J-MS
JOURNAL MOBILE TECHNOLOGIES

Received: 23 Jul 2026 | Revised: 26 Aug 2026 | Accepted: 1 Sept 2026 | Published: 10 Sept 2026 E-ISSN: 2986-478X, P-ISSN: 2986-1535

DOI: 10.59431/jms.v4i2.992

RESEARCH ARTICLE

Understanding Push Notification Fatigue: User Tolerance and Management Behavior in Mobile Applications

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Abstract
Push notifications are widely used by mobile applications to deliver timely information and maintain user engagement. However, excessive, repetitive, irrelevant, or poorly timed notifications may contribute to interruption, cognitive burden, emotional irritation, and notification fatigue. This proposed study examines push notification fatigue, user tolerance, and notification management behavior among mobile application users in Thailand. Using a cross-sectional survey design, the study will collect data from approximately 280 Android and iOS smartphone users who receive push notifications daily. The study integrates daily notification frequency, perceived notification load, notification relevance, timing appropriateness, actionability, perceived user control, notification fatigue, user tolerance, and management behavior. Respondents will be grouped into light-, medium-, and heavy-notification-load users based on their reported daily notification frequency. Quantitative data will be analyzed using descriptive statistics, reliability testing, group comparison tests, correlation analysis, and multiple regression. Open-ended responses will be analyzed through thematic content analysis to identify characteristics of useful and intrusive notifications. The study is expected to contribute to the literature by treating notification fatigue as a distinct user experience rather than a general extension of smartphone overuse, social media fatigue, or technostress. Practically, the study may inform more user-centered notification design by emphasizing relevance, appropriate timing, actionability, proportional urgency, privacy protection, and meaningful user control.

Keywords
Push Notifications; Notification Fatigue; User Tolerance; Notification Management; Mobile Applications.

1 | INTRODUCTION

Push notifications have become a central communication feature of mobile applications. They enable applications to deliver social updates, reminders, news, transactional information, security alerts, and promotional messages without requiring users to open the applications. When notifications are relevant and appropriately timed, they can help users obtain important information and complete necessary actions. However, as more applications compete for users' attention, the volume and diversity of notifications received throughout the day have also increased. Push notifications may therefore shift from useful communication tools to sources of interruption, cognitive burden, and psychological strain. Existing research demonstrates that users' responses to mobile notifications are shaped not only by notification frequency but also by content importance and the context in which a notification is received. In a large-scale assessment of mobile notifications, Sahami Shirazi *et al*. (2014) showed that users assign different levels of importance to notifications and respond to them differently according to their source and context. Visuri *et al*. (2019) similarly found that users' interactions with smartphone notifications are related to notification content, perceived importance, and recent notification frequency. These findings indicate that notification load cannot be evaluated solely by counting the number of messages received. A notification may be tolerated when it is expected, relevant, or urgent, but it may be considered intrusive when it arrives at an inappropriate time or provides little value.

From an interruption perspective, notifications compete with users' ongoing activities and require them to decide whether to attend to, postpone, dismiss, or ignore incoming information. Ohly and Bastin (2023) found that task interruptions caused by notifications from communication applications were related to users' strain and performance. Their findings also suggest that reducing notification interruptions may benefit some users, although disabling notifications can generate concern about missing important information and may encourage self-interruption in others. Özdemir *et al*. (2024) also found that users' experiences with push notifications vary according to daily context. Poorly timed notifications can cause annoyance and stress, whereas notifications that correspond to users' activities and preferences may be evaluated more positively. Both interruption frequency and contextual appropriateness are therefore important for understanding the psychological effects of notifications. Continuous notification exposure may also contribute to information overload and digital stress. Stephens *et al*. (2017) conceptualized communication overload as a condition in which communication demands exceed an individual's capacity to process incoming information effectively. In mobile environments, such demands may arise from message volume, the variety of communication channels, and the pressure to remain continuously available. The Digital Stress Scale developed by Hall *et al*. (2021) includes connection overload and online vigilance, which are especially relevant to notification experiences. Connection overload concerns distress caused by excessive digital input, including messages and notifications, while online vigilance reflects persistent attention to online communication. These dimensions provide a theoretical basis for explaining why repeated notifications may produce fatigue even when individual messages are relatively brief. Notification-related strain is also closely associated with technostress. Salo *et al*. (2019) showed that the continuous and unpredictable demands of social networking services can create concentration, sleep, identity, and social relationship problems. Push notifications contribute to these demands by introducing unexpected interruptions and maintaining users' awareness of incoming digital communication. Frequent or poorly managed communication can also blur the boundary between personal and occupational activities. In this study, notification fatigue is understood as a notification-specific manifestation of broader digital stress and information overload, characterized by feelings of being overwhelmed, irritated, mentally exhausted, or unwilling to respond to incoming notifications.

The issue is particularly relevant in Thailand, where mobile technologies are extensively integrated into educational, occupational, commercial, and social activities. Research involving Thailand-based populations has provided evidence of the negative consequences of intensive digital connectivity. Boonjing and Chanvarasuth (2017) examined the risk of mobile phone overuse and proposed that communication and information overload contribute to technostress, which can subsequently affect personal health and work-related outcomes. Imjai *et al*. (2024) found that digital connectivity among Generation Z undergraduates in Thailand could produce feelings of disturbance and loss of focus and may negatively affect users' social and emotional functioning. Related studies reinforce this pattern. Sriwilai and Charoensukmongkol (2016), using data from employees in Thailand, found that social media addiction was associated with reduced mindfulness, emotion-focused coping, and greater emotional exhaustion. Thanasrivanitchai and Torasamphan (2024) examined technostress and job burnout in organizations in Thailand, identifying techno-invasion, techno-insecurity, and techno-uncertainty as important sources of occupational strain, while Kaewpradit *et al*. (2025) investigated excessive digital screen time among university students in Thailand and its associations with mental health, sleep quality, and academic performance. Although these studies did not specifically measure push notification fatigue, they indicate that constant digital connectivity can have consequences extending beyond application use, including fatigue, reduced concentration, emotional strain, and difficulties separating digital demands from everyday life.

Evidence directly concerning notification design in the Thai context remains more limited. Jarupreechachan *et al*. (2023) examined the design implications of Do Not Disturb features using Thai students and workers living in Taiwan.

Their study proposed an approach that allowed users to reduce interruptions while continuing to receive essential alerts from selected applications or contacts. This approach illustrates an important tension in notification management: users may want fewer interruptions but may also experience anxiety when they believe that important messages could be missed. Completely disabling notifications may therefore not represent an optimal solution for all users, whereas more granular controls based on application, contact, urgency, or time may provide a better balance between accessibility and psychological comfort. Notification practices can also raise concerns about manipulative application design. Nimkoompai (2022) identified notification fatigue as a risk associated with dark patterns in the user experience of e-commerce applications. In this context, repeated notifications may not merely result from poor design but may reflect deliberate attempts to capture attention and influence user behavior. Promotional notifications can become especially problematic when they are repetitive, irrelevant, difficult to control, or delivered without adequate consideration of users' preferences. These findings indicate the need to examine notification fatigue not only as an individual psychological response but also as an outcome influenced by application design and engagement strategies.

Users may respond to notification overload through several management behaviors. Passive responses include dismissing messages without reading them, delaying responses, and repeatedly ignoring particular types of notifications. More active responses include muting applications, disabling selected notification categories, activating Do Not Disturb functions, changing alert settings, or uninstalling applications. Pretolesi *et al*. (2025) found that excessive frequency, low relevance, and disruption of ongoing activities were important sources of irritation in mobile health and well-being notifications. Their findings also suggested that users may respond to excessive notifications by disabling them rather than immediately deleting the application. Kim and Park (2025) further noted the potential value of notification customization and user-driven delivery modes in balancing information needs with cognitive load. These studies indicate that perceived control may reduce the negative effects of notification exposure and allow users to retain notifications that they consider valuable.

Despite growing attention to digital overload, technostress, and mobile interruption, several gaps remain. Research in Thailand has largely concentrated on mobile phone overuse, digital connectivity, social media addiction, screen time, and organizational technostress, while push notification fatigue has received less direct attention. Limited evidence is also available on whether users with light, medium, and heavy notification loads differ in their tolerance and management behavior. The relative effects of promotional, social, news, reminder, transactional, and security notifications among Thai users have not been sufficiently compared, and few studies combine users' quantitative evaluations with descriptions of actual notifications they consider good or bad. Addressing these gaps is necessary because recommendations based solely on international evidence may not fully represent the digital practices, communication expectations, and application-use contexts of users in Thailand. Therefore, this study investigates push notification fatigue, user tolerance, and notification management behavior among mobile application users. A survey of 280 respondents will examine daily notification frequency, perceived notification load, notification type, content relevance, timing appropriateness, actionability, perceived user control, notification fatigue, user tolerance, and management behavior. Respondents will be categorized into light-, medium-, and heavy-notification-load groups to identify differences in tolerance and management strategies. The study will also analyze users' examples of effective and ineffective notifications to develop a taxonomy of notification characteristics. By integrating evidence from notification research with Thailand-based studies of technostress and digital overload, this study aims to provide practical guidance for designing notifications that support application engagement while respecting users' limited attention. Accordingly, this study has the following objectives:

1) To examine the frequency and types of push notifications received by mobile application users.
2) To assess users' notification fatigue and tolerance levels.
3) To compare fatigue, tolerance, and management behavior among light-, medium-, and heavy-notification-load users.
4) To examine how notification relevance, timing, actionability, and perceived user control relate to notification fatigue.
5) To identify the strategies users employ to manage excessive or unwanted notifications.
6) To identify the characteristics that distinguish useful notifications from annoying or intrusive notifications.
7) To formulate practical recommendations for user-centered notification design.

The study addresses the following research questions:

1) RQ1: What types and volumes of push notifications do mobile application users receive daily?
2) RQ2: Which notification types are perceived as the most annoying or intrusive?
3) RQ3: How does notification load relate to notification fatigue and user tolerance?
4) RQ4: Do notification fatigue, tolerance, and management behavior differ among light-, medium-, and heavy-notification-load users?
5) RQ5: How are notification relevance, timing, actionability, and perceived user control associated with notification fatigue?
6) RQ6: What strategies do users employ to manage excessive or unwanted notifications?
7) RQ7: What characteristics distinguish good notifications from bad notifications?.

2 | LITERATURE REVIEW

2.1 Notification Fatigue, Digital Overload, and Mobile Interruptions

Push notifications enable mobile applications to communicate with users without requiring the applications to be actively opened. They can deliver social messages, reminders, news, transactional updates, security alerts, health information, and promotional content. Their value depends on whether the benefit of the information justifies the attention demanded from the user. Each notification may require users to interrupt an ongoing activity, evaluate the message, and decide whether to open, postpone, dismiss, or ignore it. As users install more applications and receive notifications from multiple sources, these repeated decisions may create an accumulating cognitive burden. A large-scale assessment by Sahami Shirazi *et al*. (2014) showed that notifications are not perceived equally; their importance and the likelihood of user interaction vary according to category and context. Visuri *et al*. (2019) similarly demonstrated that users' interactions with smartphone notifications are related to content importance and recent notification frequency. Notification exposure should therefore not be understood only as the total number of messages delivered, because source, purpose, content, urgency, and delivery context collectively determine whether a notification is experienced as useful or disruptive.

Notification fatigue refers to the cognitive, emotional, and behavioral exhaustion that can arise when users are repeatedly exposed to notifications perceived as excessive, repetitive, irrelevant, or intrusive. Cognitively, it may appear as fragmented attention, difficulty concentrating, or reduced ability to distinguish important messages from less important ones. Emotionally, users may feel overwhelmed, irritated, anxious, or mentally exhausted. Behavioral manifestations include dismissing messages without reading them, postponing responses, muting applications, disabling notification permissions, and reducing application use. Notification fatigue differs from objective notification frequency because it represents a subjective response. Two users receiving a similar number of notifications may experience different fatigue levels depending on message relevance, daily activities, social responsibilities, and ability to control notification delivery. Conversely, a relatively small number of poorly timed or repetitive promotional notifications may be sufficient to create annoyance.

The concept is closely connected to information and communication overload. Stephens *et al*. (2017) explained that communication overload occurs when communication demands exceed an individual's capacity and available resources to process them effectively. Such overload is not determined only by message volume; it can also result from multiple communication channels, ambiguous content, high response expectations, and the speed at which information arrives. In mobile environments, notifications intensify these demands by making incoming communication continuously visible through sounds, vibrations, badges, banners, and lock-screen messages. Hall *et al*. (2021) offer a complementary perspective through the Digital Stress Scale, particularly its dimensions of connection overload and online vigilance. Connection overload represents distress associated with excessive input from digital sources, including messages and notifications, while online vigilance reflects persistent mental attention to digital communication. These dimensions help explain why users may remain psychologically occupied by notifications even when they do not immediately interact with them.

The application of digital-stress measurement across different cultural settings also demonstrates the need for careful adaptation. Zhang *et al*. (2023) validated a Chinese version of the Digital Stress Scale and used translation and psychometric testing to account for linguistic and cultural differences. Funke *et al*. (2026) subsequently examined its cross-cultural application and developed a shorter scale. These studies provide methodological support for adapting overload and vigilance measures to Thai smartphone users. However, digital stress is broader than notification fatigue and includes experiences not directly caused by notifications. A notification-fatigue instrument should therefore retain only conceptually relevant dimensions, modify item wording specifically for push-notification experiences, and undergo expert review, translation, pilot testing, reliability analysis, and validity assessment before use.

Technostress provides another theoretical basis for understanding notification fatigue because it refers to strain resulting from users' difficulty in managing the demands associated with information and communication technology. In Thailand, Boonjing and Chanvarasuth (2017) investigated the risks of mobile-phone overuse and indicated that communication and information overload may contribute to technostress, frustration, and negative personal or occupational outcomes. Thanasrivanitchai and Torasamphan (2024) also examined technostress and employee burnout in organizations in Thailand, identifying technology-related demands such as techno-invasion as relevant to occupational strain. Push notifications can contribute to techno-invasion by extending work-related communication into personal time and encouraging users to remain continuously reachable. Although these studies did not directly measure notification fatigue, they provide a contextual basis for examining it as a notification-specific form of digital strain.

Research involving Thai participants also suggests that intensive digital connectivity has consequences for attention and emotional well-being. Imjai *et al*. (2024) found that digital connectivity among Generation Z undergraduates in Thailand was associated with disturbance and loss of focus and could negatively affect aspects of

social skills and emotional intelligence. Sriwilai and Charoensukmongkol (2016), using data from employees in Thailand, connected social media addiction with reduced mindfulness, coping patterns, and emotional exhaustion. Kaewpradit *et al*. (2025) examined excessive digital screen time and its associations with mental health, sleep quality, and academic performance among university students in Thailand, while Mongkhon *et al*. (2021) found that extensive exposure to COVID-19-related information among people in Thailand was associated with psychological problems, including anxiety and insomnia, with social media serving as a major information source. These studies concern broader digital exposure rather than push notifications specifically and should not be interpreted as direct evidence of notification fatigue. They nevertheless demonstrate that persistent connectivity, intensive information exposure, and technology use are relevant well-being issues within the Thai context.

Push notifications also function as external interruptions. When a notification arrives during work, study, rest, or interpersonal activity, it redirects attention toward an unplanned stimulus. Even if users decide not to open it, noticing and evaluating the notification may disturb concentration, and returning to the original task can require additional cognitive effort. Ohly and Bastin (2023) found that task interruptions caused by notifications from communication applications were associated with users' strain and performance. Reducing interruptions generally offered benefits, but the effects varied between individuals. Some users experienced lower stress and improved productivity, whereas others increased their manual checking or became anxious about missing important messages. Completely disabling notifications may therefore reduce external interruptions while creating self-interruptions for users with strong expectations of availability.

The timing and context of delivery are consequently as important as frequency. Özdemir *et al*. (2024) showed that smartphone push-notification experiences vary across daily contexts and that ill-timed notifications can produce interruption, annoyance, and stress. Mehrotra and Musolesi (2017) similarly argued that notifications delivered at inappropriate moments can disrupt users and potentially contribute to application abandonment. This concern has encouraged the development of intelligent notification systems that consider user activity, availability, and message importance. However, automated systems may not always determine interruptibility accurately because an appropriate time for one user or notification category may be inappropriate for another. A social message, for example, may be welcome during leisure time but distracting during work, while an urgent security warning may justify interruption in either situation. These findings support measuring timing appropriateness separately from notification frequency.

From an attention perspective, push notifications allow applications to compete for a limited user resource even when the applications are not being actively used. Frequent notifications may create more opportunities for immediate interaction, but they may also weaken the perceived importance of individual messages and undermine long-term trust. The findings of Sahami Shirazi *et al*. (2014) and Visuri *et al*. (2019) indicate that sending more notifications does not necessarily generate more meaningful engagement. This concern becomes particularly important when notifications are used as persuasive design mechanisms. Nimkoompai (2022) identified notification fatigue as a risk associated with dark patterns in e-commerce applications, suggesting that repeated notification delivery may sometimes reflect deliberate efforts to capture attention, create urgency, or influence user decisions. Notification fatigue should therefore be considered not only an individual inability to manage technology but also a possible consequence of engagement strategies that prioritize short-term interaction over user autonomy and well-being.

2.2 User Tolerance and Notification Management Behavior

User tolerance represents the extent to which individuals are willing to accept notification volume and interruption without experiencing substantial annoyance, fatigue, or avoidance. Tolerance is not a fixed threshold determined exclusively by the number of notifications received. It varies according to message relevance, usefulness, timing, urgency, actionability, application category, and personal expectations. Notifications concerning account security, payment confirmation, travel changes, or scheduled activities may be accepted because their immediate benefits are apparent. Social notifications may also be tolerated when they come from important contacts. By contrast, repetitive promotional messages may be evaluated negatively when they interrupt users without offering corresponding value. The relationship between notification frequency and fatigue is therefore likely to depend on how users evaluate the content and purpose of incoming messages.

Relevance refers to the extent to which notification content corresponds with users' interests, needs, or current circumstances, while actionability concerns whether the message supports a clear and useful response. Sahami Shirazi *et al*. (2014) established that perceived importance varies across notification categories, and Visuri *et al*. (2019) showed that content importance influences users' interaction decisions. Pretolesi *et al*. (2025) found that irrelevant content, excessive frequency, advertising, and disruption of ongoing activities were important sources of irritation in mobile health and well-being applications. These findings suggest that frequent notifications may remain tolerable when they consistently provide value, whereas low-value messages can create fatigue even at a lower frequency. Actionable notifications may further reduce cognitive burden by clearly explaining what has happened

and what the user can do next. In an alert-based application designed for Bangkok, Heeptaisong *et al*. (2026) emphasized concise and actionable notification content while identifying control over notification frequency and thresholds as an important design consideration. Although the study concerned air-pollution alerts rather than general mobile notifications, it provides locally relevant evidence for the importance of brevity, actionability, and control.

Perceived control may protect users from notification fatigue by allowing them to determine which applications, message categories, contacts, and times deserve interruption. Jarupreechachan *et al*. (2023) investigated an extension of the Do Not Disturb feature with Thai students and workers living in Taiwan. Their design allowed essential notifications from selected applications or contacts to remain available while other interruptions were restricted. The study illustrates the limitations of an all-or-nothing approach: users may want to protect their concentration but remain reachable for critical work or personal communication. However, its small and geographically specific sample means that its findings should be interpreted as preliminary design evidence rather than generalized to all Thai smartphone users. Kim and Park (2025) likewise examined user-centered notification modes and argued that fine-grained customization can balance cognitive load with information needs. Together, these studies indicate that user control may be more effective than simply maximizing or minimizing the number of delivered notifications.

When users consider notifications excessive or intrusive, they can employ passive, selective, or restrictive management strategies. Passive behaviors include ignoring alerts, dismissing them without reading, delaying responses, and allowing notifications to accumulate. Selective behaviors involve muting particular applications or conversations, disabling specific categories, adjusting sounds and vibrations, hiding lock-screen content, or activating Focus and Do Not Disturb modes. Restrictive behaviors include disabling all notifications from an application, reducing application use, or uninstalling the application. These actions should not automatically be interpreted as complete rejection of an application. Selective management may enable users to continue using a service while reducing its claims on their attention. It can therefore function as a coping strategy through which users restore autonomy and align communication demands with personal preferences.

Pretolesi *et al*. (2025) found that users were likely to disable notifications when their frequency became excessive, but this did not necessarily mean that they would immediately delete the application. In contrast, prolonged dissatisfaction, declining trust, or repeated interruption may eventually contribute to broader disengagement. Salo *et al*. (2019) showed that technostress associated with social networking services can affect concentration, sleep, identity, and social relationships, indicating that persistent communication demands may produce consequences beyond momentary annoyance. Bhumithavara and Sun (2025) further described notification dependence as involving social pressure, habitual checking, and fragmented attention. Their qualitative findings may help explain why some users continue monitoring notifications despite experiencing negative consequences, although the publication should be treated as supplementary evidence and its methodological quality should be considered carefully.

Individual and social differences can also affect management behavior. Tugtekin *et al*. (2020) identified relationships among fear of missing out, problematic smartphone use, and social networking service fatigue, while Świątek *et al*. (2023) emphasized the role of self-control in the relationship between problematic smartphone use and social media fatigue. These studies do not examine general mobile push notifications directly, but they suggest that users with high fear of missing out or lower self-regulatory capacity may be less willing to disable alerts. Such users may tolerate high notification loads, experience fatigue while remaining connected, or repeatedly check applications when external notifications are silenced. Occupational expectations can create a similar pattern when employees feel required to respond quickly. In the Thai context, evidence concerning technostress, work–life balance, and emotional exhaustion suggests that persistent availability can blur the boundary between professional and personal activities (Sriwilai & Charoensukmongkol, 2016; Thanasrivanitchai & Torasamphan, 2024; Sudson & Hinthaw, 2025).

The literature also supports an initial distinction between good and bad notifications. Good notifications are generally relevant, timely, concise, credible, actionable, and proportionate to the urgency of the information. They clearly identify their source and purpose, avoid unnecessary repetition, and give users meaningful control over delivery. Bad notifications tend to be irrelevant, repetitive, poorly timed, misleading, excessively promotional, or difficult to manage. However, this distinction is context dependent rather than absolute. A promotional notification may be useful when the user has requested it and the offer is timely, while a normally valuable reminder may become intrusive if it is repeated too often. Therefore, a taxonomy of notification quality should not be based only on predefined researcher categories. It should also incorporate users' descriptions and evaluations of actual notification experiences.

2.3 Research Gap and Conceptual Framework

The reviewed literature indicates that notification fatigue emerges through the interaction of notification

exposure, message characteristics, interruption context, individual expectations, and perceived control. International notification research provides evidence concerning content importance, timing, frequency, interruptibility, customization, and user responses (Sahami Shirazi *et al*., 2014; Mehrotra & Musolesi, 2017; Visuri *et al*., 2019; Ohly & Bastin, 2023; Özdemir *et al*., 2024; Kim & Park, 2025; Pretolesi *et al*., 2025). Thailand-based research has examined mobile-phone overuse, digital connectivity, social media addiction, screen time, information exposure, technostress, and emotional exhaustion (Boonjing & Chanvarasuth, 2017; Imjai *et al*., 2024; Kaewpradit *et al*., 2025; Mongkhon *et al*., 2021; Sriwilai & Charoensukmongkol, 2016; Thanasrivanitchai & Torasamphan, 2024). More directly, Jarupreechachan *et al*. (2023) investigated notification-control design, while Nimkoompai (2022) discussed notification fatigue as a risk associated with e-commerce dark patterns. Nevertheless, Thailand-based evidence remains concentrated on broad digital strain rather than users' everyday experiences with push notifications across multiple mobile applications.

Several gaps therefore remain. Notification fatigue has not been sufficiently investigated as a distinct phenomenon among mobile application users in Thailand. Evidence from technostress, excessive screen time, social media fatigue, and information exposure provides useful context, but these constructs cannot substitute for direct measurement of notification-related fatigue. Previous studies have also not adequately compared users with light, medium, and heavy notification loads, even though high objective exposure may not always produce fatigue if the notifications are relevant, while users with lower exposure may still feel overloaded by intrusive content. Limited evidence is available regarding how Thai users evaluate different categories, including promotional, social, news, reminder, transactional, security, and system notifications. Existing research also rarely combines standardized survey measures with open-ended examples that explain why particular notifications are considered good or bad.

To address these gaps, the proposed framework positions perceived notification load, relevance, timing appropriateness, actionability, and perceived user control as the principal factors associated with notification fatigue. Perceived load and poorly designed notification characteristics are expected to be positively associated with fatigue, whereas relevance, appropriate timing, actionability, and control are expected to be negatively associated with fatigue. Notification fatigue is subsequently expected to be associated with lower user tolerance and more frequent management behaviors, such as ignoring, dismissing, muting, customizing, disabling, or uninstalling. The framework also compares light-, medium-, and heavy-notification-load users to identify whether exposure level corresponds with different fatigue and management patterns. Because the study uses cross-sectional survey data, these relationships will be interpreted as associations rather than causal effects. Based on the literature, the study proposes the following hypotheses:

1) H1: Perceived notification load is positively associated with notification fatigue.
2) H2: Notification relevance and timing appropriateness are negatively associated with notification fatigue.
3) H3: Perceived user control is negatively associated with notification fatigue.
4) H4: Notification fatigue is negatively associated with user tolerance.
5) H5: Notification fatigue is positively associated with notification management behavior.
6) H6: Notification fatigue and management behavior differ significantly among light-, medium-, and heavy-notification-load users.

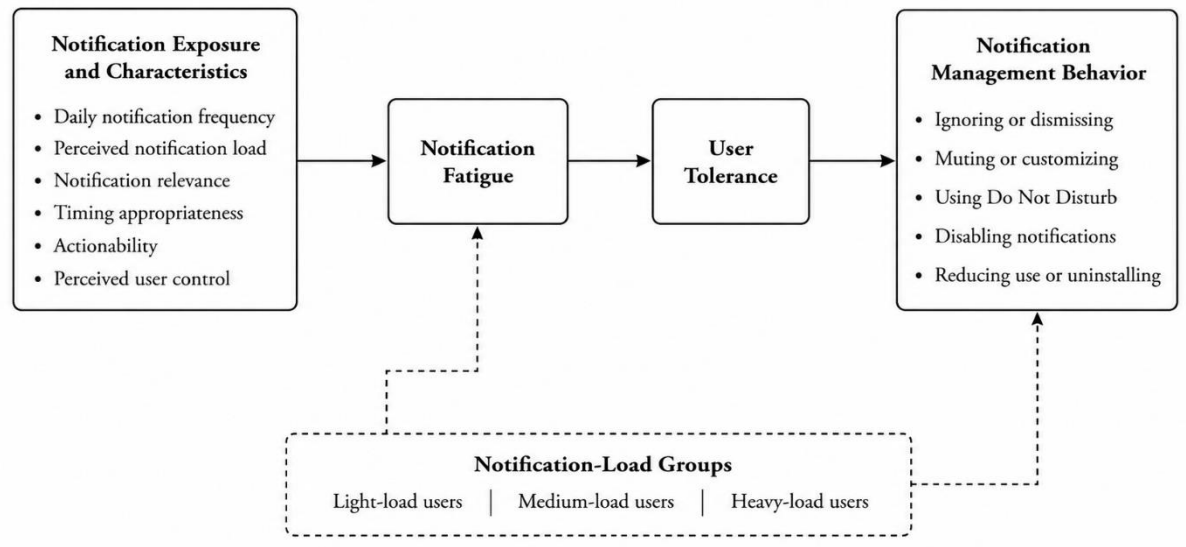

Figure 1. Conceptual Framework of Push Notification Fatigue, User Tolerance, and Notification Management Behavior

The framework integrates objective exposure with subjective experience. Daily notification frequency represents the estimated level of exposure, whereas perceived notification load captures whether that exposure feels excessive to the user. This distinction is important because notification fatigue may be shaped more strongly by perceived burden than by notification count alone. Relevance, timing, and actionability represent notification-design characteristics, while perceived control reflects users' ability to regulate delivery. Fatigue, tolerance, and management behavior represent the principal psychological and behavioral outcomes. Together, these variables provide a focused model that can be tested through a survey of 280 respondents without making the research design unnecessarily complex.

3 | METHOD

3.1 Research Design, Participants, and Data Collection

This study will employ a cross-sectional survey design to examine push notification fatigue, user tolerance, and notification management behavior among mobile application users in Thailand. This design is appropriate because the study aims to measure notification exposure and user perceptions, test relationships among variables, and compare respondents with different levels of daily notification exposure. The survey will primarily use quantitative measures and will include two open-ended questions asking respondents to describe notifications they consider useful or intrusive. These qualitative responses will provide contextual explanations for why users tolerate, ignore, customize, disable, or otherwise manage particular notifications. Because the data will be collected at one point in time, the findings will be interpreted as statistical associations rather than causal relationships. The target sample will consist of approximately 280 respondents recruited through convenience and snowball sampling. Survey invitations will be distributed through universities, workplaces, social media platforms, messaging applications, and online communities in Thailand to reach respondents with varied demographic and smartphone-use characteristics. Eligible participants must be at least 18 years old, currently reside in Thailand, use an Android or iOS smartphone, regularly use at least three mobile applications, and receive push notifications daily. Screening questions at the beginning of the questionnaire will verify these criteria. Because the sample will not be selected through probability sampling, the findings cannot be assumed to represent all smartphone users in Thailand, and this limitation will be acknowledged in the interpretation.

The online questionnaire will remain accessible for approximately three to four weeks. Before participating, respondents will receive information about the study's purpose, participation requirements, estimated completion time, data handling procedures, and voluntary nature. Informed consent will be required before they continue. No directly identifying details, such as full names, telephone numbers, usernames, account numbers, or exact home addresses, will be collected. Respondents will also be informed that they may stop before submitting the questionnaire and may leave the open-ended questions unanswered. Data collection will begin only after the necessary institutional permission or ethical approval has been obtained. Quality-control procedures will be applied before responses are included in the final dataset. Submissions will be excluded if participants do not meet the eligibility criteria, leave substantial sections incomplete, provide duplicate responses, complete the questionnaire in an implausibly short period, or show clear indications of careless responding. Straight-line response patterns will be reviewed but will not lead to automatic exclusion unless accompanied by other evidence of poor response quality. Extremely high notification-count estimates will also be examined carefully rather than removed immediately because some users may genuinely receive a large number of notifications. All exclusion decisions and the final number of valid responses will be documented transparently.

3.2 Questionnaire and Measurement

The questionnaire will be developed in English and Thai and organized into several components. The first component will collect demographic and smartphone-use information, including age, gender, education, occupation, operating system, average daily smartphone-use duration, number of regularly used applications, and number of applications that send notifications. The second component will measure notification exposure by asking respondents to estimate the average number of notifications they receive daily and indicate how frequently they receive promotional, social, news, reminder, transactional, security, work-related, and system notifications. Where possible, participants will be encouraged to consult device settings, notification history, or digital well-being records before estimating their daily notification volume. However, this measure will remain self-reported because notification records differ across devices and operating systems. The main perceptual constructs will include perceived notification load, notification relevance, timing appropriateness, actionability, perceived user control, notification fatigue, and user tolerance. Perceived notification load will refer to the extent to which respondents feel that incoming notifications exceed their available attention or processing capacity. Relevance will reflect whether notification content corresponds to users' interests, needs, and current circumstances. Timing appropriateness will

assess whether notifications tend to arrive at suitable moments, while actionability will measure whether notifications communicate a clear purpose and meaningful next step. Perceived user control will concern respondents' ability to adjust notification sources, categories, timing, frequency, sounds, and visibility. These constructs will be measured using five-point Likert-scale statements ranging from 1 = strongly disagree to 5 = strongly agree.

Notification fatigue will be operationalized as cognitive, emotional, and behavioral exhaustion associated with repeated notification exposure. Its items will address feeling overwhelmed by incoming alerts, losing concentration, experiencing annoyance, becoming mentally tired, ignoring messages automatically, and having difficulty distinguishing important notifications from unimportant ones. The measurement will draw conceptually on connection overload and online vigilance from the Digital Stress Scale developed by Hall *et al*. (2021), together with notification-specific evidence from Sahami Shirazi *et al*. (2014), Visuri *et al*. (2019), Ohly and Bastin (2023), and Özdemir *et al*. (2024). The original Digital Stress Scale will not be reproduced directly because it addresses broader digitally mediated experiences. Instead, relevant concepts will be adapted into items that refer specifically to mobile push notifications. User tolerance will reflect respondents' willingness to continue accepting notifications under conditions such as relevance, urgency, appropriate timing, personalization, or immediate usefulness. Notification management behavior will be measured through the reported frequency of ignoring or dismissing messages, delaying notification checking, muting applications or conversations, disabling selected categories, adjusting sound or vibration, hiding lock-screen content, activating Focus or Do Not Disturb, disabling all notifications from an application, reducing application use, or uninstalling applications. These behavioral items will use a five-point frequency scale ranging from 1 = never to 5 = very often. This distinction is important because users may accept notifications while still customizing them, or experience fatigue while avoiding setting changes because of concern about missing essential information.

Two open-ended questions will ask respondents to describe one notification they considered good or useful and one they considered bad, annoying, or intrusive. Respondents will also be asked to explain which features influenced their judgments. Screenshots will not be required because notification displays may contain private messages, financial information, security codes, health details, or other personal data. If respondents voluntarily mention identifiable information, these details will be removed or generalized before analysis and reporting. The responses will be used to refine the literature-based taxonomy of notification quality, particularly in relation to relevance, timing, urgency, clarity, brevity, usefulness, actionability, repetition, promotional intent, and user control. The initial questionnaire will be reviewed by two or three experts with relevant experience in information systems, mobile computing, user experience, behavioral research, or survey design. The English and Thai versions will undergo translation and back-translation to preserve conceptual equivalence. A pilot study involving approximately 25–30 eligible smartphone users who will not participate in the main study will then be conducted to evaluate completion time, item clarity, technical functionality, and preliminary reliability. Feedback from experts and pilot participants will be used to revise unclear, overlapping, or culturally unsuitable statements.

Table 1. Operationalization and Measurement of the Study Variables

Variable	Operational Definition	Proposed Indicators	Measurement
Daily notification frequency	Estimated number of push notifications received during a typical day	Total daily notifications	Numerical estimate
Perceived notification load	Degree to which incoming notifications feel excessive or difficult to process	Excessive volume, accumulation, processing burden	Five-point Likert scale
Notification relevance	Degree to which notification content corresponds to users' needs and interests	Personal relevance, usefulness, contextual suitability	Five-point Likert scale
Timing appropriateness	Suitability of the time and situation in which notifications arrive	Suitable timing, interruptibility, contextual fit	Five-point Likert scale
Actionability	Extent to which notifications provide a clear purpose and meaningful response	Clarity, usefulness, clear next action	Five-point Likert scale
Perceived user control	Ability to regulate notification delivery and presentation	Control over source, category, timing, frequency, and alert mode	Five-point Likert scale
Notification fatigue	Cognitive, emotional, and behavioral exhaustion associated	Overwhelm, disrupted concentration, irritation, mental	Five-point Likert scale

	with notifications	fatigue, automatic ignoring	
User tolerance	Willingness to accept and continue receiving notifications	Acceptance, willingness to retain alerts, tolerance under valuable conditions	Five-point Likert scale
Management behavior	Actions used to regulate or avoid notification demands	Ignoring, muting, customizing, disabling, and uninstalling	Five-point frequency scale
Notification quality	Characteristics influencing evaluations of good and bad notifications	Relevance, timing, urgency, clarity, brevity, repetition, and control	Open-ended responses

3.3 Data Analysis

The analysis will begin with data cleaning and descriptive examination. Frequencies and percentages will summarize demographic characteristics, smartphone-use patterns, notification categories, and individual management behaviors. Means, standard deviations, medians, interquartile ranges, and observed ranges will be calculated where appropriate. Both means and medians will be reported for daily notification frequency because notification counts may be positively skewed by a smaller group of highly connected respondents. Missing values, unusual estimates, response-completion times, and response patterns will be evaluated before composite scores are constructed. The internal consistency of each multi-item construct will be assessed using Cronbach's alpha, with values of at least 0.70 generally treated as acceptable. Corrected item-total correlations will be examined to identify items that do not perform consistently with their scale. If the sample and item structure are adequate, exploratory factor analysis may be conducted to determine whether the adapted items correspond to their intended dimensions. Suitability for factor analysis will be assessed using the Kaiser–Meyer–Olkin measure and Bartlett's test of sphericity. Items with weak factor loadings or substantial cross-loadings may be removed when the decision is theoretically justified. Composite scores will then be calculated by averaging the retained items for perceived load, relevance, timing appropriateness, actionability, perceived control, notification fatigue, user tolerance, and management behavior. Respondents will be classified into light-, medium-, and heavy-notification-load groups using tertiles derived from the observed distribution of daily notification frequency. The lower third will represent light-load users, the middle third medium-load users, and the upper third heavy-load users. This data-driven method is preferred because the literature does not provide a universally accepted notification-count threshold applicable to all smartphone populations. The actual numerical boundaries and number of respondents in each group will be reported after data collection. Perceived notification load will be analyzed separately because objective frequency and subjective burden represent related but distinct aspects of notification exposure.

Group differences in notification fatigue, tolerance, and management behavior will be tested using one-way analysis of variance when distributional and variance assumptions are adequately satisfied. Welch's analysis of variance may be used when group variances are unequal, while the Kruskal–Wallis test will provide a nonparametric alternative when parametric assumptions are substantially violated. Significant overall tests will be followed by appropriate pairwise comparisons. Categorical behaviors, such as whether respondents have ever disabled notifications or uninstalled an application because of excessive alerts, will be examined using cross-tabulations and chi-square tests. Effect sizes and confidence intervals will accompany significance tests so that the practical importance of the differences can be evaluated. Pearson or Spearman correlation analysis will initially examine relationships among the principal constructs. Multiple regression analysis will then test whether perceived notification load, relevance, timing appropriateness, actionability, and perceived user control are associated with notification fatigue. Further models will examine whether notification fatigue is associated with user tolerance and management behavior while accounting for relevant participant characteristics, such as age, occupation, daily smartphone use, and number of notification-sending applications. Multicollinearity, residual patterns, influential observations, and other relevant assumptions will be examined before interpretation. A significance level of 0.05 will be used, although interpretation will emphasize effect sizes, confidence intervals, and consistency with the conceptual framework rather than statistical significance alone.

The open-ended responses will be analyzed through thematic content analysis. An initial coding framework will be developed from the literature and will include relevance, usefulness, timing, urgency, clarity, brevity, personalization, actionability, repetitiveness, intrusiveness, promotional intent, and user control. Additional themes will be created when participants identify important characteristics not represented by the initial categories. Where feasible, two researchers will independently code a subset of responses and compare their interpretations to improve consistency. Disagreements will be resolved through discussion and refinement of the coding definitions. The frequencies of recurring themes may be reported, but the analysis will focus primarily on explaining why specific notification characteristics are accepted or rejected. Short anonymized quotations or carefully translated excerpts may be included to illustrate important themes without revealing participants' identities. Quantitative and qualitative evidence will be integrated during interpretation. Statistical results will identify broad relationships and

differences among notification-load groups, while open-ended responses will explain the practical characteristics underlying those patterns. For example, a high notification count may not produce severe fatigue when messages are transactional and relevant, whereas a smaller number of repetitive promotional messages may be experienced as intrusive. Combining the two forms of evidence will allow the study to develop notification-design recommendations that reflect both measurable patterns and users' everyday experiences.

4 | RESULTS AND DISCUSSION

4.1 Expected Results

This study is expected to contribute to the literature by treating push notification fatigue as a distinct user experience rather than merely as an extension of smartphone overuse, social media fatigue, or general technostress. Previous studies have shown that intensive digital connectivity can contribute to interruption, overload, emotional exhaustion, and reduced concentration, but limited attention has been given to how users in Thailand experience notifications across different categories of mobile applications. By examining daily notification frequency together with perceived notification load, relevance, timing appropriateness, actionability, and perceived user control, this study is expected to clarify the relationship between objective notification exposure and subjective notification burden. The comparison of light-, medium-, and heavy-notification-load users is expected to show whether higher exposure corresponds with stronger fatigue, lower tolerance, and more frequent notification management behavior. However, the study does not assume that notification count alone determines fatigue. Users with high notification exposure may report lower fatigue when notifications are relevant, useful, and controllable, whereas users with lower notification frequency may still experience fatigue when messages are repetitive, poorly timed, or promotional. This distinction is important because the same number of notifications may be evaluated differently depending on message value, timing, urgency, and perceived control. The study is also expected to improve understanding of notification tolerance. Rather than defining tolerance as a fixed numerical threshold, the study views it as a context-dependent willingness to accept interruption. Users may tolerate urgent security alerts, payment confirmations, transportation updates, personal messages, or reminders because such notifications offer immediate value. In contrast, tolerance may be lower for repetitive advertising, artificial urgency, generic recommendations, or notifications unrelated to an application's core purpose. The open-ended responses are expected to support the development of a taxonomy of notification characteristics that distinguish useful notifications from annoying or intrusive ones.

4.2 Discussion

The expected contribution of this study lies in its focus on notification fatigue as a notification-specific form of digital strain. The conceptual framework suggests that notification fatigue is not determined by frequency alone, but by the interaction between perceived load, relevance, timing appropriateness, actionability, and perceived user control. This view is consistent with prior research showing that users' responses to notifications depend on content importance, interruption context, and the perceived value of the information. Therefore, the study is expected to provide a more specific explanation of how notification experiences differ from broader forms of smartphone overuse or technostress. From a practical perspective, the study may support mobile application developers, user-experience designers, product managers, and digital marketers in developing more user-centered notification strategies. Notification performance is often assessed through immediate indicators such as delivery rate, opening rate, click-through rate, conversion, or return to the application. Although these indicators are useful, they do not fully capture the long-term effects of repeated interruption. A strategy that increases short-term interaction may also increase annoyance, encourage users to mute notifications, weaken trust, or contribute to application abandonment. Notification success should therefore be evaluated through a balance between engagement and user well-being rather than by delivery frequency alone.

Developers should prioritize relevance by ensuring that notifications correspond with users' interests, previous choices, and current needs. Promotional messages should offer recognizable value and be consistent with the categories to which users have agreed. Transactional, security, and service-related notifications should remain clearly distinguishable from promotional messages so that users can retain essential alerts without accepting unnecessary marketing. Applications should also avoid sending several notifications that communicate substantially the same information within a short period. When reminders are necessary, their frequency should be proportionate to the importance and time sensitivity of the task. Timing, actionability, and user control are also central to responsible notification design. Urgent account-security alerts or immediate transactional problems may justify real-time delivery, whereas recommendations, summaries, and promotional messages can often be delayed, batched, or presented when the user next opens the application. A useful notification should communicate what occurred, why the information matters, and what the user can do next. Vague text, unclear calls to action,

exaggerated urgency, and clickbait wording may increase cognitive burden and reduce trust. Applications should therefore provide understandable controls for notification categories, frequency, sound and vibration, lock-screen visibility, quiet periods, and high-priority alerts. Table 2 presents preliminary design recommendations derived from the conceptual framework and reviewed literature. These recommendations should be revised after the empirical survey results and open-ended responses have been analyzed.

Table 2. Preliminary Recommendations for User-Centered Push Notification Design

Design Aspect	Recommended Practice	Practice to Avoid
Relevance	Deliver content that corresponds with user needs, choices, and application activity	Sending generic or unrelated messages to all users
Frequency	Limit unnecessary repetition and allow users to select delivery frequency	Maximizing notification volume to increase short-term interaction
Timing	Match delivery time to urgency and permit quiet hours or preferred periods	Sending nonurgent notifications during work, study, rest, or sleep
Actionability	Explain what occurred and provide a clear, meaningful next step	Using vague wording, misleading links, or unclear calls to action
Urgency	Reserve immediate interruption for genuinely time-sensitive information	Creating artificial urgency for promotional purposes
Customization	Offer category-, frequency-, time-, and alert-level controls	Providing only an all-or-nothing notification setting
Transparency	Explain why notifications are requested and what users will receive	Requesting permission without describing the intended messages
Privacy	Minimize sensitive lock-screen content and permit visibility controls	Displaying personal, financial, or confidential information by default
Evaluation	Monitor disabling, muting, dissatisfaction, and retention alongside engagement	Relying only on opening, clicking, or conversion rates

These recommendations may also benefit operating-system designers. Android and iOS already provide notification channels, summaries, Focus modes, quiet periods, and application-level permissions, but users may not understand or regularly use these features. Simplified explanations, clearer category labels, and accessible controls could help users manage notification demands without disabling all alerts. Systems could also provide periodic summaries of which applications send the most notifications and allow users to adjust them directly. However, such summaries should support user decisions rather than automatically restrict important communication. For users, the study may increase awareness that notification management does not require choosing between receiving every alert and disabling all notifications. Selective controls can help preserve useful information while reducing unwanted interruption. Users may retain transactional, security, or essential interpersonal alerts while silencing repetitive marketing and low-priority updates. Regularly reviewing notification permissions, disabling unused categories, establishing quiet hours, and selecting exceptions for important contacts may reduce digital burden without requiring complete disconnection.

5 | CONCLUSIONS

Push notifications are valuable communication mechanisms, but their effectiveness depends on whether the information they deliver justifies the attention they require. Frequent, repetitive, irrelevant, or poorly timed notifications may fragment concentration, contribute to digital overload, and encourage users to ignore, mute, disable, or avoid application communication. However, notification frequency alone cannot fully explain fatigue. Users may tolerate a high volume of notifications when the messages are relevant, urgent, actionable, and controllable, while reacting negatively to fewer notifications that are perceived as intrusive or low in value. This proposed study will examine push notification fatigue among approximately 280 mobile application users in Thailand by integrating daily notification frequency, perceived notification load, relevance, timing appropriateness, actionability, perceived user control, user tolerance, and notification management behavior. It will also compare light-, medium-, and heavy-notification-load users and use open-ended responses to identify the characteristics of notifications that users perceive as useful or intrusive. This approach is intended to connect measurable patterns with users' everyday experiences of mobile application notifications.

The expected contribution of the study is both theoretical and practical. Theoretically, it will distinguish notification-specific fatigue from broader concepts such as technostress, social media fatigue, and problematic

smartphone use while connecting it to communication overload and mobile interruption. Practically, the study may inform notification strategies that preserve useful communication without unnecessarily competing for users' attention. Relevance, appropriate timing, clear actionability, proportional urgency, privacy protection, and meaningful user control should form the basis of responsible notification design. However, the final recommendations should be revised according to the actual survey findings and should not be presented as empirically confirmed before data collection and analysis are completed.

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How to cite this article: Srisawat, T., Wongsuwan, S., & Chaiyaporn, S. (2026). Understanding Push Notification Fatigue: User Tolerance and Management Behavior in Mobile Applications. *Journal Mobile Technologies (JMS)*, *4*(2), 106–120. https://doi.org/10.59431/jms.v4i2.992.