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ORIGINALS

Digital Intervention to Reduce Risk Practices in Antibiotic Home storage: Pilot Test

Intervención Digital para disminuir prácticas de riesgo en el almacenamiento de antibióticos: prueba piloto

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ABSTRACT:
Introduction: Incorrect and excessive storage of antibiotics is a behavior observed in communities, and it is a main factor that leads to self-medication. In addition to clinical factors, Antimicrobial Resistance has become a main problem worldwide. Digital interventions provide cost-effective solutions to promote healthy behaviors, coupled with the practicality of instant messaging and the use of a behavior change model, allowing to increase the probability of success.
Objective: To determine the effectiveness of a digital intervention to reduce risky practices in home antibiotic storage in an urban community in Mexico.
Material and methods: An intervention study with a quantitative approach, descriptive, longitudinal, and quasi-experimental scope, carried out with 35 families in their homes through the instant messaging type "WhatsApp". The RiALMeH instrument was applied to later follow an intervention with materials and activities from home and apply it again to check changes.
Results: Before the intervention, the average was 19.8 points, participation was 100% in at least one of the activities and only 7 families did not carry out the final activity. After the intervention, the average score obtained in RiALMeH was 16.1, obtaining a significant result in the change, after 7 weeks of study.

Conclusion: The digital intervention was significant in achieving a change in family behavior, observations are made to the materials according to the doubts expressed.

Keywords: Drug Storage; E-Health; Antimicrobial Resistance.

RESUMEN:
Introducción: El almacenamiento incorrecto y excesivo de antibióticos es una conducta observada en las comunidades y es uno de los principales factores que conllevan a la automedicación. Esto anterior, sumado a los factores hospitalarios, convierte a la Resistencia Antimicrobiana en uno de los principales problemas a nivel mundial. Las intervenciones digitales, proveen soluciones costo-efectivas para promover de conductas saludables, aunado con la practicidad de la mensajería instantánea y la utilización de un modelo de cambio de conducta, permite aumentar las probabilidades de éxito.
Objetivo: Determinar la eficacia una intervención digital para disminuir las prácticas de riesgo en el almacenamiento de antibióticos en el hogar en una comunidad urbana de México.
Material y métodos: Estudio de intervención con enfoque cuantitativo, de alcance descriptivo, longitudinal y cuasiexperimental (medición pre-post), llevado a cabo con 35 familias en sus hogares a través de mensajería instantánea tipo "WhatsApp", se aplicó el instrumento RiALMeH para posteriormente seguir una intervención con materiales y actividades desde casa y, aplicarlo nuevamente para comprobar cambios.
Resultados: Previo a la intervención el promedio fue de 19.8 pts, la participación fue del 100% en al menos una de las actividades y solamente 7 familias no realizaron la actividad final. Posterior a la intervención el promedio del puntaje obtenido en el RiALMeH fue de 16.1, obteniendo un resultado significativo en el cambio, posterior a las 7 semanas de estudio.
Conclusión: La intervención digital fue significativa para el cambio de conducta familiar, se realizan observaciones a los materiales de acuerdo con las dudas expresadas.

Palabras clave: Almacenaje de Medicamentos; Salud Digital; Farmacorresistencia.

INTRODUCTION

Digital interventions in the health science fields have revolutionized the way professionals address complex problems and promote healthy behaviors in communities. These strategies allow people for broader and personalized access to information and encourage responsible practices in diverse health contexts [(1)]. This enables work to promote healthy behavior and optimize the management of medical resources. Consequently, digital interventions in nursing have emerged as an innovative tool to address behavioral phenomena in the home [(2)].

Furthermore, these strategies, which permit several problems be addressed from home, facilitate significant changes in health behaviors from their own spaces. The effectiveness of digital interventions is improved by using behavior change models, defined as theories or conceptual frameworks designed to understand, predict, and facilitate change in specific behaviors [(2, 3)].

One of these models, the COM-B (Capability, Opportunity, Motivation, and Behavior) model, focuses on human behavior and suggests that behavior (B) is the result of the interaction between capability (C), opportunity (O), and motivation (M). This model provides a robust theoretical framework for designing effective interventions, as it allows for the identification of the factors that influence the behaviors of the individuals targeted [(4)]. In this regard, the COM-B model emerges as a valuable theoretical and practical tool for understanding and addressing the factors that influence medication management. This integrative approach has proven effective in interventions that seek to modify health-related behaviors [(2, 5)].

On the other hand, antimicrobial resistance (AMR) is one of the most significant threats to global public health in the 21st century [6]. This phenomenon occurs when microorganisms, such as bacteria, viruses, fungi, and parasites, develop the ability to resist the effects of medications designed to eliminate them or inhibit their growth. As a result, previously treatable (individual) infections become more difficult to manage, leading to higher rates of morbidity, mortality, and healthcare costs [6].

Among the factors that can increase AMR is home self-medication. Improper storage of antimicrobials at home can be considered a determining risk factor for developing self-medication. This behavior is characterized by the exposure of drugs to inadequate temperature, humidity, and light exposure, altering their stability or efficacy. Additionally, the storage of leftover or expired medications increases the risk of misuse, such as self-prescribing for the treatment of infections without the supervision of a healthcare professional [7, 8].

In this regard, a 2022 study on antibiotic storage characteristics in a suburban population in Yucatán, Mexico, identified improvement areas in the use of home containers, the room where they are stored, and the disposal process of antibiotics at home. Therefore, behavioral change interventions become sources for improving proper management [7]. In addition, the safer disposal of medications is an essential component of family health management. The proper management of unused or expired medications is essential to prevent environmental contamination and minimize the risk of poisoning or accidental consumption. [9, 10]. For family practices in the community, this skill involves separating antibiotics and other medications that are in poor condition or expired and taking them to an appropriate collection center for final disposal or destruction [11].

Despite their potential protective effect, interventions aimed at optimizing these practices in homes, particularly in Mexican communities, are lacking. This contrasts with the growing evidence that homes act as critical points in the antibiotic use chain, where prolonged storage, unregulated consumption, and improper disposal can contribute to increased AMR through informal and excessive access, inadequate storage in areas of the home with high temperatures or humidity, and inappropriate disposal [7, 11].

So, it is essential to develop new strategies that involve families and promote sustainable behavioral changes. Evidence suggests that digital interventions can improve adherence to healthy behaviors and facilitate better self-care management in homes [12, 13]. These strategies aim not only to reduce the risks associated with improper antibiotic home storage, but also indirectly to improve families' relationships with medicines, reduce self-medication practices without a prescription or in conditions that compromise their effectiveness [6, 14]. Based on the text above, this article aims to determine the effectiveness of a digital intervention to reduce risky practices in the storage of antibiotics at home in an urban community in Mexico.

MATERIAL AND METHODS

This is a quantitative approach study, descriptive scope, longitudinal, and with a quasi-experimental design, which used a combination of quantitative and qualitative techniques to pilot test a digital intervention. The study was conducted during two periods, from March to April and from November to December 2024, the first with seventeen families and the second with eighteen. The study unit were families, defined

as people living in the same household (rather than individuals), each household being a unit. These were obtained through non-probability sampling with convenience selection, with snowball recruitment from an urban area of Yucatan, Mexico. The inclusion criteria for participation in the research were stored antibiotics in the last year, having a cell phone with access to Wi-Fi, and having instant messaging applications (WhatsApp). On the other hand, those households where only one person lived (single-person families) or those who did not wish to participate or sign the informed consent were excluded; Finally, families who wished to withdraw at any point in the study were eliminated. Following the recruitment, selection, and elimination process, thirty-five families remained.

MEANS USED FOR ASSESSMENT AND EVALUATION

Two tools were used for the assessment: a semi-structured interview and the Risk in Antibiotic Storage at Home (RiALMeH) instrument.

The first part of the assessment was conducted qualitatively (through semi-structured interviews) with the person responsible for managing medications in the homes. Knowledge, attitudes, practices, motivations, and key moments surrounding antibiotic storage behaviors were investigated. Some of the triggering questions were: How do you store antibiotics at home? What precautions or recommendations should one take when storing antibiotics? What is the best way to dispose of antibiotics when I'm no longer taking them? This guide of questions was previously validated by experts external to the researchers, in social pharmacology, pharmacy research, and primary care physicians. The researchers recorded the interviews for later accurate transcription and interpretation of the findings. Field diaries were used to triangulate the information obtained.

Subsequently, the RiALMeH instrument was applied, which was designed and validated by Aké Didier, Cohuo Sheila, and Balam Maricela [15]. This tool was validated in 2022, obtaining Cronbach's alpha value of 0.77 for the validation of statistical reliability and a value of 0.547 for the KMO test, of construct consistency, both acceptable. It has a total of ten items divided into four components: family characteristics, container, home storage, and final disposition. It can be categorized into Low Risk (10-19 pts.), Medium (20-28 pts.), and High (29-38 pts.). After reviewing the normality of the data, the Wilcoxon signed-rank test was used to establish the differences.

PARTICIPANT RECRUITMENT PROCESS

The researchers extended invitations and presented the intervention process to the primary caregivers via instant messaging, including the topics, the tasks to be performed, and the evaluation process. If the participants agreed, they signed the informed consent form, followed by an interview and the instrument application. Thirty-seven families were invited, of which 35 accepted. The RiALMeH instrument was applied, a sociodemographic data form, and semi-structured interviews.

INTERVENTION CHARACTERISTICS

The intervention phase lasted seven weeks for each family and was based on the COM-B model, which included audiovisual educational materials, home activities, process

evaluation questions, and motivational messages. Each component of the model was addressed. The educational materials were sent in video and audio formats, followed by an infographic that summarized the information contained in the video, and then instructions on how to carry out the activities. The process evaluation questions were the final activity of the week. Table 1 shows a summary of the activities and the educational content of the intervention, as well as the component of the model they address. It is important to highlight that, although the educational materials were sent for three weeks, activities related to reinforcing the habit were carried out during the seven weeks.

Table 1. Summary of digital intervention planning

Stage	Educational Content	Tasks	COM-B Model Component
Week 1	Does not apply	• Presentation. • Interview. • RiALMeH application.	Does not apply
Week 2	• Ideal features for my home medicine cabinet. • Protection of antibiotics and other medications from light, heat, and moisture. • Places in the home to store antibiotics and other medications.	• Send a photo of the first-aid kit and where antibiotics are stored at home. • Answer two questions from the educational material at least two days after sending it. • Motivational message.	Capability Motivation
Week 3	• Risks of excess medications and antibiotics at home. • Risk of having expired or spoiled medications and antibiotics.	• Review and classify the medicine cabinet according to its condition (in good/poor condition) and usefulness (useful now/not useful now). • Answer two questions from the teaching materials at least two days after delivery. • Motivational message.	Capability Motivation Opportunity
Week 4	• Safe disposal of antibiotics and other medications. • Authorized collection centers. • Risk of sharing medications with family and friends.	• Location of the nearest collection center. • Express commitment to take unusable or damaged medications to the collection center. • Answer two questions from the educational material at least two days after delivery. • Motivational message.	Capability Motivation Opportunity
Week 5	Does not apply	• Share the knowledge with my family. • Share the evidence in the audio form from recordings, photographs, and/or video.	Motivation Opportunity
Week 6	**Intervention free week**		

Stage	Educational Content	Tasks	COM-B Model Component
Week 7	Does not apply	• Interview on changes in storage practices and satisfaction with the intervention. • Reapplication of the RiALMeH instrument.	Does not apply

Source: Prepared by the authors.

POST-INTERVENTION EVALUATION

During the intervention last week, the homes were visited again, and interviews were conducted to determine changes in their knowledge, practices, and attitudes regarding the home storage of antibiotics and other medications. The aspects of satisfaction and the effectiveness of the intervention were also addressed, including time, materials used, communication channels, feasibility of the tasks, etc. Finally, the RiALMeH instrument was applied to determine whether the risk of storage wrong practices decreased.

ETHICAL AND BIOSAFETY CONSIDERATIONS

It is important to stablish that this research was conducted under the guidelines of the General Health Law on Health Research in Mexico. In Article 17, it classifies this intervention as minimal risk, as it addresses prospective studies that employ data management through procedures common to routine physical or psychological examinations for diagnosis or treatment, applicable to digital interventions, where contact with people was minimized [16]. Furthermore, it is recognized that the principles of autonomy, justice, beneficence, and non-maleficence were respected, as the benefits outweighed the anticipated risks. It is important to highlight that this work was evaluated by the Ethics Committee of the educational institution with approved number 03/22. Finally, it is established that all participants obtained their respective written informed consent.

RESULTS

In total, 35 families were worked with, and it was found that each family consisted of an average of six members. The index/key person generally refers to the family member with whom primary communication was established during the intervention and who managed the medications at home. It is reported that all 35 families completed the WhatsApp intervention within the established seven weeks. Regarding the interviews conducted before administering the instrument, it was revealed that families had a partial understanding of the topic, mainly focused on knowledge of expiration dates and the identification of spoiled medications. Generally, families knew that medications should be stored in dry areas; however, many were unaware of the importance of keeping them at a controlled temperature, which is crucial to preserving their effectiveness.

PRE-INTERVENTION ASSESSMENT

Family Characteristics. The sample consisted of 35 families. In 80% of cases (n=28), the primary caregiver responsible for medication management was a mother or wife. Family composition varied widely in terms of age: 94.2% of families (n=33) included adults, while 34.2% (n=12) included older adults. The sample also included children as young as 5 years and adolescents as young as 12 years. Regarding scholar attainment, 28.5% of families (n=10) had a basic education, 25.7% (n=9) had completed high school, and 65.7% (n=23) had a college education. Several families had an extended structure, including daughters-in-law and granddaughters-in-law, with a predominance of women in the household.

In terms of health coverage, 77.1% of families (n=27) had some form of social security, which provided access to medical services and medications; however, not all families were able to utilize these benefits optimally. The most reported conditions were systemic arterial hypertension (SAH) in 42.8% of families (n=15), type 2 diabetes mellitus in 28.5% (n=10), and type 1 diabetes mellitus in 5.7% (n=2). Isolated cases of other conditions were also reported, including allergies, attention-deficit/hyperactivity disorder (ADHD), kidney failure, hyperthyroidism, Cushing's syndrome, and senile dementia.

Medication Container and Home Storage Conditions. An assessment of home storage conditions revealed that medications were frequently stored in inappropriate locations using non-airtight containers. Specifically, 31.5% of families (n=11) used drawers, 28.5% (n=10) used plastic boxes, 17.2% (n=6) used cardboard boxes, and 8.5% (n=3) used plastic or shopping bags. Regarding storage locations within the home, 31.4% of families (n=11) stored medications in the kitchen, 25.7% (n=9) in the dining room, and 22.8% (n=8) in the living room. These practices indicate significant variability and a general lack of knowledge regarding proper home storage medication.

Medication Disposal. Regarding the final disposal of medications, 37.1% of families (n=13) reported regularly checking expiration dates. However, most were unaware of the correct disposal methods. Twenty percent (n=7) disposed of medications by flushing them down the toilet, and 22.8% (n=8) reported giving unused medications away. At the start of the intervention, 54.2% of families (n=19) were categorized as having a "medium risk" level for home medication storage, while 45.7% (n=16) were at "low risk." The mean score on the RiALMeH instrument was 19.8 points, which corresponds to the "medium risk" category.

DIGITAL EDUCATIONAL CONTENT

During the interventions, the videos were on weekly basis, scheduled between Mondays and Tuesdays. They had a maximum duration of 4 minutes and included images, icons, photographs, essential information on the topic, and audio narration of the text. After the videos were sent, several questions arose among participants (Table 2), especially regarding medication identification and classification, quality storage criteria, the effects and risks of expired medications at home, medication disposal, the implementation of new habits, among others.

Table 2. Inquiries discussed during the intervention.

Subject	Depiction	Example question
• Medication Identification.	Most families reported not knowing how to check or identify the expiration date and general condition of medications, expressing confusion when trying to understand the labels.	How do I know when an antibiotic is no longer good, even if it hasn't expired?
• Medication Storage.	Families expressed uncertainty about the ideal conditions (temperature, humidity, etc.) for storing their medications, questioning whether they should be in the kitchen, the bathroom, or somewhere else.	Where is the best place to store medications?
• Medication Classification.	Doubts about classification strategies arose frequently, such as whether to organize by medication type, expiration date, or use frequency.	What is the best way to organize my medications?
• Effects and Risks of Expired Medications at Home.	Some families were not fully informed about the dangers associated with taking expired medications and expressed concerns about the potential health consequences.	What can happen to me if I accidentally take expired medication?
• Medication Disposal.	There was confusion about whether it was safe to dispose of expired medications in the common trash or if they should be taken to collection centers, leading many families to express uncertainty about the proper process. Several families asked if it really matters.	What should I do with expired antibiotics if I can't take them to a collection center?
• Implementation of New Habits.	There was concern about the sustainability of these practices learned during the intervention and how to integrate these new habits into their daily lives.	What could happen if my medications piled up again?
• Family Participation.	Families were unsure about the best ways to communicate and educate other members about proper medication, care and storage.	How can I motivate my family to follow these practices?

Source: Prepared by the authors.

It's worth noting that all questions were resolved immediately after they were raised via WhatsApp and subsequently compiled to improve the teaching materials used.

TASKS CARRIED OUT

Various activities were carried out, such as organizing medications at home, ensuring proper disposal at authorized points, and answering questions about the materials sent that week. Regarding the motivational messages, all were received with thanks, reactions to the message, and enthusiastic responses. The percentage distribution of correct and incorrect responses sent per week can be seen in Table 3.

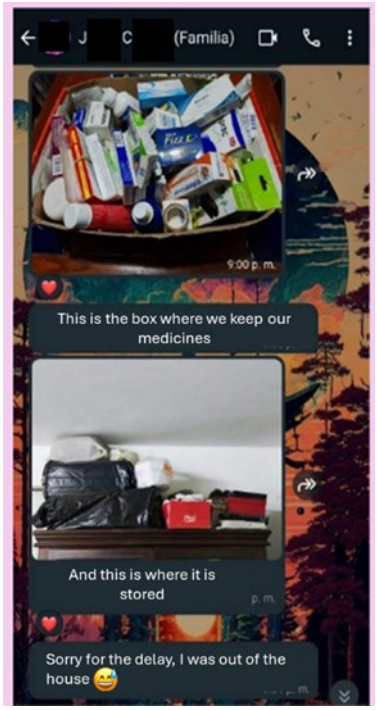
Table 3. Description of responses in the feedback.

Educational Content	Correct answers percentage	Incorrect answers percentage	Example question
• Ideal features for my home medicine cabinet. • Protecting antibiotics and other medications from light, heat, and moisture. • Places in the home to store antibiotics and other medications.	91.4% (32)	8.5% (3)	What is NOT a recommended place to store your medicine kit? 1) The bedroom where you sleep 2) In the living room 3) In the kitchen or bathroom*
• Risks of excess medications and antibiotics at home. • Risk of having expired or spoiled medications and antibiotics.	74.2% (26)	25.7% (9)	What is one of the risks of excess medication in the home? 1) It increases the risk of accidental ingestion 2) It can promote self-medication 3) All of these are correct*
• Safe disposal of antibiotics and other medications. • Authorized collection centers. • Risk of sharing medications with family and friends.	94.2% (33)	5.7% (2)	What are examples of medications to be discarded? 1) Medications I was prescribed and am currently taking 2) Medications for common problems we have at home 3) Expired and spoiled medications*

Note: * Correct answer**. Source:** Prepared by the authors.

Review and Classification of Medicine Cabinets. An audit of the medicine cabinets revealed several suboptimal storage practices. In terms of organization, 71.4% of families (n=25) used non-recommended containers, such as cardboard boxes or plastic containers without lids, the latter leaving medications exposed to sunlight. Furthermore, cabinets were often overcrowded, with a large quantity of medications stored in a very small space alongside expired medications and other medical supplies. Many families also demonstrated inappropriate storage locations, such as the kitchen or bathroom. Finally, 14.2% of families (n=5) lacked a designated storage area for their medications. Figure 1 illustrates the related messaging conversation for this activity.

Figure 1. Example of chat conversation to medication review (medication kit and home area storage).



Commitment to Dispose the Unusable or Damaged Medications at a Collection Center. Following the interventions, 28 families committed to disposing of their medications at a designated collection center. Of these, 35.7% (n=10) successfully disposed of expired medications at a center prior to the conclusion of the intervention. This demonstrates a positive behavioral shift towards the safe disposal of antibiotics and other medications. Conversely, seven families reported being unable to do so due to a lack of time or means.

Sharing Information with Family. The post-intervention data indicates that 80% of families (n=28) who actively participated began sharing information on proper medication management with other family members or friends, suggesting a multiplier effect of the intervention. This behavior was corroborated by evidence (photos, videos, or audio recordings) submitted by the families to the researcher's chat conversation. The remaining 20% (n=7) did not provide evidence of having shared the information.

POST-INTERVENTION EVALUATION

The family intervention aimed to mitigate risky practices in the storage of antibiotics and other medications. Knowledge of appropriate storage locations improved significantly: while 45.7% of families (n=16) felt confident about storing their antibiotics correctly at baseline, this proportion increased to 91.4% (n=32) in the post-intervention evaluation.

Data from the RiALMeH instrument revealed substantial improvements in home medication storage and disposal practices. Regarding containers, 80% of families (n=28) adopted the use of lidded plastic medicine cabinets, replacing inappropriate storage solutions; the remaining families expressed a commitment to making this change. All families (100%) reported storing their medications in a bedroom or a more suitable location. Furthermore, 71.4% (n=25) committed to regularly checking

medication expiration dates. Concerning the disposal of unused medications, 94.2% (n=33) acknowledged that they should not share them but should instead take them to an authorized collection center.

A comparison of pre- and post-intervention RiALMeH scores confirmed the intervention's effectiveness. The mean post-intervention score was 16.1 points, indicating a shift to the "low risk" category. The Shapiro-Wilk test was used to assess the normality of the score distributions ($W = 0.201$, $p < 0.001$), which determined the data were not normally distributed. Consequently, the Wilcoxon signed-rank test was employed. The test results ($W = 59$, $p < 0.001$) demonstrated a statistically significant reduction in risk scores, with a median difference of 4 points between the pre- and post-intervention assessments.

DISCUSSION

This study aspired to improve practices regarding how antibiotics and other medications are stored in families' homes through a digital intervention. This intervention presented various strengths and areas of opportunity. However, it is important to highlight the need for further studies focused on behaviors, not just characterization or knowledge, to improve and empower families based on their own contexts and resources.

Behaviors related to the storage of antibiotics and other medications in the present study were assessed using the recently developed RiALMeH instrument, yielding a medium risk classification with an average score of 19.8. This score reflected that most families had basic or upper secondary formal education, used inadequate containers or medicine cabinets, stored medications in areas of the home exposed to humidity and/or heat, and disposed of them incorrectly. These results are consistent with the findings reported by a group of researchers who, after evaluating 350 homes in Libya, identified that medication management at home was predominantly the responsibility of women with secondary education (81%), who stored medications primarily in the kitchen (49%), and mostly disposed of them in the common trash (91.1%). These findings reinforce the need for globally standardized recommendations for proper medication management at home [17].

Digital interventions offer various benefits, considering the cost-effectiveness, scope, and coverage versus traditional educational interventions. Through this intervention, a high level of family participation was observed in the implemented activities related to the review and classification of medicine cabinets, as well as a commitment to the correct disposal of medications. This coincides with the results of a systematic review establishing that digital interventions tend to be more effective in changing behavior when activities such as modifying the home environment, social connection with the family, text messages and motivational calls, are added [18]. Similarly, the benefits of using instant messaging, WhatsApp in this study are noted, since it is an application widely used by people in urban areas of all ages, allowing immediate direct interaction not only in the form of text, but also in digital audiovisual content [19].

It is important to highlight that this study obtained a high efficacy result in the intervention, having a significance of less than 0.01 with a median difference of four points, which may indicate a high probability of success if carried out in larger populations. These results coincide with those presented in a digital intervention in

homes of 33 couples with the objective of reducing weekly drinking habits in England. At the end of their 6-month intervention, significant results were obtained in the reduction of alcohol consumption (β = -17.4, 95% CI -36.1 to 1.4; P = .007; Hedges g = -0.53). Among the common factors, the commitment of the participants stands out, as well as the use of a behavioral model in the intervention [21].

Among the limitations, it is established that the lack of a control group prevents more robust statistical inferences. This, coupled with the lack of a normal distribution, could create opportunities for increasing the sample size. Another significant operational limitation is that participants must have access to a mobile device with internet access and the WhatsApp application installed at home, as well as a basic understanding of its features.

CONCLUSSION

This pilot test of a digital intervention to reduce risky behaviors in the storage of antibiotics and other medications is highly effective, achieving a decrease in the instrument score and implementing household tasks. It can be implemented in a greater number of homes by improving knowledge, maintaining motivation (in the intervention's interaction with improving behavior), increasing awareness about medications in the home, improving the quality of the medicine cabinet and moving the location or room where medications are stored to a safer location, as well as informing people about where and how to properly dispose of unused antibiotics. Questions expressed by participants are added to the communication materials to increase their effectiveness and potential for automation. It is important to include digital tools within the nurse's tools to empower people from their homes, promoting their self-care.

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