ ). This successful training, rooted in the lifestyle medicine for DM-Coach curriculum, suggested enhanced capacity for peer support and community health promotion. This capacity building is vital, as interventions delivered by community workers can be highly effective in improving diabetes knowledge and self-care behaviors, potentially overcoming barriers of access and literacy common in resource-limited settings.<sup>26</sup>

### **Community-Based Approach and Promising Strategy**

The core value of this study lies in its community-based framework, which leveraged local health personnel and volunteers as peer coaches, embedded within existing healthcare infrastructure.

**Feasibility and sustainability:** The utilization of community members as DM coaches represented a promising strategy for scaling diabetes prevention efforts. This approach builds local capacity for chronic disease management, enabling sustained support through social networks and cultural understanding.<sup>27</sup>

**Considerations for broader implementation:** A notable characteristic was that 38.2% of DM coaches were government officers or public sector employees, who may have advantages in education, organizational skills, and health system familiarity. This raises questions about scalability to lay community members. However, substantial participation of agricultural workers (39.3%) and excellent clinical outcomes across educational levels suggested feasibility in diverse populations. Future implementation should consider: 1) testing effectiveness with community health volunteers without government employment; 2) providing additional support (ongoing mentorship, simplified materials, mobile technology) for coaches with lower baseline education; and 3) adapting training based on participants' prior health knowledge and teaching experience.

The lifestyle medicine intervention targeted 6 evidence-based pillars including 1) nutrition: low-glycemic index foods, portion control using Thai hand measurements, and

reduced refined carbohydrates; 2) physical activity: 150 minutes/week moderate-intensity exercise through daily activities and resistance training; 3) sleep: 7-8 hours/night with good sleep hygiene; 4) stress management: Buddhist meditation-adapted mindfulness and breathing exercises; 5) social connections: peer support and community engagement; and 6) avoidance of risky substances: alcohol reduction and tobacco cessation. Health literacy was reinforced through teach-back methods for glucose monitoring and self-care. These culturally adapted components have made the intervention replicable in similar resource-limited settings throughout Thailand and Southeast Asia.

**Model alignment:** The design of the program, incorporating awareness activities, group learning, and goal setting based on the stages of change and peer professional concepts, aligned with successful LSM models.<sup>7, 28</sup> The successful implementation across 7 provinces demonstrated the feasibility of integrating this approach into existing Thai healthcare infrastructure, making it a promising strategy for diabetes prevention which could be adapted and scaled within similar resource settings.

### Validity and Informative Value of the Design

Although baseline differences represented a methodological limitation, the pragmatic design directly addressed key questions of real-world implementation: 1) whether trained peer coaches could deliver effective interventions to community members, as evidenced by equivalent FBG outcomes; 2) whether intensive training combined with self-application provided additional benefits beyond peer coaching, which was demonstrated by superior diastolic BP control; and 3) whether the approach was feasible within existing community health infrastructure, confirmed by successful multi-provincial implementation.

While a fully randomized design with balanced baseline characteristics would enhance causal inference, such an approach would reduce external validity by failing to reflect the conditions under which programs are deployed in community health systems. The purposive design employed here aligned with real-world practice, wherein health volunteers and staff are trained as coaches to support community members.

### Limitations

Several limitations should be considered when interpreting these results:

**Nonrandomized design:** The purposive selection of participants based on community roles limited causal inference. While this study's LMM analysis adjusted for baseline demographic and clinical differences, residual confounding could not be entirely excluded. The DM coach group's higher baseline education, health literacy, and health system involvement might have contributed to differential engagement with lifestyle modifications, although this also reflects the reality of community health leadership capacity. Future randomized controlled trials with balanced baseline characteristics through random assignment would strengthen causal inference.

**Baseline group differences:** Significant differences in education, occupation, health insurance, and baseline knowledge/lifestyle medicine scores between groups arose from purposive selection. Although the LMM adjusted for these factors, the differential socioeconomic profiles might have influenced intervention responsiveness beyond measured confounders. This limitation was recognized, and findings have been interpreted with caution, emphasizing that observed differences might reflect both intervention effects and baseline group characteristics.

**Short follow-up period:** The 3-month active intervention and immediate post-assessment precluded evaluation of long-term sustainability. Diabetes prevention requires sustained behavior change over years, and whether the observed improvements persist 6-12 months postintervention remains unknown. The brief timeline also limited this study's ability to detect outcomes requiring longer observation periods, such as diabetes incidence or longer-term cardiovascular events.

**Limited generalizability:** The study was conducted in 7 provinces of northeastern Thailand with specific cultural, linguistic, and healthcare system characteristics. Generalizability to urban populations, other regions of Thailand, or other countries requires cautious consideration. The agricultural economy, Buddhist cultural context, and existing community health volunteer infrastructure all influenced intervention design and implementation.

### Recommendations for Future Research and Studies in Thailand

Future research should extend follow-up periods to evaluate the long-term sustainability of behavior changes and the prevention of diabetes incidence. In addition, cost-effectiveness analyses are needed to provide robust evidence for decision-makers regarding the scalability of this model. Comparative studies across diverse community contexts, including rural and urban populations, would further clarify the adaptability and generalizability of the intervention.

### Policy Recommendation

The positive outcomes of this program support its integration into Thailand's health system, particularly in rural and underserved areas where access to specialized diabetes care remains limited. Policymakers should prioritize investment in community-based DM coach training as a scalable and sustainable strategy for diabetes prevention. Embedding this approach within primary healthcare services, supported by ongoing research and monitoring, can strengthen national efforts to reduce the growing burden of diabetes and serve as a model for other resource-constrained settings.

## Conclusions

This study has demonstrated that an integrated DM coach training program, combining lifestyle medicine and health literacy, effectively improved clinical outcomes, knowledge, and lifestyle practices among individuals with prediabetes in Thai communities. By building local coaching capacity, the program not only addressed immediate health needs but also established a sustainable community resource for ongoing diabetes prevention. These findings highlight the feasibility and impact of community-based approaches in reducing diabetes risk in resource-limited settings.

### Additional Information

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# Laparoscopic Vesicovaginal Fistula Repair: 2 Cases From Chaophrayayommarat Hospital

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## Abstract

**Background:** Vesicovaginal fistula (VVF) is a distressing complication most commonly resulting from gynecologic surgeries, particularly abdominal hysterectomy. Laparoscopic repair offers a minimally invasive alternative to open surgery, providing favorable outcomes and quicker recovery.

**Case Presentation:** This report presented 2 cases of posthysterectomy VVF managed at a provincial hospital. The first case was a 39-year-old woman who developed persistent urinary leakage one month after abdominal hysterectomy. Imaging revealed a 3-mm fistula near the left ureteric orifice, and cystoscopy showed a 1 cm defect. The second case was a 45-year-old woman who presented with leakage 16 months posthysterectomy and intraoperative bladder repair. Imaging and cystoscopy confirmed a 6-mm midline fistula. Both patients underwent laparoscopic transabdominal VVF repair using the O'Connor technique. Key surgical steps included cystotomy, layered closure with nonoverlapping sutures, and omental interposition. Ureteral stenting was used to prevent injury, and Foley catheters were left for 2 weeks postoperatively. Both surgeries were completed successfully without major complications. Operative times were approximately 4 hours. Blood loss was minimal. Patients were discharged within 3-5 days, and followed-up at 1, 3, and 6 months which confirmed complete continence and improved quality of life.

**Conclusions:** Laparoscopic VVF repair is a feasible technique to minimize postoperative pain and length of hospital stay, as well as enhance access to quality of care and reduce the burden of referral to tertiary centers.

**Keywords:** Vesicovaginal fistula, Laparoscopic surgery, Complications, Gynecologic surgery, Urinary incontinence

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## Introduction

Vesicovaginal fistula (VVF) is an abnormal connection between the bladder and the vagina that results in continuous urinary incontinence. It significantly impacts psychological well-being and social participation among affected women. Surgical repair is the primary treatment method, yet patients in provincial hospitals are often referred to tertiary centers in Bangkok due to the lack of experienced surgeons, increasing financial and logistical burdens on patients and families.

Historically, VVF repair began with pioneering efforts by J. Marion Sims in the 19th century using open surgery, which became the standard.<sup>1</sup> However, the advent of minimally invasive surgery (MIS) in the late 20th century introduced laparoscopic techniques to urology and gynecology.<sup>2</sup> With high costs and limited availability of robotic systems in provincial hospitals, laparoscopic repair has emerged as a viable and effective alternative.<sup>2,3</sup>

Compared to open surgery, laparoscopic repair offers numerous benefits, including smaller incisions, reduced pain, shorter hospital stays, and improved cosmetic outcomes. Vaginal approaches, while scar-free externally, may be technically challenging in cases with high or large fistulas.<sup>4</sup> Laparoscopy enhances visualization, facilitates precise dissection, and adheres to key principles such as adequate tissue mobilization, tension-free multilayer closure, and interposition of well-vascularized tissue like omentum. First reported in 1994, laparoscopic VVF repair has shown comparable success to open methods with fewer complications and faster recovery.<sup>4, 5</sup>

Comparing outcomes between laparoscopic and traditional open repair of VVF reveals several important considerations: reduced postoperative complications: laparoscopic repair is associated with significantly less intraoperative blood loss, lower postoperative pain, and reduced need for analgesics compared to open surgery.<sup>4</sup> The smaller incisions result in a lower risk of surgical wound infection and incisional hernia.

Shorter hospital stay: due to its minimally invasive nature, laparoscopic VVF repair typically leads to a significantly shorter hospitalization period (2-4 days) compared to open surgery (7-10 days), facilitating faster return to normal daily activities.<sup>4</sup>

Comparable success rates: several studies have demonstrated that laparoscopic VVF repair achieves success rates — defined by fistula closure and restored continence — comparable to open transabdominal approaches.<sup>4, 5</sup> While the learning curve for laparoscopic repair may be steeper, experienced surgeons can achieve excellent outcomes.

Improved visualization: the magnified view provided by laparoscopy enables precise dissection and repair, which is particularly beneficial in complex fistulas or in cases requiring adhesiolysis due to prior surgeries.<sup>6</sup>

Cosmetic advantages: the smaller incisions used in laparoscopy result in less noticeable scarring compared to the large abdominal incision required in open surgery.<sup>6</sup>

Laparoscopic repair of VVF is a technically demanding procedure that has been predominantly reported from academic hospitals in major cities such as Bangkok. This is because VVF is a relatively rare condition, and the surgical management requires advanced laparoscopic expertise that is typically concentrated in high-volume teaching hospitals. Consequently, there are very few reports of laparoscopic VVF repair being performed in provincial hospitals.

Therefore, performing laparoscopic VVF repair in a provincial hospital, even with a limited number of cases, represents a worthy achievement. It has demonstrated that such complex reconstructive urological surgery can be successfully carried out outside renowned academic centers, reflecting both the capability of the surgical team and the growing potential of regional hospitals in providing advanced minimally invasive care.

## Case Presentation

**Case 1:** a 39-year-old woman without comorbidity presented with continuous vaginal urine leakage one month after abdominal hysterectomy for myoma uteri. A computed tomography (CT) imaging revealed a 3-mm VVF near the left ureteric orifice, but cystoscopy identified a 1 cm fistula (Figure 1A).

After counseling, she opted for laparoscopic repair. The surgery was performed 3 months after clinical presentation of fistula. The patient received a vaginal cleansing before entering the operating theatre and also prophylactic antibiotics, which were ceftriaxone 2 g and metronidazole 500 mg intravenously. After properly scrubbed and

prepped, cystoscopy was performed to retain ureteral stents, small plastic stent in the VVF, and Foley catheter with 10 mL balloon. Hasson technique was implemented for port placement (Figure 1B).

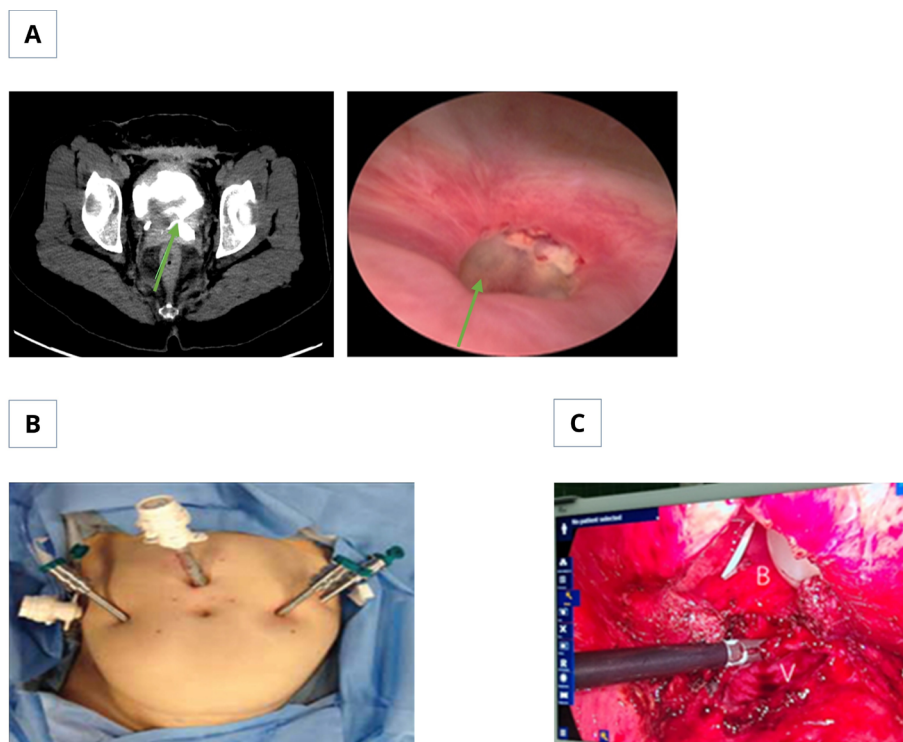
Surgery included lysis of abdominal adhesion to expose bladder and vaginal vault. Sponge stick was used to put inside vaginal canal to identify vaginal vault. Cystotomy just above the vaginal vault was performed using Metzenbaum scissors to reveal VVF. Cold cut dissection of bladder wall from vagina was done with minimal coagulation to preserve blood supply of the bladder (Figure 1C).

After proper plane was accomplished, separate layered closures were done using 3-0 polyglactin round needle, with nonoverlapping sutures between bladder and vaginal defect. Omental interposition was also performed and fixed between bladder and vagina using the same suture material. Tube drain was placed near repair site to monitor leakage. The procedure lasted 4 hours with 200 mL blood loss. She recovered well with minimal pain and was discharged on postoperative day 3 with a Foley catheter in place for 2 weeks. Cystography showed no leakage, so the urethral catheter was then removed. Follow-up at 1, 3, and 6 months confirmed complete continence and satisfactory recovery. The patient reported much-improved quality of life and could resume sexual activity with her husband.

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**Figure 1. Patient 1**

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A, Computed tomographic and cystoscopic view of a 1 cm vesicovaginal fistula (arrow).

B, Laparoscopic port placement for laparoscopic vesicovaginal fistula repair (top, head; bottom, feet).

C, Laparoscopic view showing plane of dissection between bladder and vagina (B, bladder; V, vagina).

**Case 2:** a 45-year-old healthy woman developed continuous leakage 16 months after total abdominal hysterectomy with left oophorectomy, during which bladder repair was performed. CT showed a 4-mm midline posterior bladder fistula, and cystoscopy confirmed a 6-mm VVF (Figure 2A).

After counseling, she chose laparoscopic repair. The patient received a vaginal cleansing before entering the operating theatre and also prophylactic antibiotics, which were ceftriaxone 2 g and metronidazole 500 mg intravenously. After properly scrubbed and prepped, cystoscopy was performed to retain ureteral stents, small plastic stent in the VVF, and Foley catheter with 10 mL balloon. Hasson technique was implemented for port placement (Figure 2B).

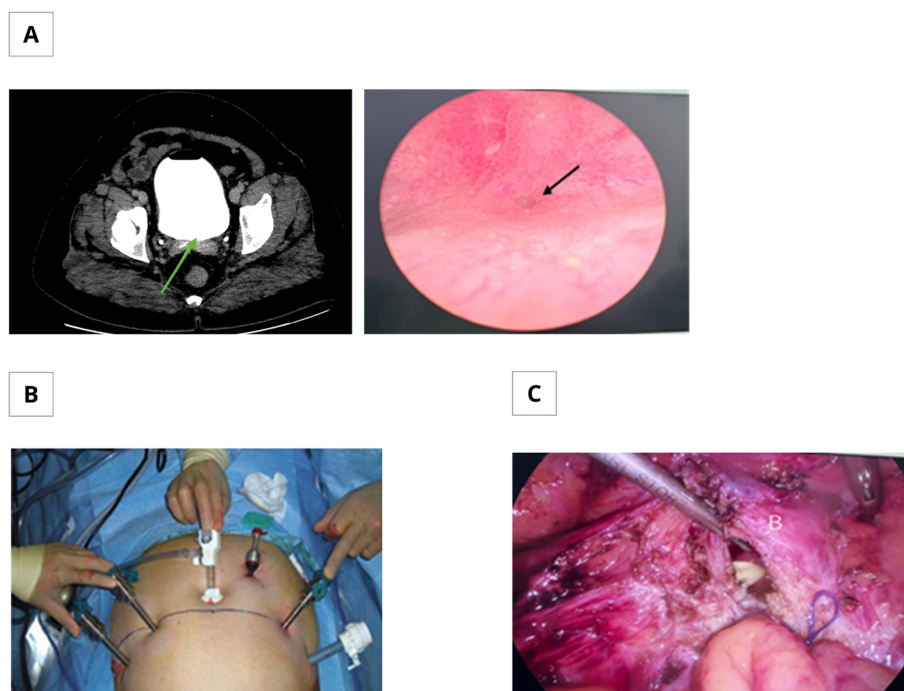
Dense adhesions were encountered due to previous intraoperative bladder repair. The bladder and vaginal wall were dissected separately using sponge stick to identify vaginal vault and closed in layers. A round needle 3-0 polyglactin was used for bladder and vaginal closure. Omentum was interposed at the fistula repair site (Figure 2C).

The operation lasted 4 hours and 15 minutes with 20 mL blood loss. Postoperatively the patient recovered uneventfully with mild pain and was discharged on day 5 with a Foley catheter for 2 weeks. Cystography 2 weeks postoperative showed no leakage, so the urethral catheter was then removed. A 6-month follow-up confirmed resolution of symptoms and improved quality of life.

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**Figure 2. Patient 2**

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A, Computed tomographic and cystoscopic view of 6 mm vesicovaginal fistula (arrow).

B, Laparoscopic port placement for laparoscopic vesicovaginal fistula repair (top, head; bottom, feet).

C, Interposition of omentum between vagina and bladder (B, bladder).

## Discussion

The choice for VVF repair is crucial for an excellent outcome, depending on the fistula's size, location, and whether the patient has undergone prior radiation therapy. Details are as follow.

The transvaginal approach is generally an excellent choice of approach particularly for smaller, lower-lying, nonradiated, and recurrent fistulas. This method, which is exemplified by techniques like the Latzko repair, is considered minimally invasive, offering the patient a shorter operative time and a faster recovery compared to the transabdominal approach. It avoids an abdominal incision. However, the technique has its limitations since it provides limited visualization for high-lying or complex fistulas, can be technically challenging with a very small vagina, and may sometimes be associated with vaginal shortening.

The transabdominal approach, performed as an open surgery or, more commonly today, using laparoscopic or robotic techniques, is reserved for more complex, high-lying, or recurrent fistulas. The chief advantage is the excellent visualization of the lesion, making it possible to address complex issues like ureteral involvement through easier ureteral stenting and repair. Furthermore, this approach allows interposition of well-vascularized tissue, such as the omentum, to significantly increase success rate. Even so, even the minimally invasive laparoscopic/robotic versions typically require a longer operative time and multiple ports, while traditional open surgery results in a much longer recovery time.

A sophisticated variant of the transabdominal method is the laparoscopic/robotic repair with limited cystotomy, which is adapted from the conventional O'Connor technique. This technique involves making a small, controlled incision (cystotomy) directly on the bladder dome to access and close the fistula from the bladder side. Its main benefit is the reported high success rate (approaching 100% in initial series) due to the ability to place precise sutures and effectively interpose the omentum. It is praised for minimizing the overall bladder dissection. The primary drawbacks are that it is technically demanding, requiring advanced skills, and it involves entering the peritoneal cavity.

An even newer, highly minimally invasive development is the single-port transvesical repair. This method involves inserting all necessary instruments through a single small incision made directly into the bladder wall. Patients benefit from minimal pain, maximum cosmetic appeal, and potentially the fastest recovery among the abdominal routes. It also offers direct visual access to the fistula from the bladder. However, this is a very new technique with limited long-term data, requires specialized surgical equipment, and presents a steep learning curve due to restricted instrument movement.<sup>7-9</sup>

In this study's case series, the transabdominal approach with omental interposition flap was chosen, because in both cases the fistulas were located above the trigone near the bladder dome, in which the transvaginal route might be difficult to repair. Moreover, tissue interposition can reinforce wound healing and prevent recurrence of fistula. This study has demonstrated that laparoscopic transabdominal VVF repair can be safely and effectively performed in provincial hospitals. Both patients experienced complete symptom resolution without significant complications. These outcomes aligned with existing literature reporting success rates and reduced postoperative morbidity comparable to open surgery.<sup>4-6</sup>

In both cases, VVF developed post-hysterectomy, reflecting global data identifying gynecologic surgeries as a leading cause, particularly abdominal hysterectomy.<sup>7</sup> Imaging and cystoscopy played crucial roles in diagnosis and surgical planning, and ureteral stenting helped prevent iatrogenic injury.<sup>8</sup>

This study's technique followed recognized principles: adequate tissue mobilization, tension-free multilayer closure, and omental interposition. Low blood loss, moderate operating time, and brief hospitalization reflect the advantages of laparoscopy in minimizing pain and enhancing recovery.<sup>9</sup>

There are notable differences between tertiary academic centers and provincial hospitals in Thailand in terms of surgical resources and case exposure. Academic hospitals are typically equipped with advanced technology, a larger number of operating rooms, and a greater variety of surgical instruments and energy devices that facilitate complex laparoscopic procedures. Moreover, there are surgeons with extensive experience and subspecialty training, supported by well-structured multidisciplinary teams and readily available anesthetic and nursing staff specialized in minimally invasive surgery.

In contrast, provincial hospitals usually have very limited resources and fewer opportunities to perform complex reconstructive cases such as VVF repair. The lower-case volume significantly affects the learning curve and experience of surgeons in such specialized procedures. Therefore, successful laparoscopic VVF repair in a provincial setting underscores both the surgical skill and adaptability of the team, and it signifies the growing capability of regional hospitals to manage complex urological conditions with minimally invasive techniques.

## Conclusions

With limited resources and experiences in a provincial hospital, laparoscopic VVF repair is feasible. It remains another surgical technique to minimize postoperative pain and length of hospital stay, as well as enhance access to quality of care and reduce the burden of referral to tertiary centers. However, more cases are required to further confirm its effectiveness and safety in provincial hospital setting.

### Additional Information

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# Conventional vs Combination of Conventional and Digital Approaches to Prosthetic Rehabilitation of Orbital Defect: Case Report

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## Abstract

**Background:** Presently, the digital impression and fabrication techniques for maxillofacial prostheses have been introduced. The efficient, easy and accessible one was created, selected, performed and compared with the conventional one.

**Case Presentation:** Prosthetic reconstructions were performed in a large and unfavorable facial defect, involving left orbital and intimately surrounding structures, with 2 different approaches: conventional approach vs combinational approach. One-month and 6-month follow-up visits were conducted. The results revealed that the combined technique overcame the conventional one in term of patients' comfort, risk of trauma, laboratory workload, mold accuracy and split mold fabrication, whereas, the inferior appearance of skin texture from the scan powder and the layer lines on the printed mold surface was noticeable.

**Conclusions:** Digital technique can be utilized to support, replace and even outperform conventional technique in certain steps of maxillofacial prosthesis fabrication which decreases workload and increases patient satisfaction.

**Keywords:** 3D printing, Orbital prosthesis, Split mold, Case report

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## Introduction

Sinonasal squamous cell carcinoma is a rare form of head and neck malignancy, with an incidence of 3%,<sup>1, 2</sup> while squamous cell carcinoma (SCC) of the ethmoid sinus is even more infrequent. Since ethmoid cancer in the early stage of the disease is difficult to be recognized, most patients are diagnosed with locally advanced SCC of the ethmoid sinus. Ethmoid cancer extends into the surrounding anatomical structures with ease, including the skull base plate, intracranial organs, orbital content and facial skin. Surgery, radiotherapy or chemoradiotherapy are treatments of choice.<sup>1</sup> Relatively high incidences are reported in Asia and Africa, and in individuals who have been exposed to wood dust, nickel, industrial fumes, textile dust, asbestos and formaldehyde. Other suggested risk factors are chronic sinusitis, allergies, nasal polyposis and tobacco smoking.<sup>3</sup>

A facial defect as a consequence of the cancer treatments, results in multiple functional and psychosocial difficulties. The mid-face reconstruction or rehabilitation is easily perceived by an observer due to its location, especially for the orbital defect which with the normal adjacent one makes a comparison obvious. Despite advancement in surgical techniques, the restoration of orbital defects is considered as one of the most difficult procedures, in term of the risk of complications and the final aesthetic outcome.<sup>4</sup> Moreover, large and unfavorable facial defects present challenges for prosthetic reconstruction as

a result of movable tissue margin, large heavy prostheses, lack of retention and reduced marginal adaptation of the prostheses.

The conventional workflow is performed by facial impression with impression material, fabrication of stone molds, sculpting wax patterns and silicone processing. The prosthetic outcomes can vary with patient, defect and healthcare professional factors. While a conventional workflow requires skill-dependent, artistically driven, time-consuming, and labor-intensive expertise,<sup>5</sup> as well as possible patient discomfort<sup>6</sup> and risk of trauma, this traditional technique has been used for a long time with the advantages of instrument and material availability and acceptable final outcomes.

The full digital workflow has the potential to provide an efficient, standardized and affordable treatment in the future. It starts by scanning the patient to obtain anatomic data with high speed, precision and safety. A design program then processes and modifies the scan data using a digital database<sup>7</sup> or mirror image of the contralateral side<sup>8</sup> to facilitate the generation of anatomic parts during the design process. Then, the 3D printing of silicone is the last step to fabricate maxillofacial prostheses.<sup>9</sup> Presently, several authors have introduced the digital impression and fabrication techniques including computerized tomography scanning and computer-aided design,<sup>10</sup> magnetic resonance imaging, laser, stereophotogrammetry,<sup>11</sup> monoscopic photogrammetry<sup>12</sup> and direct 3D printing of silicone.<sup>9</sup> There are advantages and disadvantages in each technique. Intraoral scanners are commonly available in dental clinics. They reduce the gag reflex, especially in maxillectomy patients and the risk of retention of the impression material in the defect.<sup>13</sup> Moreover, they can obtain enough detail to reproduce skin textures for maxillofacial prostheses.<sup>14</sup> However, accurate reproduction of large and flat topographical areas such as the face is limited because the sensor recognizes fewer reference points.<sup>15</sup> In addition, the direct 3D printing of silicone facial prosthesis has been reported to have inferior clinical outcome due to poor marginal adaptation and color match,<sup>9</sup> poor mechanical properties and untested biological responses.<sup>16</sup> Therefore, the combined technique<sup>16, 17</sup> of printed negative molds and the conventional silicone processing was chosen.

This case report details the medical history of the patient and the procedures of maxillofacial prosthetic fabrication in one unfavorable orbital defect with 2 approaches. The results were compared and discussed regarding the patient, clinician and lab technician perspectives.

## Case Presentation

A 57-year-old female patient with left orbital defect was referred to the Dental Division for prosthetic reconstruction. She presented with a chief complaint of limitation of the existing orbital prosthesis in term of difficulty in retention and a desire for prosthetic improvement of appearance. Due to her history of allergy to medical adhesive which created reactions including the redness and scaly skin, she had used transparent film dressings to hold the prosthesis in place (Figure 1) which made difficulty in insertion, ruined the prosthesis and looked unnatural.

The patient reported a history of keratinizing squamous cell carcinoma (T<sub>4</sub>N<sub>0</sub>M<sub>0</sub>) at her left ethmoid sinus status post recurrences and multiple resections including wide excision, left orbital exenteration and craniotomy, along with chemotherapy and radiotherapy. The residual tumor at temporal lobe and brain edema had been followed up annually since then. The classification of orbital exenteration was type III, which are cases with

penetration of the skull base, which imply a pterional craniotomy as a surgical approach to the affected brain structures.<sup>18</sup> The clinical examination revealed a defect that extended vertically from the left eyebrow to nearly the inferior rim of the nose, horizontally from ipsilateral margin of the nose to left lateral canthus and the posterior border to cranial floor. The surrounding tissue was movable when she lifted her eyebrows or smiled. There was moderate deformity of nose and left nasolabial fold.

The radiographic examination (Figure 2) demonstrated the evidence of left temporal craniotomy, left orbital exenteration and left mastoidectomy with resection of the posterior-inferior wall of the left external auditory canal, abutting the superficial left parotid lobe and the posterior aspect of the left temporomandibular joint, without new discrete enhancing lesion to suggest local tumor recurrence. The surrounding bone was insufficient for craniofacial implant. The existing orbital prosthesis was made 14 years ago with the problems of discoloration and retention due to the change in shape of the defect and the prosthesis, along with the adhesive allergy issue. After discussion, the patient desired a new orbital prosthesis with better appearance and stability without using adhesive nor craniofacial implant.

For conventional approach, a facial moulage was obtained by using light bodied polysulfide (Permlastic, Kerr), gauze strips and plaster (Snow white plaster No. 2, Kerr) (Figure 3A). Gypsum type V (Velmix, Rocky) was poured to fabricate the facial cast. The ocular prosthesis was fabricated and set the gaze. The wax-up (Figure 4A), showed acceptable marginal adaptation, and was refined until satisfied by the patient. On the stone mold, posterior side, the wax-up margin was elongated to create more surface into tissue undercut, whereas, on the anterior side, the margin was shortened due to no need for adhesive space. Conventional technique for silicone processing was performed by mixing 2-part silicones (Platinum Silicone Elastomer VST-50, Factor II) in ratio 10:1 by weight, according to the manufacturer's instructions. The intrinsic color (Functional Intrinsic, Factor II) and additional materials like flock were added to match the patient's skin tone in different areas such as upper eyelid, lower eyelid, nasofacial sulcus, cheek and forehead. Thixotropic agent was combined to thicken the silicone. The mixed and pigmented silicone was gradually smeared on the facial side of the mold to mimic the color of the patient's skin in each area. The remaining silicone was put into a plastic syringe and injected in all areas

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**Figure 1. Existing Orbital Prosthesis Was Retained by Transparent Tape**

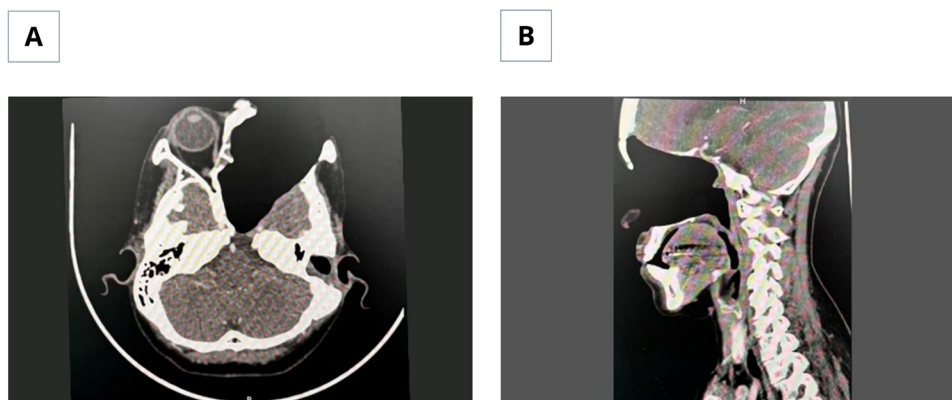
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**Figure 2. Preoperative Computerized Tomography Scan**

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A, Axial view.

B, Sagittal view.

of the mold. The mold was closed and kept under hydraulic press of 500 kg for more than 8 hours to cure at room temperature. Demolding and trimming were carefully performed. After the prosthesis was completed, extrinsic color (Functional Extrinsic, Factor II) was added chair side to imitate the non-defect side.

For digital assisted conventional approach, the patient was scanned with the 3D scanner (Artec Space Spider, Artec3D) (Figure 3B). The mold was designed with 3D design software (Materialise 3-matic, Materialise) and printed with a fused deposition modeling (FDM) 3D printer (Flashforge Guider IIs, Zhejiang Flashforge 3D Technology) in polylactic acid material (PLA). The PLA printing parameters were layer height 0.2 mm, nozzle diameter 0.4 mm, extrusion temperature 210 °C, build-plate temperature 50 °C, infill percentage 15% and print speed 60 mm per second. Postprocessing was removal of support structures and smoothing those areas. The sculpted wax pattern was performed on the printed mold as analog method (Figure 4B). After completed wax try-in on the patient, the sculpted wax on the printed mold was sprayed with scanner spray and then scanned from the front and the back. From the scan data, operating with the same 3D design software, 3D printer and 3D printing material as the former printed mold, design modification was created for the indexed 6-piece negative mold which was then deployed to the mold in PLA (Figure 5). After that the silicone prosthesis was fabricated from the printed split mold and then extrinsic painting was performed in the same way as the conventional approach.

On delivery, both facial prostheses were tried-in and delivered to the patient (Figure 6). Instructions were given to the patient regarding application, removal and care of the prostheses. Both prostheses showed acceptable marginal adaptation. Also, the retention from tissue undercut was sufficient to maintain each prosthesis in place without using silicone adhesive or transparent film dressing as before. However, the surface texture of the one from the combined technique was scanty inferior in appearance. After wearing a 2-week rotation on each piece, irritation or sore area was not detected on the patient's soft tissue. The patient had no complaint on aesthetic and comfort. The retentions from both prostheses were sufficient that she felt confident with no concern about prosthesis dislodgement during the day.

At 6-month follow-up, marginal adaptation, retention and color stability remained adequate for both prostheses over time. Although the conventional prosthesis created insignificant pressure on medial soft tissue and was slightly difficult to insert and remove, the patient reported comfortable daily usage of both prostheses.

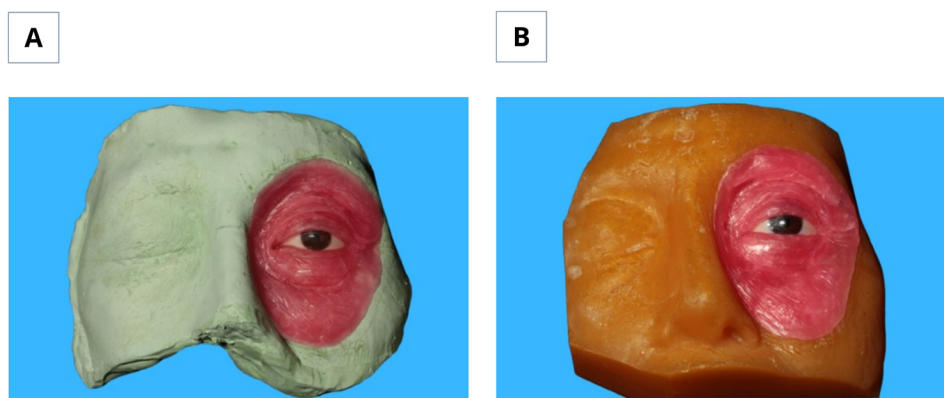
**Figure 3. Conventional Facial Impression Created Patient Discomfort and Minor Distortion While Patient Digital Image Revealed Those Disadvantages Less in This Large Extension of Orbital Defect**



A, Conventional facial impression.

B, Patient digital image.

**Figure 4. Both Wax Patterns on Conventional Stone Mold and Printed Mold Showed Acceptable Marginal Adaptation on Patient Tissue**



A, Conventional stone mold.

B, Printed mold.

**Figure 5. 3D Printed Indexed 6-Piece Negative Mold for Fabricating Silicone Orbital Prosthesis**



**Figure 6. Final Prostheses on Delivery Visit From Conventional and Combination Techniques**



A, Conventional technique.

B, Combination technique.

## Discussion

The thrust in cancer care is not simply on survival but on rehabilitation, which aims to improve multiple impairments and quality of life, enhancing patient's comfort and psychological morale.<sup>6</sup>

The sheer size of the facial prosthesis presented retention, weight, fabrication and patients' comfort challenges, as did maintaining closed margins abutting movable tissues. A variety of retentive methods for facial prostheses have been suggested such as retained by adhesive, attachment to osseous integrated implants, teeth,<sup>19</sup> magnets,<sup>20,21</sup> eyeglasses,<sup>22</sup> denture<sup>23</sup> or even existing bone-anchored reconstruction plates.<sup>24</sup> However, the survival rate of implants in irradiated patients is lower than in nonirradiated patients.<sup>25</sup> In this case report, not only compromised quality, but also insufficient quantity of the surrounding bone

contradicted the craniofacial implant option. Moreover, the patient had a history of medical adhesive allergy. Therefore, the undercut of encircling soft tissue was selected for the retentive method.

Due to the considerable size and extensive border of the orbital defect in this case, a large amount of impression material was used in the conventional method. This created patient discomfort and potential tissue trauma if there was a lack of proper defect preparation. Also, its heaviness can create tissue displacement resulted in minor distortion as the patient reported slight pressure on soft tissue only with the conventional one. Digital impression is more accurate, nonintrusive and design processes can be saved for future reproduction.<sup>14</sup> Nevertheless, in this case, a minor limitation was the sensor tip which was quite large which created difficulty in accessing to the undercut area of the defect.

Implementing a 3D printing service in a hospital requires establishing facilities, legal and medical documentation, and funding/billing. The difficulty in setting up and high initial investment on equipment and materials are worthwhile in terms of advancement of healthcare, more resiliency to clinical operation and also cost-effectiveness.<sup>26</sup> In this case, the setting was also in a hospital and centralizing the 3D printing operations can offer advantages in various applications for education, treatment and research.<sup>26, 27</sup>

Furthermore, from this report, the digital approach also aided in fabrication of the split mold, which is impossible to obtain from the conventional technique. The split mold made it easier and eliminated the risk of prosthesis tear, while removing the silicone prosthesis out of the mold especially in this case which utilized soft tissue undercut for retention.

Material of choice for the printed molds in this report was PLA because it is a widely used plastic filament material in FDM 3D printing. Nonetheless, PLA has a relatively low heat resistance,<sup>28</sup> and then it is unable to be cleaned up with steam cleaner to get rid of the residual wax, which consequently creates a risk of contamination in a silicone setting. In this case, gauze soaked in isopropyl alcohol (IPA) was scrubbed on the mold surface as cleaning method because IPA does not dissolve or significantly damage cured PLA, even with prolonged soaking. Alternatively, different printing materials can be selected such as heat resistant PLA,<sup>28</sup> polyetheretherketones, fluorinated polymers, polyurethanes, and polyacrylates<sup>29</sup> which have higher heat resistance and can be cleaned with steam cleaner.

Scanner powder or spray are used to coat reflective, shiny or dark objects to create matte surfaces that allow the 3D scanner's light to be detected more easily and uniformly. Spray systems produce thinner layering and create superior marginal adaptation of final restorations than powder systems.<sup>30</sup> In this case, the sculpted wax was unable to be scanned without the coating because of its reflection, so the scanner spray was used (Figure 7). However, the loss of skin texture detail on the sculpted wax pattern, which resulted from scanner spray coating was found. This shortcoming might be caused by the thickness of scanner spray and the unfavorable coating technique. Similarly, some studies have reported that the homogeneity and thickness of coatings were influenced by the clinician's experience<sup>30</sup> and poor-quality coatings have been related with defective marginal adaptation of the restorations.<sup>31</sup> Also, the thicknesses (10 to 30 mm) of various coatings exhibit considerable variability.<sup>32</sup> Besides, the modelling material which was wax may be replaced with modelling clay (sculptor's clay), plaster or plastolene.<sup>33</sup>

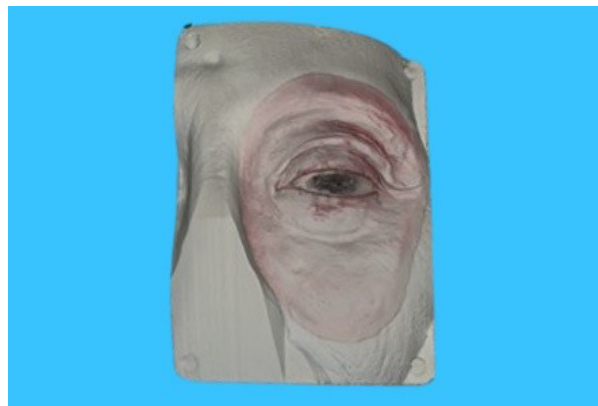
Moreover, for the appearance aspect, the step effect, which is the visible layered appearance of the printed objects, (Figure 8) was noticeable. Also, these unnatural stripes from the 3D printing complicated extrinsic coloring.

From patient perspectives, she preferred scan to analog impression, because of shorter period of time, absence of substantial matters on her face, absence of unpleasant odor from impression material and lesser emotional impact. For the final prostheses, although slight irritation during insertion and removal was found with the conventional one, the patient was satisfied with retention, appearance and ease-of-use of both prostheses.

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**Figure 7. Scan Powder Eliminated Skin Texture Detail on Sculpted Wax Pattern Resulting in Loss of Natural Appearance in Final Prosthesis**

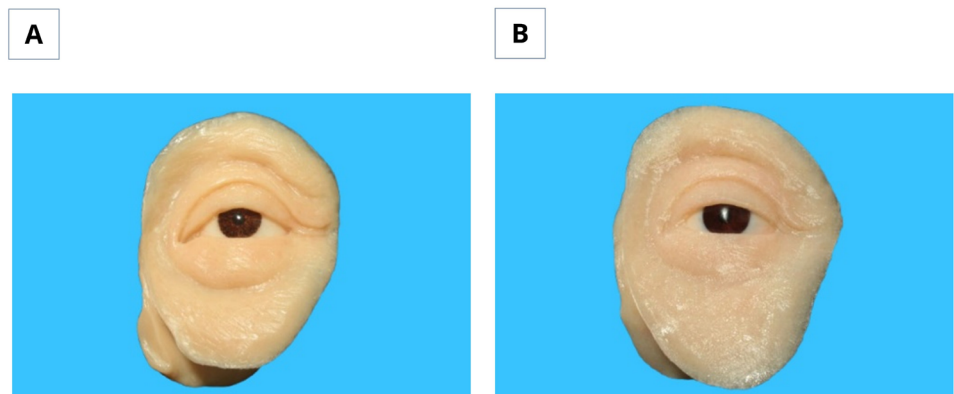
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**Figure 8. Definitive Prostheses From Conventional and Combination of Conventional and Digital. Notice Skin Texture Was Impaired on the One From Combination Technique**

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A, Conventional technique.

B, Combination technique.

## Conclusions

In conclusion, the combined technique overcame the conventional one in term of patients' comfort, risk of trauma, laboratory workload, mold accuracy, split mold fabrication, and reproducibility, whereas, the inferior appearance of skin texture from the scanner spray and the layer lines on the printed mold surface were presented. Although digital techniques presented some limitations in this case report, the advancement of this technology will make it replace and even surpass the analog technique in the future of the maxillofacial prosthodontic field.

## Additional Information

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Conceptualization: Nuntaporn Rojanasakul

Methodology: Nuntaporn Rojanasakul

Project Administration: Nuntaporn Rojanasakul

Writing – Original Draft: Nuntaporn Rojanasakul

Writing – Review & Editing: Nuntaporn Rojanasakul

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