Revista Facultad de Ingeniería (Rev. Fac. Ing.) Vol. 34, No. 73.
L-ISSN: 0121-1129, e-ISSN: 2357-5328.

DOI: 10.19053/01211129.v34.n73.2025.19138

EXPLORING THE IMPACT OF A PERSUASIVE APP (PERSUDRINK 50+) TO PROMOTE HYDRATION IN MIDDLE-AGED ADULTS: DESIGN AND PILOT TEST

Explorando el impacto de una aplicación persuasiva (PersuDrink 50+) para promover la hidratación en adultos de mediana edad: diseño y prueba piloto

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Recieved: 30-03-2025
Accepted: 08-08-2025

ABSTRACT

Adequate daily hydration is essential for optimal health, yet one third of adults worldwide fail to meet recommended water intake. The risk is especially pronounced among adults aged 50–65, who record the lowest consumption and are at increased risk of dehydration related complications affecting digestive, respiratory, nervous systems, among others. Although several mobile interventions have been made to promote fluid intake, only a few employ evidence-based persuasive strategies or are tailored to the specific habits and motivations of middle-aged adults. This study introduces PersuDrink 50+, a persuasive mobile application designed for healthy individuals aged 50–65 to improve hydration behaviors. The app integrates goal setting, real time feedback, and personalized reminders grounded in the Persuasive Systems Design framework. A three-day pilot with six participants (mean age = 57 ± 2.73 years) evaluated its impact on knowledge of hydration benefits, attitudes toward drinking water, perceived self-control, intention to increase intake, and actual consumption. Pre- and post-intervention surveys measured these constructs, while the app's built-in tracker logged daily fluid volume. Results demonstrated gains

How to cite: M. A. Huerta-Espinoza; J. C. Valliagomez-Garcia; I. E. Espinoza-Curiel; J. Martínez-Miranda; J. Mercado & J. Mendoza-Tene, "Exploring the Impact of a Persuasive App (PersuDrink 50+) to Promote Hydration in Middle-aged Adults: Design and Pilot Test". *Revista Facultad de Ingeniería*, vol. 34, no. 73, e19138, 2025. https://doi.org/10.19053/01211129.v34.n73.2025.19138

across all outcomes: knowledge scores rose from 1.4 to 3.0, perceived control from 5.75 to 8.10, attitudes from 7.36 to 9.28, and intention from 6.33 to 8.63. Correspondingly, participants increased or decreased their daily water intake to align with the WHO recommendation of ≥2 L/day. While the small sample and short test time do not enable generalizing about it, these preliminary findings suggest that PersuDrink 50+ enhances hydration knowledge and motivation in a short time frame. Future work will involve a larger randomized controlled trial and extended test time and follow up to assess the long-term effectiveness of the system.

Keywords: eHealth; healthy behavior; middle-aged adults; mobile health apps; persuasive apps; water intake.

RESUMEN

Una hidratación diaria adecuada es esencial para una salud óptima; sin embargo, un tercio de los adultos en todo el mundo no alcanza los niveles recomendados de ingesta de agua. El riesgo es especialmente pronunciado en adultos entre 50 y 65 años, quienes registran el consumo más bajo y corren un mayor riesgo de sufrir complicaciones relacionadas con la deshidratación que afectan, entre otros, a los sistemas digestivo, respiratorio y nervioso. Aunque existen varias intervenciones móviles para promover la ingesta de líquidos, pocas emplean estrategias persuasivas basadas en la evidencia o se adaptan a los hábitos y motivaciones específicos de los adultos de mediana edad. Este estudio presenta PersuDrink 50+, una aplicación móvil persuasiva diseñada específicamente para personas sanas entre 50 y 65 años con el fin de mejorar sus hábitos de hidratación. La aplicación integra el establecimiento de objetivos, comentarios en tiempo real y recordatorios personalizados basados en el marco de diseño de sistemas persuasivos. Una prueba piloto de tres días con seis participantes (media de edad = 57 ± 2,73 años) evaluó su impacto en el conocimiento de los beneficios de la hidratación, las actitudes hacia el consumo de agua, el autocontrol percibido, la intención de aumentar la ingesta y el consumo real. Las encuestas previas y posteriores a la intervención midieron estos constructos, mientras que el rastreador integrado en la aplicación registró el volumen diario de líquidos. Los resultados demostraron mejoras en todos los aspectos: las puntuaciones de conocimiento aumentaron de 1,4 a 3,0, el control percibido de 5,75 a 8,10, las actitudes de 7,36 a 9,28 y la intención de 6,33 a 8,63. En consecuencia, los participantes aumentaron o disminuyeron su ingesta diaria de agua para ajustarse a la recomendación de la OMS de ≥2 l/día. Aunque la pequeña muestra y la breve duración de la prueba limitan la generalización, estos resultados preliminares sugieren que PersuDrink 50+ mejora los conocimientos y la motivación en materia de hidratación en un breve periodo de tiempo. En el futuro, se llevará a cabo un ensayo controlado aleatorio más amplio y se prolongará la duración de la prueba con un seguimiento más extenso para evaluar la eficacia a largo plazo del sistema.

Palabras clave: adultos de mediana edad; aplicación móvil de salud; aplicación persuasiva; comportamiento saludable; consumo de agua; *eHealth*.

EXPLORANDO O IMPACTO DE UM APLICATIVO PERSUASIVO (PERSUDRINK 50+) PARA PROMOVER A HIDRATAÇÃO EM ADULTOS DE MEIA-IDADE: DESIGN E TESTE PILOTO

RESUMO

A hidratação diária adequada é essencial para uma saúde ideal; no entanto, um terço dos adultos em todo o mundo não atinge os níveis recomendados de ingestão de água. O risco é particularmente elevado entre adultos de 50 a 65 anos, que apresentam o menor consumo e maior probabilidade de sofrer complicações relacionadas à desidratação que afetam, entre outros, os sistemas digestivo, respiratório e nervoso. Embora existam diversas intervenções móveis para promover a ingestão de líquidos, poucas utilizam estratégias persuasivas baseadas em evidências ou se adaptam aos hábitos e motivações específicos dos adultos de meia-idade. Este estudo apresenta o PersuDrink 50+, um aplicativo móvel persuasivo desenvolvido especificamente para pessoas saudáveis entre 50 e 65 anos, com o objetivo de melhorar seus hábitos de hidratação. O aplicativo integra definição de metas, feedback em tempo real e lembretes personalizados baseados no modelo de design de sistemas persuasivos. Um teste piloto de três dias com seis participantes (idade média = 57 ± 2,73 anos) avaliou o impacto do aplicativo no conhecimento sobre os benefícios da hidratação, nas atitudes em relação ao consumo de água, no autocontrole percebido, na intenção de aumentar a ingestão e no consumo real. Questionários aplicados antes e depois da intervenção mediram esses constructos, enquanto o rastreador integrado no aplicativo registrou o volume diário de líquidos. Os resultados mostraram melhorias em todos os aspectos: as pontuações de conhecimento aumentaram de 1,4 para 3,0; o controle percebido, de 5,75 para 8,10; as atitudes, de 7,36 para 9,28; e a intenção, de 6,33 para 8,63. Consequentemente, os participantes ajustaram seu consumo diário de água para atender à recomendação da OMS de ≥ 2 L/dia. Embora o pequeno tamanho da amostra e a curta duração do teste limitem a generalização, esses resultados preliminares sugerem que o PersuDrink 50+ melhora o conhecimento e a motivação

relacionados à hidratação em um curto período de tempo. Futuramente, será realizado um ensaio clínico randomizado mais amplo, com maior duração e acompanhamento prolongado, para avaliar a eficácia de longo prazo do sistema.

Palavras-chave: adultos de meia-idade; aplicativo móvel de saúde; aplicativo persuasivo; comportamento saudável; consumo de água; *eHealth*.

1. INTRODUCTION

Adequate water intake is essential for proper physical and mental functioning. Insufficient hydration can lead to health issues such as kidney stones, headaches, thermoregulatory problems, and urinary tract infections [1], [2]. The body can experience a water deficit in just a few hours due to reduced intake or increased loss, for example, through sweating. Normally, thirst and beverage consumption during meals help maintain hydration and stable body water levels.

Recommended daily water intake varies by institution. According to the U.S. National Institutes of Health (NIH), adults over 19 should consume 3.7 liters for men, and 2.7 liters for women, including both beverages and water from food [1]. The European Food Safety Authority (EFSA) recommends 2.5 liters for men and 2 liters for women [2]. Physical activity and environmental conditions can affect these needs, but both organizations highlight plain water as the primary source of hydration.

Global studies indicate that up to one-third of people do not meet the recommended intake due to preferences for other beverages [3], limited awareness [4], and cultural or attitudinal factors [5]. It is particularly concerning that adults, especially those aged 50-65, tend to have the lowest water consumption [5], [6]. They are especially at risk because they consume the least amount of water despite increasing hydration needs that are critical for physical and mental health [7], [8].

Institutional strategies, such as public campaigns and educational programs, have been implemented to encourage water consumption. However, their effectiveness is limited by repetitive messaging, lack of personalization, and insufficient motivational appeal; few of them are aimed at middle-aged adults [9]. Given the lifestyle changes common in this age group [10], there is a clear need for accessible, engaging tools that educate, build confidence, and sustain interest in hydration. Persuasive technologies provide an opportunity to enhance knowledge, skills, and user experience through interactive platforms while fostering lasting changes in attitudes and behaviors [11].

Many technologies aim at monitoring and promoting water consumption, including mobile apps, smart bottles, and interactive or gamified systems. Mobile applications allow users to track daily intake and connect to smart devices. Sensor-equipped smart bottles measure consumption, temperature, and water quality, and send reminders via LEDs or alarms. While functional, these products often target the mass market, focusing on tracking rather than on the behaviors behind hydration. As a result, users may abandon them or fail to develop lasting habits. This highlights the need for personalized behavior-change strategies that promote sustainable hydration without constant reliance on technology.

Academic and commercial solutions have explored different approaches. **Smart bottles** like SmartOn [12] and HydrationCheck [13] monitor intake and water quality through sensors, pairing with apps to log data and send reminders. **Mobile apps** such as Splash [14] use NFC-tagged cups and customizable goals, while **gamified apps** like Dropdash [15] create personalized daily hydration challenges through machine learning. Although these systems support water intake, their persuasive mechanisms are often unclear, which hinders long-term impact.

Other **persuasive and gamified technologies** aim at engaging users through interactivity. Playful Bottle [16] combines a game with a mobile app to increase intake, Disruptbottle [17] uses visual cues of urgency and surprise, and Bootsma et al. [18] designed a game for children that rewards correct water placement. While effective for younger users, these approaches often emphasize novelty or commercial appeal over sustainable behavior change; therefore, the need for tailored systems for adults aged 50–65 stands out.

The objective of this study was to design and develop PersuDrink 50+, a persuasive app promoting hydration in middle-aged adults, and to evaluate its impact on knowledge, self-control, attitudes, intentions, and behaviors. Three main research questions guided the investigation:

1. Which persuasive techniques effectively promote adequate water intake in middle-aged adults?
2. How can these techniques be optimally incorporated into a mobile app to improve hydration habits?
3. Can a persuasive app positively influence attitudes, intentions, and behaviors related to water consumption in this demographic?

2. METHODS

The following sections present the app's design, development, and key features, as well as the pilot study evaluating its impact.

2.1. PersuDrink 50+

2.1.1 Foundations

PersuDrink 50+ builds on eDrinking 50+ [19] an app designed to help adults aged 50–65 meet hydration goals through features like water tracking, reminders, logs, and motivational messages. eDrinking 50+ showed high usability and acceptance. PersuDrink 50+ enhances this by adding persuasive techniques to further improve water intake and user experience. PersuDrink 50+ draws on three behavioral theories: Theory of Planned Behavior [20], which links norms, attitudes, and perceived control to behavioral intention; Fogg's Persuasive Technology Theory [21], which states that behavior occurs when motivation, ability, and prompts converge; and Skinner's Operant Conditioning, which emphasizes learning through consequences.

PersuDrink 50+ employs persuasive techniques across three categories—Primary Task Support, Dialogue Support, and System Credibility Support—to foster motivation, guide behavior, and promote hydration. Under Primary Task Support, *Reduction* simplifies self-monitoring through an intuitive registration process and graphical water intake tracking with a history log; *Tunneling* guides users step-by-step toward proper hydration with reminders and insights; *Tailoring* provides recommendations based on physiological needs, lifestyle, and hydration challenges; and *Personalization* adjusts goals and reminders according to routines, weight, and activity level. *Self-monitoring* enables users to track daily progress and review past hydration patterns. Dialogue Support includes *Praise* for achieving goals, *Rewards* such as virtual crowns, *Reminders* to encourage timely intake, *Suggestions* based on real-time tracking, *Liking* through a user-centered, visually appealing design, and *Social Role* via a virtual water drop character offering guidance and reminders. System Credibility Support incorporates *Trustworthiness* with scientifically validated content, *Surface Credibility* through professional UI/UX design, and *Verifiability* by providing access to external sources. These techniques collectively enhance motivation, engagement, and adherence, similar to strategies employed in apps like Headspace [22] and MyFitnessPal [23].

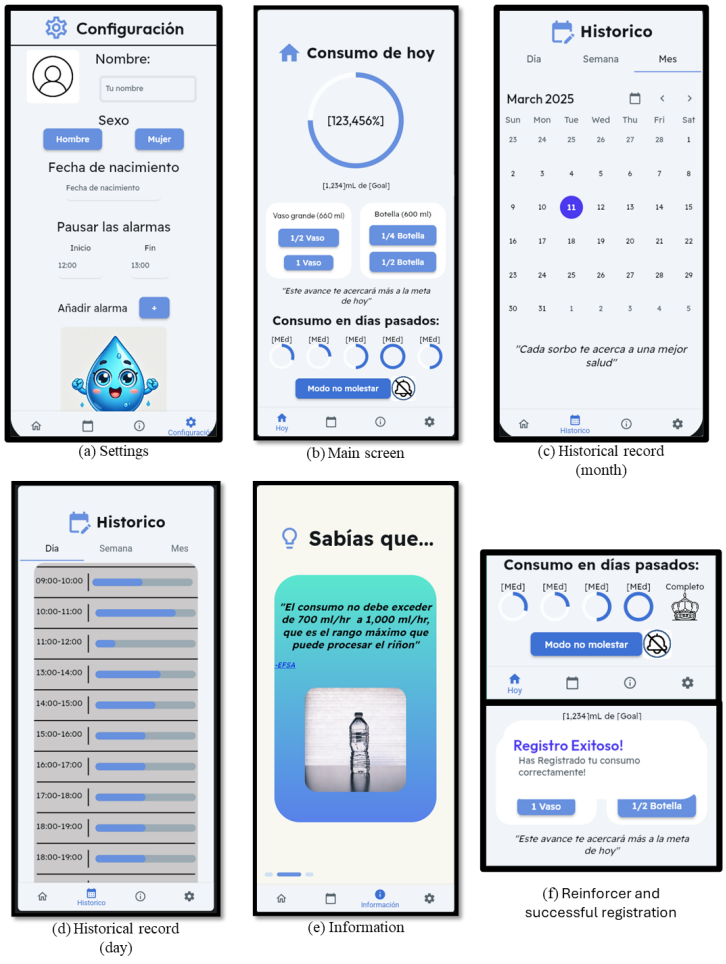
2.1.2 Design and Development Process

The app was developed using Persuasive Systems Design (PSD) and User-Centered Design (UCD), following an iterative four-cycle process informed by expert and user feedback. PSD guided persuasive feature integration in four steps—context analysis, factor assessment, feature design, and experimentation—while UCD ensured alignment with user needs. Based on behavior change theories, initial mockups illustrated core principles across three sections: consumption log, main screen, and information section.

After ethical approval, a medium-fidelity Figma prototype was reviewed by experts (developers, psychologists, nutritionist), and feedback informed refinements. A second prototype was tested with six users (M = 57, SD = 2.73) using Figma Mirror. It showed positive responses to reinforcements, interface trustworthiness, and the logging method, while the in-app character was optional. Final improvements led to a high-fidelity functional prototype in Flutterflow for Android. The next section presents the final design.

2.1.3 Description of PersuDrink 50+

The final version of PersuDrink 50+ consists of four main sections (Figure 1). In *Settings*, users provide demographic data and set personalized hydration reminders. The *Today* section enables water intake logging in various units and shows daily and weekly progress with adjustable notifications. *History* displays intake data by day, week, and month, including detailed daily logs for habit analysis. *Information* presents rotating messages on hydration benefits and risks to support routine formation.



(a) Settings (b) Main screen (c) Historical record (month)

(d) Historical record (day) (e) Information (f) Reinforcer and successful registration

Figure 1. *Screens of PersuDrink 50+ sections.*

2.2. Pilot Test

A pilot study was conducted in Mexico in July 2024 using convenience sampling. Ten adults aged 50–65, without conditions restricting water intake, were recruited via phone. Participation was voluntary and unpaid. After informed consent and a pre-evaluation questionnaire, the app was installed on participants' phones and demonstrated. They explored it independently, with support as needed; researchers avoided hydration advice, referring users to the app's information section. The test lasted three days.

The following variables were measured pre- and post-intervention: hydration knowledge, perceived control, attitude, intention to change, and water intake. Knowledge was assessed through three open-ended questions on intake, distribution, and gender-specific guidelines, classified as correct or incorrect. Perceived control, attitude, and intention were measured using a 15-item questionnaire on a 10-point Likert scale (1 = "Totally disagree," 10 = "Totally agree"), with statements such as "I have adequate knowledge to consume the recommended daily amount of water." Water intake was automatically logged by the app in milliliters. Data were analyzed in Microsoft Excel. For perceived control, attitude, and intention, averages and standard deviations were calculated. Responses about Knowledge were assessed individually for accuracy. Water intake data were graphed and monitored to identify changes over time.

Ethical considerations guided the study and app development. Content relied on credible sources, and participants were informed of objectives, risks, and their right to withdraw at any time without consequences.

3. RESULTS

This section analyzes the results obtained from users' pre- and post-evaluations, highlighting any notable trends, improvements, or observed changes in participants.

3.1. Participant Characteristics

Out of the 10 adults invited, five volunteers (two men and three women), aged 54 to 59 (M = 56.6, SD = 2.06), participated in the final evaluation. None had pre-existing health conditions that could affect their water intake. Four were actively employed, while one was retired.

3.2. Results Overview

User answers were documented for initial and final interviews to facilitate a pre/post comparison. The averages of these results are shown in Table 1. They demonstrate an increase in all evaluated sections. Below, we describe the analysis of each variable.

Table 1. Pre-test and Post-test results of the measured variables.

Variable	Value Range	Pre-test Result	Post-test Result
Knowledge about hydration	0 to 3	1.4 0.49	3 0
Perceived self-control	1 to 10	5.71 2.87	8.10 2.48
Attitude toward behavior	1 to 10	6.33 3.38	8.63 1.09
Intention to change behavior	1 to 10	7.36 3.84	9.28 0.4

3.3. Knowledge About Hydration

As shown in Table 1, the pre-test average was 1.4 (SD = 0.49); the first question recorded the fewest correct answers. In the post-test, all participants achieved the maximum score, with KnQ-2 and KnQ-3 answered correctly, thus confirming the effectiveness of the app's informational component to improve knowledge on hydration.

3.4. Perceived User Self-control

This section showed the greatest improvement, rising from 5.75 to 8.1, though it remained the lowest overall. PCQ-2 increased from 6.4 to 9.2, suggesting benefits from more dynamic infographics. As user #4 noted, "I like it because it provides new information, but I prefer more details and a more dynamic section." PCQ-4, despite improving from 4.4 to 7.2, remained the lowest, thus highlighting challenges in integrating water intake into daily routines and the need for further refinement.

3.5 Attitude Towards Behavior

Attitudes improved from 7.36 to 9.28 in the post-questionnaire, though growth was the lowest among sections and variability remained limited. While AtQ-3 slightly declined (9.2 to 9.0), results indicated that users were still influenced by family or friends promoting other beverages. Nevertheless, AtQ-2 and AtQ-3 showed full correctness in the second questionnaire, underscoring the effectiveness of the informational section in fostering positive hydration attitudes.

3.6. Intention to Change Behavior

Intention scores increased from 6.33 to 8.63, showing the second largest gain after perceived control. Items InQ-4, InQ-5, and InQ-6 improved by an average of 2.6 points. InQ-6 (SD = 1.09) reflects strong commitment to drinking water even during busy periods. As user #4 stated, "I like that it always reminds me because I attend the notifications even when I'm immersed in work." This underscores the role of notifications in sustaining goals. Overall, participants reported greater willingness to monitor intake and maintain hydration, thus indicating that the app's design effectively supports long-term healthy habits.

3.7. Water Consumption During the Test

As shown in Figure 2, users U1, U3, U4, and U5 increased their intake. U5 was closer to the 2000 ml target, while U2 reduced it from 2265 ml to 1980 ml, moving closer to the goal. These patterns highlight the importance of balanced intake rather than simply increasing consumption.

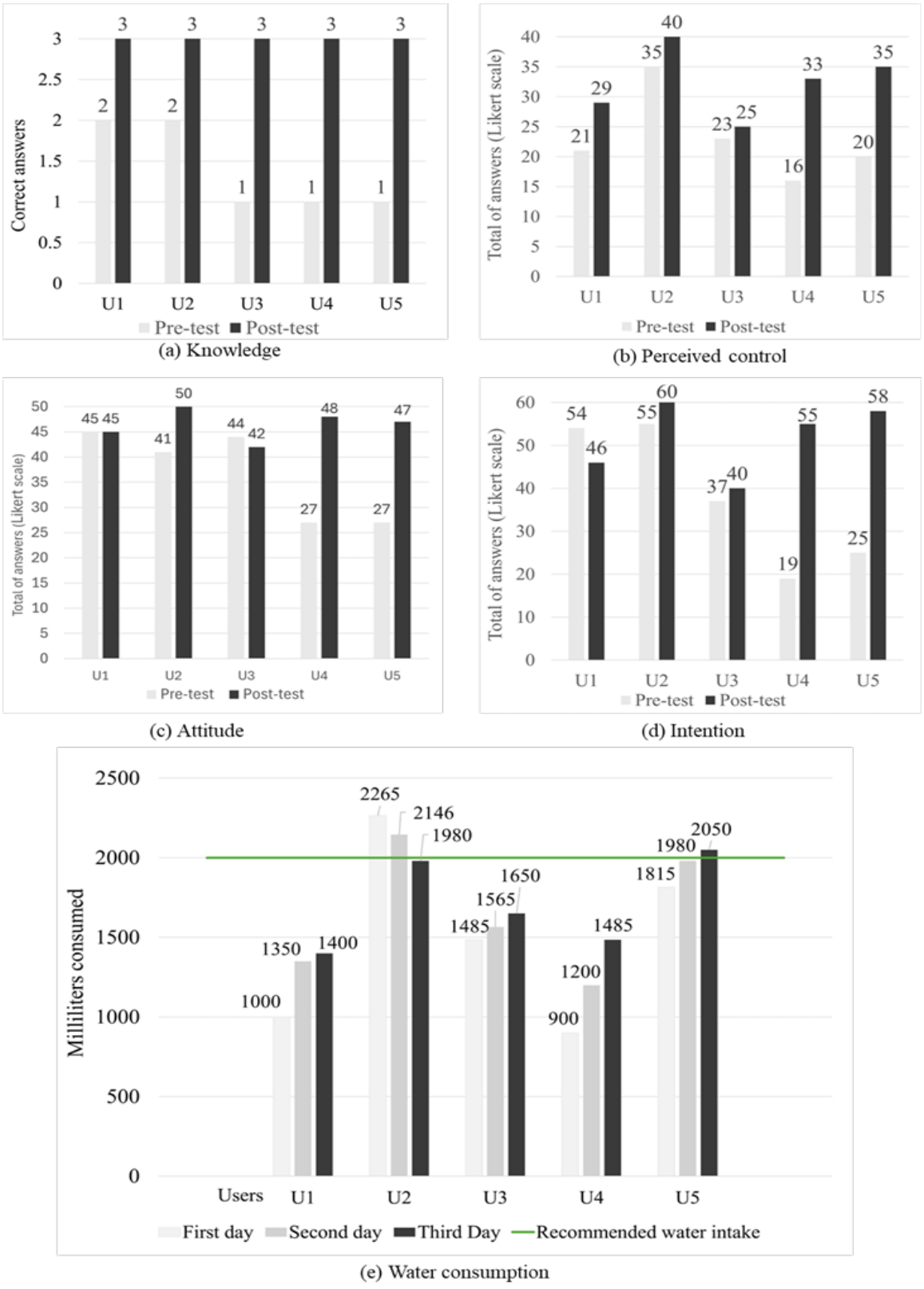


Figure 2. *Questionnaire and water consumption results.*

3.8. Use of the App

In addition to the post-questionnaire, metrics from the integrated OneSignal API tracked user activity, including time spent, access frequency, and notification interaction. On average, users spent 5.87 minutes per day on the app, accessed it 11.7 times daily, and interacted with 16% of notifications during the 3-day test period.

4. DISCUSSION

This section interprets key findings, discusses their significance, compares them to existing research, notes study limitations, and outlines implications for practice and future research.

4.1. Main Findings

Which persuasive techniques can encourage adequate water intake among middle-aged adults?

This study identifies a set of persuasive techniques that can be integrated into an application to encourage water intake. They are categorized into "Primary Task Support," "Dialogue Support," and "System Credibility Support." These techniques form a comprehensive framework designed to drive behavior change in middle-aged adults.

Compared to previous studies, such as Playful Bottle [16] and Disruptbottle [17], our approach focuses on water intake tracking and incorporates persuasive strategies to foster long-term behavior change. For example, techniques like reduction, tunneling, and self-monitoring, which are present in systems like SmartOne [12] are enhanced in our study by offering personalized feedback and tailored hydration goals. This personalized approach has been shown to increase engagement and adherence; then, it sets our study apart from others like HydrationCheck [13], which, while offering reminders and tracking, lacks customization for individual users.

Our "Dialogue Support" category includes techniques like praise, rewards, and social roles; they further distinguish our app. While gamified systems like Dropdash [15] use rewards to encourage hydration, our app introduces a virtual hydration expert who provides personalized, socially engaging feedback. This approach aligns with research suggesting that social influence and personalized guidance are essential for effective behavior change, especially in older adults [24]

Finally, "System Credibility Support" emphasizes trust and verifiability—areas often overlooked in systems like Splash [14] which prioritize convenience over reliability. Our framework ensures that users have access to credible, trustworthy sources, thus reinforcing confidence in the app's recommendations and supporting long-term adherence to hydration goals.

How can these persuasive techniques be optimally integrated into a mobile application to improve hydration habits in this demographic?

Integrating persuasive techniques in PersuDrink 50+ is key to promoting hydration habits in middle-aged adults. The app includes four main sections: *Settings*, *Today*, *History*, and *Information*, each designed to implement strategies that foster long-term behavior change. The *Settings* section allows users to personalize hydration reminders, supporting personalization and enhancing engagement. This contrasts with more

generic systems like HydrationCheck [13]. The *Today* section simplifies hydration tracking, supporting self-monitoring and reduction by allowing users to log daily intake. This detailed feedback helps users manage hydration more effectively than basic tracking apps like Splash [14]. The *History* section encourages tunneling, allowing users to reflect on their hydration patterns and gradually adjust. This approach is more comprehensive than basic tracking, as seen in SmartOne [12]. Finally, the *Information* section provides dynamic, personalized messages that send congratulations and reminders, enhancing ongoing engagement. Unlike static reminders in Dropdash [15], this evolving content helps maintain motivation.

Can a persuasive app positively influence middle-aged adults' attitudes, intentions, and behaviors regarding water consumption?

Results suggest that PersuDrink 50+ effectively improved users' attitudes, intentions, and knowledge; consequently, it has the potential to influence their behavior regarding hydration. Observed increases in perceived control, behavioral intention, and hydration knowledge highlight the impact of persuasive strategies on habit formation. These findings align with previous research on persuasive health technologies, such as SmartOne [12] and HydrationCheck [13], emphasizing the benefits of tracking and reminders but often lacking behavioral reinforcement. A key contribution of this study is the role of digital interventions in enhancing perceived control, a critical factor for long-term behavior change. The app empowered users to regulate hydration by offering personalized tracking and feedback. However, perceived control remained the lowest-scoring category post-intervention. It highlights the need for further refinement to integrate hydration into daily routines better. This challenge mirrors findings from gamified systems like Dropdash [15], where engagement was high, but real-life habit adoption was inconsistent. Social influences also played a role, as some users preferred sugary beverages despite improved hydration attitudes. Research by [24] highlights the importance of social support in sustaining behavior change, thus suggesting that future iterations could incorporate peer engagement features. Regarding water intake, most users increased consumption, with one reaching the 2000 ml target and another adjusting downward to optimal levels. This underscores the importance of not just increasing intake but achieving balanced hydration. Similar to Playful Bottle [16] and Disruptbottle [17], our study reinforces that effective behavior change requires more than simple tracking.

5. CONCLUSIONS

This study presents PersuDrink 50+, a persuasive mobile app designed to improve hydration in adults aged 50–65. Unlike typical hydration apps, it integrates persuasive strategies—Primary Task Support, Dialogue Support, and System Credibility Support—through features such as personalization, self-monitoring, tunneling, and dynamic feedback to encourage behavior change.

A three-day pilot with five participants showed improvements in hydration knowledge, perceived control, attitudes, and behavioral intention, thus supporting findings from prior research on persuasive technology. Personalized reminders, credible information, and self-monitoring played a key role in these positive outcomes.

However, long-term adherence remains challenging. Lower post-test scores in perceived control suggest the need for adaptive goals and stronger engagement mechanisms. Additionally, social influences affected beverage choices, indicating that peer support could further enhance effectiveness. While the small sample size and short duration do not allow us to draw broad conclusions, results highlight the feasibility and potential of mobile persuasive interventions for promoting healthy hydration in middle-aged adults.

6. LIMITATIONS AND FUTURE WORK

This study has several limitations. The small sample (N=5) do not enable generalizing; then, larger, more diverse groups are needed to validate findings. Although perceived control improved most, it remained the lowest, indicating challenges in forming hydration habits. Future research should explore adaptive goals and reinforcements to boost control. Social influences also led some users to prefer sugary drinks, suggesting that peer-based features like social challenges may help. Data relied on self-reports and external logging (OneSignal), limiting accuracy. An internal tracker could improve behavior analysis. The three-day duration also restricts insight into long-term change; extended studies with tracking devices are recommended.

AUTHOR'S CONTRIBUTION

Marcelo Alejandro Huerta-Espinoza: Formal analysis, writing – original draft, writing-review & editing.

Juan Carlos Villagomez-Garcia**:** Writing – original draft, writing-review & editing, Software.

Ismael Edrein Espinosa-Curiel: Writing-review & editing, supervision.

Juan Martínez-Miranda: Writing-review & editing, supervision.

José Mercado: Writing-review & editing, supervision.

José Luis Mendoza-Tene: Visualization, writing-review & editing, software.

ACKNOWLEDGEMENT

This study was funded by a scholarship granted by the Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI) for authors Marcelo Alejandro Huerta-Espinoza, and Juan Carlos Villagomez-Garcia.

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