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PAPER

Sedentary: A Healthy Lifestyle App for Home Office Workers

David Mauricio[1], César Marcelo Flores-Cortegana[1], Anthony Jaimar Shuan-Arias[1], Pedro Castañeda[1](✉), Leonardo Rojas-Mezarina[2], José Luis Castillo-Sequera[3]

[1]Universidad Peruana de Ciencias Aplicadas, Lima, Perú

[2]Universidad Nacional Mayor de San Marcos (UNMSM), Lima, Perú

[3]Universidad de Alcalá, Madrid, España

pcsipcas@upc.edu.pe

ABSTRACT

Although home office employment has been happening for several decades, the COVID-19 pandemic has led to an unprecedented surge in telework. Concurrently, the prevalence of sedentary individuals has gradually increased, posing health challenges. In this study, we introduce a mobile app designed to promote healthy lifestyles (HLs) among home office workers (HOWs). Central to this app is an IBM Watson Assistant-powered Chatbot, offering remote workers a near-natural interface to enhance their well-being. Users can establish lifestyle improvement goals, receive activity reminders, earn rewards upon achieving goals, and employ their smartphone's pedometer to measure their physical activity (PA) levels. Additionally, the app includes questionnaires to gauge the user's knowledge on sedentarism and HL. The app's efficacy was assessed via a two-week trial involving 20 participants. The results showed that HL knowledge was improved in 46% of the users. Usability surveys yielded high ratings in terms of usefulness, user-friendliness, and recommendations.

KEYWORDS

home office, sedentarism, healthy lifestyle (HL), chatbot, awareness

1 INTRODUCTION

The prevalence of home office work, characterized by individuals working remotely from their homes and not necessitating physical presence at their company's facilities [1], has grown exponentially in recent years, notably expedited by the COVID-19 pandemic and its associated global health restrictions [2]. Predominantly, home office workers (HOWs) in specific fields, including education, finance, and insurance, have been compelled to transition to this work arrangement [3]. Home office working has several advantages; it contributes to personal–professional life balance, increases work flexibility and freedom, reduces commuting time and expenses, and enhances productivity and job satisfaction, among other benefits [4]. However, it has also led to marked changes in individuals' lifestyles [5, 6].

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Lifestyle, as defined by the World Health Organization (WHO), encompasses identifiable behavior patterns based on the interplay of individual characteristics, social interactions, and socioeconomic and environmental conditions [7]. The concept of lifestyle is of particular importance as it begins to take shape during adolescence and remains integral to families [8]. Diseases closely associated with lifestyle share common risk factors, namely prolonged exposure to the three modifiable behaviors of smoking, unhealthy eating, and insufficient physical activity (PA). This exposure increases the risk of chronic diseases, including heart disease, diabetes, cancer [9], and even accelerated aging [10]. Regarding HOWs, lifestyle depends on daily activities and remote work practices, often including increased consumption of high-carbohydrate and high-fat foods, potentially leading to dependency due to brain-related satisfaction and pleasure responses to these foods. Consequently, HOWs' health may deteriorate [11]. Additionally, when faced with anxiety or stress, 65% of individuals admitted to eating unhealthy foods, with 62% admitting eating hastily [12]. Such eating habits have adverse short- and long-term effects on health. Furthermore, sedentarism and a lack of PA contribute to musculoskeletal deterioration and increase the risk of future health issues, such as arthritis, arthrosis, osteoporosis, cardiovascular diseases, and obesity [13].

Healthy living pertains to daily practices that promote health and reduce functional limitations [14]. The pillars of HL encompass healthy eating (HE), regular PA, and abstaining from alcohol consumption and smoking [15]. HE is vital as it provides the essential nutrients and energy required for maintaining health [16]. PA plays a crucial role in preventing various health complications, enhancing strength and energy, reducing stress, and assisting in maintaining a healthy body weight while controlling appetite [17]. Engaging in PA can extend men's and women's lives by up to six and seven years, respectively [18], thus substantially decreasing the risk of cardiovascular diseases by 20%–35% [19].

The purpose of raising awareness about HL is to sensitize individuals to their behaviors and habits, encouraging them to make choices that enhance their quality of life and improve their health via healthy eating and physical activity (HEPA) [20]. However, the pandemic has led to a substantial increase in home-based work, which has been accompanied by low HL awareness reflected in low levels of PA among individuals. A business study involving 30 million active participants showed a 16% decline in steps taken in North America and a 38% decrease in Europe in 2020 [21]. Furthermore, the prevalence of musculoskeletal and ergonomic conditions has increased with remote work, with 86% of HOWs experiencing ergonomic concerns associated with their work equipment [22]. The WHO has stated that failing to reach minimum PA goals reduces life expectancy by 3–5 years and increases the risk of cancer, heart diseases, stroke, and diabetes by up to 30%" [7].

Numerous apps have been developed to raise HL awareness [23, 24], aiming to address health issues arising from a sedentary lifestyle. [25–30] introduced apps aiming to reduce sedentary behavior via self-control, feedback, and recommendations for interrupting prolonged sitting. [31–34] provided virtual voice assistants to offer recommendations, monitor PA, and motivate participants. Additionally, [35–37] provided guidance on PA and follow-up and included dietary advice based on HE standards. Despite the availability of these diverse functions across various apps, there is a notable absence of software that integrates all of these features. Such integration is crucial as it allows participant assessment and facilitates the delivery of recommendations and follow-up, ultimately improving the quality of life.

In this study, we propose a mobile app designed to raise awareness about HL and combat sedentarism. The app features a chatbot, delivers health-promoting information, uses the smartphone's pedometer, and includes a questionnaire to assess participants' knowledge regarding PA and HE. The main contributions of this study are as follows: a) Providing a technological model for raising HL awareness among HOWs, b) Introducing a mobile app to promote HL awareness, and c) Summarizing 13 mobile apps designed to raise HL awareness.

Six sections are included in this manuscript. Section 2 includes a literary review on apps targeting HL awareness, Section 3 presents an information technology (IT) model for raising HL awareness, Section 4 outlines the implementation of this model, Section 5 covers system validation and results. Finally, Sections 6 and 7 provide discussions and conclusions respectively.

2 MOBILE APPS FOR RAISING HL AWARENESS

A mobile app designed to raise awareness on HL can play a pivotal role in providing individuals with information, resources, and support to adopt and maintain daily healthy habits, thereby preventing chronic diseases associated with lifestyle [38]. Such apps typically consist of distinct modules, including a virtual assistant (Chatbot), assessment tools, and monitoring features.

In this context, a chatbot leverages artificial intelligence and natural language processing to emulate human conversations and understand participants' questions [39], particularly in the domains of HL [40], HE [41], and personalized exercise routines tailored to individuals' specific requirements [42]. Assessments entail the use of questionnaires to assess levels of HEPA. These questionnaires include the global PA questionnaire, which comprises 16 items that gather data on individuals' PAL during work, travel, leisure, and sedentary behavior [33], and the International Physical Activity Questionnaire (IPAQ), which features seven questions that evaluate individuals' physical activity levels (PAL) over the past week during work, transportation, and free time [43]. Monitoring of HEPA habits involve gathering data on participants' activities, including a follow-up on their progress, performance, and feedback to motivate the continuation of PA routines and thus prevent sedentary behavior [44]. For example, if individuals remain seated for more than 1 h [28], the app may suggest incorporating PA time [23–31].

Table 1 presents 13 mobile apps focused on HL awareness. This information was sourced from journals indexed in Scopus, Web of Science, and PubMed. Notably, sports training apps, such as Strava, Fitbit, Endomondo, Runtastic, and ABT [45], were excluded from this selection as they cater to individuals engaged in regular PA and do not specifically address HL awareness.

Table 1. Mobile apps that raise HL awareness through the promotion of exercise

App	Chatbot	Recommendation	Assessment	Monitoring	Results
IMPACTap [31]	–	PA	Completion of activities	PAT with wearable FitBit device	30% reduction in stress levels. 25% improvement in overall life satisfaction of users.
MedLiPal [46]	VHC	PA HE	Total PA time per week Adherence to diet	Daily step counter with wearable device	Increase of 109.8 minutes of weekly PA. Weight loss of 1.3 kg and reduction of 2.1 cm in waist circumference.
HEPAm [35]	–	HE	HEPA	HEPA	40% increase in the implementation of HE practices. 35% increase in regular PA among participating children.
Exertime [29]	–	PA (walking)	Total work-break time	Work breaks	25% increase in daily PA of employees. 15% reduction in work-related stress levels.

(Continued)

Table 1. Mobile apps that raise HL awareness through the promotion of exercise *(Continued)*

App	Chatbot	Recommendation	Assessment	Monitoring	Results
Walk@ WorkApp [28]	–	PA (walking)	Total sitting and walking time	Total sitting and walking time	Increase of 20% in the daily step count. 10% improvement in work productivity.
EMERITI Fitness [34]	VHC	—	Daily goal proposed	Steps with wearable smart bracelet	30% increase in weekly PA. 20% improvement in mobility and flexibility.
Kurbo [23]	–	PA HE	BMI Nutrition and physical activity level	Daily PAL	15% reduction in BMI of children. 60% of children adopted healthier eating habits.
Runtastic [33]	–	–	Height and weight Walking time and distance	Movement time and distance	25% increase in weekly PA of users. 10% reduction in BMI in 40% of users.
Worktivity [30]	–	PA	Total sitting and physical activity time	Total sitting and PA activity time	15% reduction in stress levels among employees. 20% increase in work productivity.
iByte4Health [24]	–	PA MA	Proposed goal	Response to self-control messages	Participants who used the application showed improvements in PA and health indicators.
SmartWalk [32]	–	PA (walking)	Heart rate Oxygenation level	Heart rate and oxygen saturation	Increase in PA levels among app users.
Cardiac RehApp [37]	–	PA	Physical aptitude Hand grip strength Heart-related anxiety scores	Hand grip strength Heart rate	Improvement in PAL measured by accelerometers. Reduction in total sitting time and increase in PA.
Kencom [36]	–	PA	Completion of activities	Step tracking	Average increase of 510 steps per day. Relationship between app usage and weight loss.

Notes: Where the acronyms are given as follows. BMI: body mass index; HE: healthy eating; MA: mental activity; PA: physical activity; PAL: physical activity level; PAT: physical activity tracking; VHC: virtual health coach.

3 AWARENESS MODEL

As shown in Figure 1, an IT model, including exercises for HOWs, was developed to enhance awareness on HL. The model comprised five core components (see Figure 1): the chatbot, dashboard, evaluator, informer, and administrator. Substantial empirical support validated the use of mobile apps to raise awareness about the importance of physical exercise in mitigating sedentarism and preventing diseases, thereby enhancing HL [28, 29, 34]. Additionally, studies have demonstrated the efficacy of chatbots in encouraging, simplifying, and facilitating the planning and monitoring of exercise activities [32].

In Figure 1, the user represents a HOW with limited PAL. A specialist (e.g., a coach or instructor) creates the questionnaires, analyzes variations in knowledge outcomes, and monitors the user's progress in their activities. In the model, participants interact with the chatbot to acquire knowledge that prompts them to reflect on the consequences of physical inactivity. Users can also access the Informer module to stay informed about the consequences of sedentarism via updates on current news, new discoveries, and research, with the specialist periodically refreshing this information via the administrator module. Furthermore, the model incorporates a questionnaire to determine the level of sedentarism and provide HL-related recommendations. The specialist evaluates the questionnaires and their results, providing feedback to participants to help them monitor their progress during assessments. The specialist can also use the dashboard to monitor participants' lifestyles to refine the recommendations and strategies.

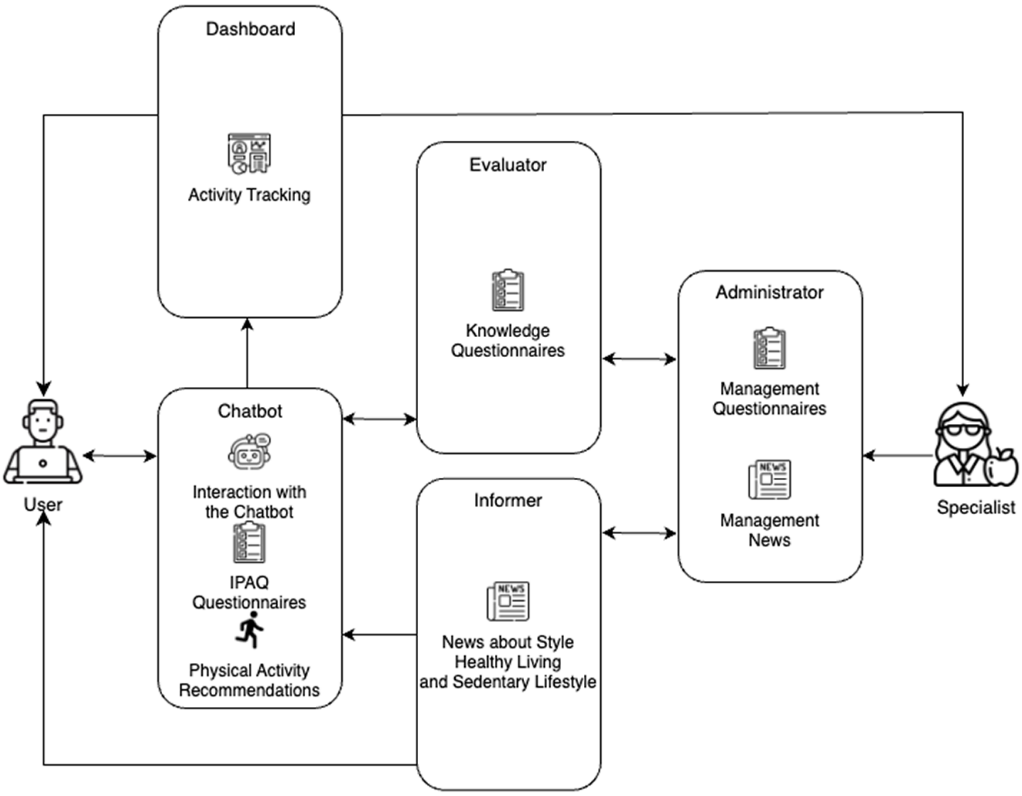

Fig. 1. IT model for raising HL awareness

3.1 Chatbot

Chatbot is a means of sensitizing HOWs about HL via a dialogue, wherein HOWs can gain insights into behaviors with short- and long-term negative effects. Chatbot comprises three components: a chat feature, the IPAQ, and recommendations. The chat relies on natural language text processing, whereas the IPAQ is an international standard created by the WHO and comprises seven questions evaluating frequency, duration, and intensity of PA across various daily contexts, categorizing them as high, moderate, or low [47]. The IPAQ also provides recommendations for each level of PA (refer to Table 2), which are used by the chatbot.

MET serves as a metabolic index measure, equivalent to 3.5 ml of oxygen per kilogram per minute, representing the minimum amount of oxygen required to maintain vital functions. An individual's MET is determined by their overall PA (including walking, moderate physical activity, and vigorous physical activity) based on the data supplied to the chatbot and questionnaire responses. Total MET for walking is calculated as follows: 3.3 × MET × (# minutes of walking) × (# days a week). For example, an individual who walks for 30 min 5 days a week will have a MET of 495 [= 3.3 × MET × (30 min of walking) × (5 days a week)]. For moderate and vigorous PA, the total MET is calculated in a similar manner but using 4 and 8, respectively, instead of 3.3.

Table 2. Physical activity levels and recommendations based on the IPAQ [47]

Physical Activity Level	Criterion 1	Criterion 2	Recommendations
Intense	Seven days of moderate physical activity with 3,000 MET-min/week	Three days or more of vigorous activity with 1,500 MET-min/week	Continue the same weekly regime of physical activity
Moderate	Five days or more of any combination of walking, moderate physical activity, or vigorous physical activity, with a total minimum of 600 MET-min	Five days of moderate physical activity or walking for 30 min/day	Complete the same regime of physical activity or meet any criterion in the next category
Low	Individual does not meet any of the criteria, as opposed to higher levels	Individual does not meet any of the criteria, as opposed to higher levels	Motivational interview, and complete a weekly activity to meet one of the goals in the next category

3.2 Informer

The Informer module serves the purpose of disseminating information on HL-related topics (e.g., PA, HE, MA, and adequate rest) and the consequences of sedentarism to improve awareness of their health-related effects. This module uses information from the WHO and SOPERFO (Peruvian Society of Ergonomics) as sources.

3.3 Administrator

In the Administrator module, specialists can manage questionnaires and responses as well as update information related to HL and the consequences of unhealthy lifestyles, sedentarism, junk food consumption, and stress to heighten participants' awareness.

3.4 Evaluator

In the Evaluator module, participants' understanding of HL is assessed using a knowledge questionnaire designed by the specialist. This questionnaire covers topics related to sedentarism, its associated risks, recommended PA, and the benefits of HL. Questionnaires can be processed automatically, and results are relayed to participants and the specialist via chatbot and dashboard, respectively. This facilitates participants' tracking of their own learning progress while interacting with the app and enables experts to assess participants' development. The knowledge questionnaire is presented in the validation process (refer to Table 3).

3.5 Dashboard

The dashboard component is used to monitor indicators associated with HL across the three dimensions of PA, HE, and mental health. This component also assesses whether participants are following recommendations and making progress toward their goals. Several of these indicators are outlined in Table 3.

Table 3. Indicators associated with HL

Physical Activity [17]	Eating [48]	Mental Health [49]
Resting heart rate	Calorie consumption	Emotional wellbeing
Body mass index control	Fiber consumption	Stress levels
Aerobic capacity improvement	Vitamin and mineral consumption	Sleep quality
	Reduction of processed food consumption	Self-care and self-esteem

The proposed HL awareness model focuses on PA; therefore, it comprises indicators pertaining to this dimension.

4 SEDENTARY SYSTEM

Implementation of the proposed IT model in the web and the mobile app "Sedentary" is described in this section.

4.1 Architecture

Figure 2 shows the logical architecture of Sedentary and its three main components that support the model modules: the mobile app, which supports the chatbot, dashboard, evaluator, and informer modules; the web app, which supports the administrator module; and the cloud provider, which offers cloud services for the storage and backup of the mobile app and web app modules.

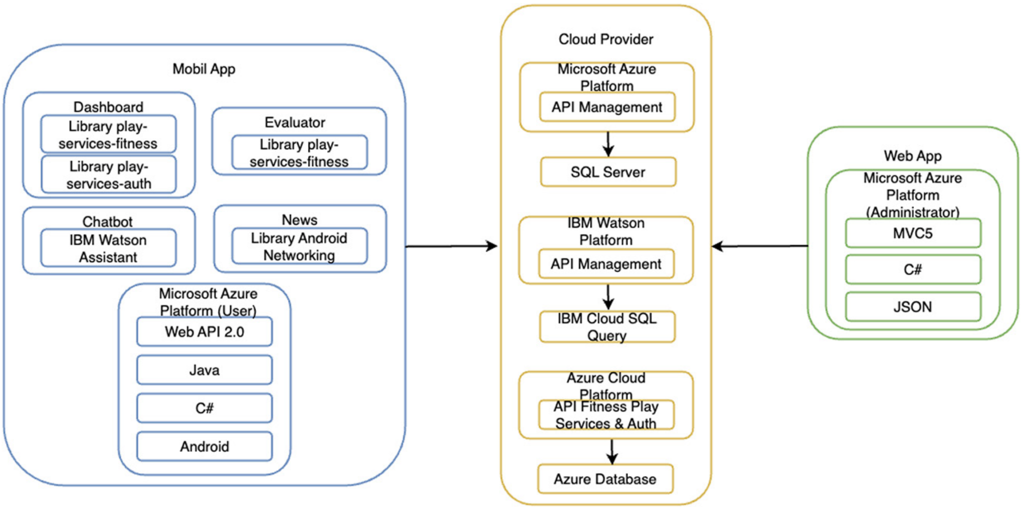

Fig. 2. Architecture of Sedentary

The physical architecture (see Figure 3) includes the technological components through which both the mobile and web apps can be accessed, catering to their respective functionalities and roles within the solution. Both of these apps, along with cloud services, are hosted on the same Microsoft Azure instance. The chatbot is hosted on the IBM cloud, and permissions for pedometer use are hosted on the Azure cloud platform. An internet connection is essential for accessing the cloud-hosted services.

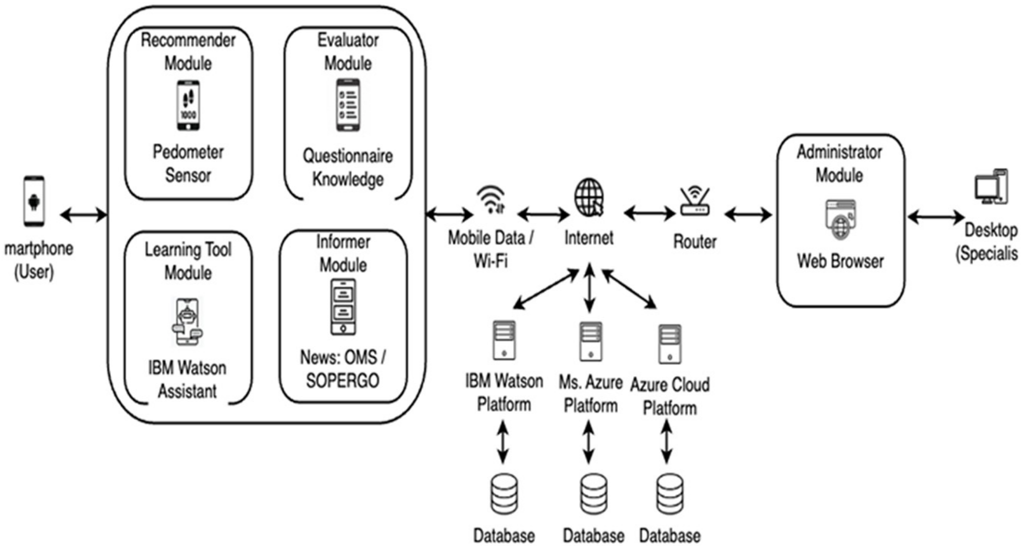

Fig. 3. Physical architecture of Sedentary

4.2 Implementation

Both the web and mobile apps were developed using C# for the backend, employing MVC5 and Web API 2.0 frameworks (which support the JSON format), respectively. Additionally, Android networking libraries were used for the mobile app, with its frontend developed using JAVA. The mobile app integrates IBM Watson Assistant, an artificial intelligence tool adept at understanding users in a given context and providing prompt, consistent, and accurate responses. The Azure cloud platform was used to set and manage permissions and access participants' sensitive information (e.g., step count) via the pedometer. Both apps were deployed in the Microsoft Azure environment. The cloud-based service consisted of two providers: Azure SQL for database management, comprising 15 tables, and IBM Watson for managing algorithms and logical structures of artificial intelligence.

4.3 Components

Chatbot: Chatbot was implemented using IBM Watson Assistant owing to its user-friendly nature, efficient understanding of natural language, and high availability. This technology features an intuitive interface and the ability to gather training data, which are subsequently processed and used in natural conversations between the chatbot and participants. Figure 4 illustrates the chatbot, distinguished by its natural language proficiency and focus on HL-related topics, mainly considering general information, the application of the IPAQ questionnaire, and recommendations regarding physical activity.

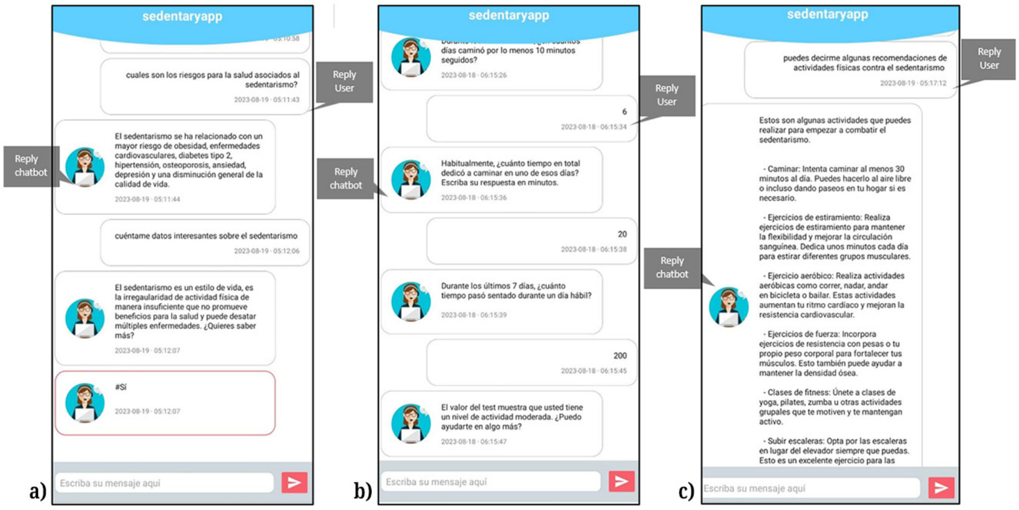

Fig. 4. Chatbot module: (a) General information, (b) IPAQ questionnaire, and (c) recommendations on physical activity

Informer (news): The implementation of the informer involved the use of Android networking libraries with the GET method, targeting the endpoint of the questionnaires saved in the backend. This design allows the administrator's entered data to be visible (see Figure 5a).

Evaluator: The evaluator was implemented using the Android networking library, employing the GET method to display questionnaires (see Figure 5b) and the POST method to collect responses. The questionnaire comprised 10 questions selected from a bank of 40 questions related to general knowledge concerning healthy habits, with these questions previously entered by the evaluator through the web app.

Dashboard: The dashboard was implemented using the play-services-fitness and play-services-auth libraries to access participants' sensitive information. The Azure cloud platform was used to set permissions regarding access to participants' steps and calories data. An example of an interface is shown in Figure 5c.

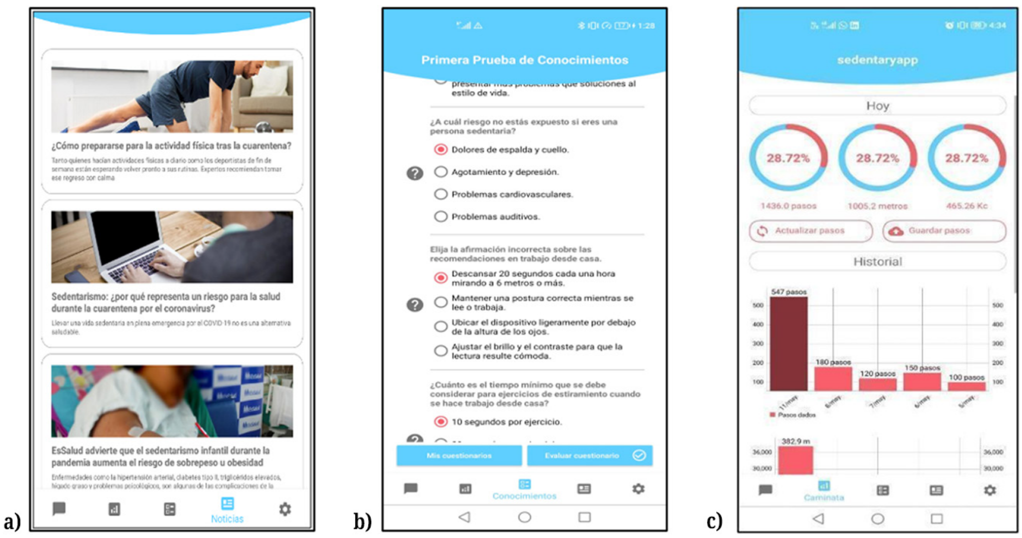

Fig. 5. Functions of Sedentary: (a) news, (b) evaluator, and (c) Dashboard

Administrator (web app): The Administrator component was implemented using MVC5, a framework designed for dynamic websites and forms, and Azure App

Service Web Apps. This component was administered by the expert (see Figure 6), allowing them to manage questionnaires and update news.

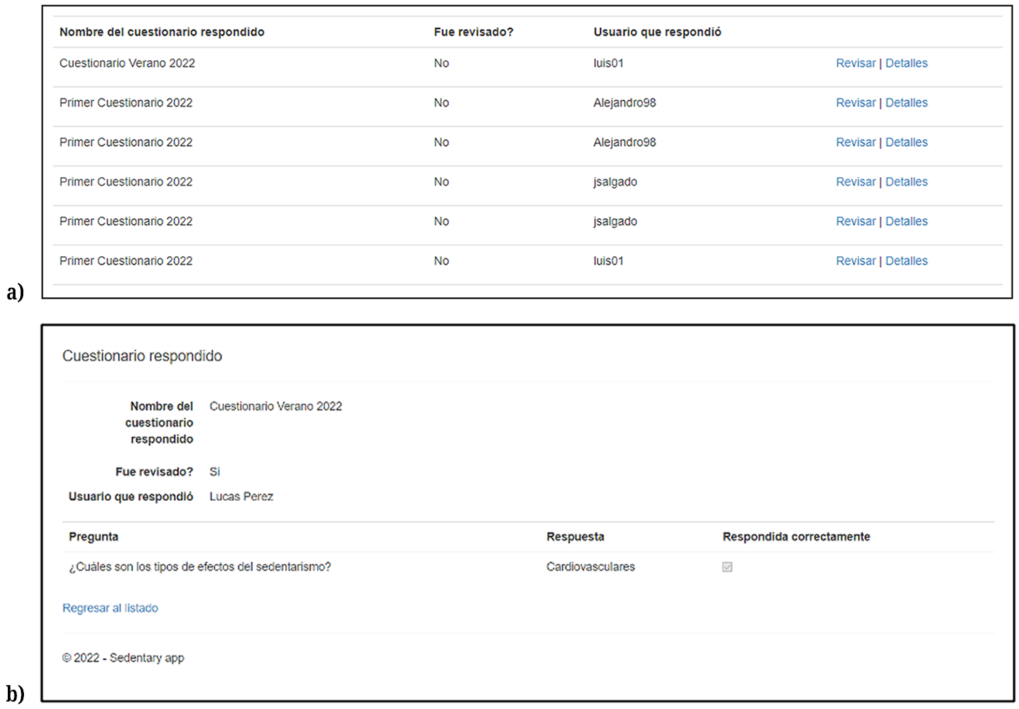

Fig. 6. Web app interfaces: (a) List of questionnaires answered, (b) Participant's responses to a questionnaire

5 EXPERIMENTS AND RESULTS

To assess Sedentary, its efficacy and usability were evaluated. Efficacy was assessed by examining the knowledge acquired about healthy life, as well as the physical activities performed. Usability was evaluated through a perception questionnaire after two weeks of interaction.

5.1 Population

The study included 20 participants working from home across seven distinct sectors in Lima, Peru. Participants were aged 21–35 years, with 35% being women and 55% working in the finance and industrial sectors (refer to Table 4). Additionally, participants' responses to questionnaires were reviewed and validated by a specialist.

5.2 Instruments

Two questionnaires were employed: a knowledge questionnaire and a usability questionnaire.

The knowledge questionnaire, used to assess participants' acquired knowledge, comprised 10 questions randomly selected from a pool of 20 questions. Each question had four possible answers designed in accordance with Peruvian guidelines on eating habits and PA [50, 51]. Table 5 shows all 20 questions with their response options, where the correct answer is "D."

Table 4. Participants' profiles

ID	Age	Sex	Type of Business	Physical Activity Level
P01	22	Male	Telecommunication	Sedentary
P02	22	Female	Education	moderately active
P03	22	Female	Insurance	Active
P04	22	Female	Education	Sedentary
P05	22	Male	Finance	moderately active
P06	22	Male	Finance	Active
P07	21	Male	Industry	moderately active
P08	24	Male	Construction	Sedentary
P09	21	Male	Industry	moderately active
P10	29	Female	Finance	Sedentary
P11	22	Male	Construction	Sedentary
P12	23	Male	Finance	moderately active
P13	28	Female	Health	moderately active
P14	25	Male	Finance	moderately active
P15	24	Male	Finance	Active
P16	35	Male	Industry	Sedentary
P17	21	Male	Finance	Sedentary
P18	22	Female	Industry	moderately active
P19	23	Male	Construction	Active
P20	35	Female	Health	Sedentary

Table 5. Knowledge questionnaire consisting of 20 questions

ID	Question	Response Options
K01	Choose the incorrect statement about sedentarism.	A: It is a lifestyle B: It is irregular physical activity that fails to provide health benefits C: It may cause multiple diseases D: It only refers to lack of physical activity
K02	How much daily physical activity is recommended by the WHO?	A: More than 1 hour a day B: More than 30 minutes a day C: 60 continuous minutes a day D: 30 minutes divided throughout the day
K03	Do elderly adults need to do physical activity?	A: They should do more exercise B: They can exercise for less than 250 minutes a week C: They should avoid exercise as it would worsen their situation D: They can exercise for less than 150 minutes a week
K04	Which of the following is not a risk if you are a sedentary individual?	A: Back and neck pain B: Exhaustion and depression C: Cardiovascular conditions D: Auditory conditions
K05	What are the health benefits of active breaks?	A: They improve work posture B: They decrease muscle tension C: They increase blood flow D: They reinforce self-esteem in the short-term

(Continued)

Table 5. Knowledge questionnaire consisting of 20 questions *(Continued)*

ID	Question	Response Options
K06	Choose the incorrect statement about recommendations regarding home office work.	A: Keep a correct posture while you read or work B: Place your device slightly below eye level C: Adjust brightness and contrast to ensure that you can read comfortably D: Every hour, take a 20-second break to look at something 6 or more meters away
K07	What is the minimum time you should spend stretching when working from home?	A: 20 seconds per exercise B: 30 seconds per exercise C: 40 seconds per exercise D: 10 seconds per exercise
K08	Choose the incorrect options for mitigating the effects of sedentarism in remote work.	A: Keep connected with your coworkers B: Use suitable equipment, such as a mouse pad and ergonomic chair C: Schedule breaks and stretch or move your legs D: Eat small portions of food
K09	If you have not performed physical activity for an extended period, can you attend the gym immediately?	A: Yes B: No C: No, the negative effects may be worse than the benefits D: Yes, but you should be in good health to safely begin a new physical activity
K10	Which of the following is a good option if you want to restart physical activity gradually?	A: Swimming B: Jumping C: Running D: Walking
K11	According to experts, how many times should you eat every day?	A: Five B: Three to five C: Whenever you are hungry D: Three
K12	Why is fiber important for your diet?	A: Because it increases food digestibility B: Because it releases water in the intestine C: Because it increases nutrient absorption D: Because it favors gastrointestinal transit
K13	How much water should you drink every day?	A: Less than one liter B: One to two liters, both in winter and summer C: One to two liters, but only in summer D: Two liters
K14	According to experts, which fats should not be excessively consumed?	A: Monounsaturated fats B: Polyunsaturated fats C: Vegetable fats D: Saturated fats
K15	What are the benefits of integral foods?	A: They have low calories B: They have low salt levels C: They have low sugar levels D: They are rich in fiber
K16	Which of the following is essential to maintaining a healthy lifestyle?	A: Regular consumption of processed foods B: Lack of physical activity C: Adequate rest and sleep D: Excessive consumption of sugary drinks
K17	Which of the following is an effective way of managing stress?	A: Ignoring stress and moving on to daily activities B: Excessive alcohol consumption C: Using relaxation techniques, such as meditation and yoga D: Increasing the consumption of foods rich in saturated fats

(Continued)

Table 5. Knowledge questionnaire consisting of 20 questions *(Continued)*

ID	Question	Response Options
K18	Which of the following food groups is considered to be the healthiest and most beneficial?	A: Fast and fried foods B: Fruits, vegetables, and legumes C: Sweets and sugary cakes D: Energy drinks and soda
K19	Which of the following statements on the importance of physical activity is true?	A: Regular exercise does not affect mental health B: Exercise helps us to maintain a healthy body weight and improves our mood C: Exercise is not related to sleep quality D: Only intense exercise is beneficial; soft exercise is not relevant
K20	How much water should you drink every day to stay hydrated?	A: At least one glass (250 ml) a day B: At least five glasses (1,250 ml) a day C: It depends on the type of drink D: At least eight glasses (2000 ml) a day

The usability questionnaire (refer to Table 6) is based on a study conducted by [52]. It includes questions on usefulness (U1 and U2), ease of use (U3 and U4), and recommendations (U5). Responses were rated on the Likert scale (1: none; 2: scarce; 3: moderate; 4: high; 5: very high), consistent with the study of [53].

Table 6. Questions in the usability questionnaire

ID	Question
U1	To what extent did the app help you identify your lifestyle and its association with your behavior?
U2	How useful do you think the app is?
U3	How often would you use the app to improve your lifestyle?
U4	How easy to use and intuitive was the app?
U5	Would you recommend this app as a means of maintaining or acquiring a healthy lifestyle?

5.3 Experiment

Before the tests, participants installed the mobile app on their Android smartphones and registered their personal data. Subsequently, they interacted with the mobile app and its modules. The knowledge questionnaire was administered during the initial session and at the end of 14 days of use of the Sedentary app, whereas the usability questionnaire was administered after 14 days of app use. In addition, physical activity was evaluated during four weeks of use of the Sedentary app. The entire experiment was carried out in four weeks.

5.4 Results

Figure 7 shows participants' knowledge levels in HL at the end of the experiment. Of the 20 individuals, 18 exhibited improved knowledge. Only participants P08 and P16 maintained their knowledge levels at 7 and 8 points (out of 10), respectively, indicating no improvement. In both cases, these participants did not actively engage with the chatbot to request recommendations or access HL-related news, whereas other participants requested an average of three recommendations and read the news. Notably, the efficacy of an HL intervention did not always reach 100%.

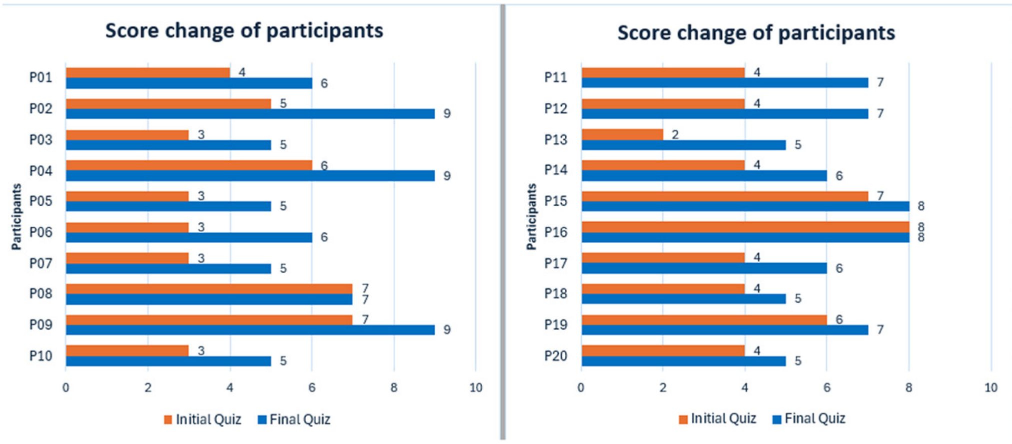

Fig. 7. Knowledge level score at baseline and after two weeks of using Sedentary

Results pertaining to the application's efficacy are presented in Table 7, where efficacy is quantified as the variation in knowledge acquired about HL between the baseline and the end of the experiment. For example, participant P02 achieved a positive efficacy of 80%, as their knowledge level improved from 5 to 9. At baseline, the average knowledge level among participants was 4.5, with the lowest and highest results being observed for participants P13 (2 out of 10) and P16 (8 out of 10), respectively. After two weeks, the average knowledge level increased to 6.6, with the participant having the lowest score (P13) progressing from 2 to 5. Furthermore, the lowest and highest results increased, reaching 5 and 9, respectively. On average, knowledge on HL increased by 46% and reached 6.6, thus indicating that Sedentary positively affected participants' HL knowledge.

Table 7. Results of efficacy assessment

Participants	Result		
	Baseline	Final	Variation
P01	4	6	50%
P02	5	9	80%
P03	3	5	67%
P04	6	9	50%
P05	3	5	67%
P06	3	6	100%
P07	3	5	67%
P08	7	7	0%
P09	7	9	29%
P10	3	5	67%
P11	4	7	75%
P12	4	7	75%
P13	2	5	150%
P14	4	6	50%
P15	6	8	33%

(Continued)

Table 7. Results of efficacy assessment *(Continued)*

Participants	Result		
	Baseline	Final	Variation
P16	8	8	0%
P17	4	6	50%
P18	4	5	25%
P19	6	7	17%
P20	4	5	25%
Average	4.5	6.6	46%

Table 8 presents the step goals of the participants, the average percentage of the goal achieved weekly during the four weeks of the study, and the total average percentage of the goal achieved by each participant. Note that the weekly step goals were set according to each participant's PA profile (refer to Table 4) at 5,000 for sedentary participants, 10,000 for moderately active participants, and 12,500 for active participants.

Table 8. Participants' physical activity result

Participants	Weekly Goal (Steps)	Avg. Week 1	Avg. Week 2	Avg. Week 3	Avg. Week 4	Total Average
P01	5,000	100%	100%	92%	100%	98%
P02	10,000	91%	100%	100%	100%	98%
P03	12,500	100%	100%	93%	91%	96%
P04	5,000	100%	100%	100%	100%	100%
P05	10,000	94%	100%	100%	98%	98%
P06	12,500	100%	95%	91%	92%	95%
P07	10,000	85%	89%	80%	90%	86%
P08	5,000	99%	98%	96%	100%	98%
P09	10,000	100%	88%	93%	100%	95%
P10	5,000	100%	98%	94%	100%	98%
P11	5,000	99%	100%	100%	100%	100%
P12	10,000	100%	100%	97%	99%	99%
P13	10,000	95%	96%	95%	98%	96%
P14	10,000	83%	90%	87%	86%	87%
P15	12,500	95%	89%	100%	91%	94%
P16	5,000	100%	100%	100%	99%	100%
P17	5,000	100%	100%	100%	100%	100%
P18	10,000	85%	90%	88%	92%	89%
P19	12,500	95%	100%	100%	91%	97%
P20	5,000	100%	99%	100%	100%	100%
Average		96%	97%	95%	96%	96%

Table 9 shows the results from the questionnaire in Table 6, which deals with participants' perceptions of the usability of Sedentary. The columns U1–U5 correspond to the questions in Table 6, and the integer values 1–5 represent the responses according to the Likert scale for each question.

Table 9. Results of the usability questionnaire

Participants	U1	U2	U3	U4	U5
P01	5	4	4	5	4
P02	4	4	4	5	4
P03	4	5	4	5	3
P04	5	4	5	4	4
P05	5	5	4	4	5
P06	5	4	4	4	4
P07	4	5	4	5	5
P08	3	4	3	3	3
P09	3	4	4	4	3
P10	4	3	4	4	4
P11	4	4	3	4	4
P12	4	5	4	4	4
P13	5	4	5	5	4
P14	3	3	3	4	4
P15	5	5	4	5	4
P16	4	3	3	4	4
P17	4	4	4	5	4
P18	3	4	4	3	3
P19	4	3	4	3	4
P20	5	5	5	4	5
Average	4.15	4.1	3.95	4.2	4

6 DISCUSSION

The results of the efficacy evaluation confirm that the "Sedentary" app improves knowledge about HL among HOWs, with an average increase of 46% in just 14 days. Increases in knowledge ranged from moderate to significant improvements, reaching up to 150% in cases such as that of participant P13. Specifically, sedentary participants showed an average increase of 40% in their knowledge, while levels for moderately active and active individuals rose by 68% and 75% respectively, demonstrating the app's ability to adapt to different initial knowledge levels. Although the lack of a control group and factors such as the Hawthorne effect could have influenced the results, the evidence suggests a substantially positive impact of the app on HL education for remote workers.

The results of the PA study (refer to Table 8) show that the “Sedentary” app has a significant impact on adopting HLs among HOWs, achieving an impressive average of 96% of the established PA goals. This high compliance is particularly notable in sedentary participants, who achieved 99% of their step goal, highlighting how increased PA can reduce the risk of chronic diseases in inactive lifestyles. Moderately active and active participants also demonstrated high compliance, reaching 93% and 95% of their goals, respectively, indicating that “Sedentary” is effective in maintaining and enhancing PA in already active individuals. The app’s adaptability to adjust goals according to the level of activity and user progress reflects its ability to personalize the application, a key principle in the design of behavioral health technologies.

The results of the usability evaluation of the “Sedentary” app (refer to Table 9) show high ratings in all evaluated categories, indicating strong support for its effectiveness in promoting HLs among HOWs. Participants highly valued the app’s ability to identify lifestyle behaviors and its overall utility (questions U1 and U2), highlighting its success in meeting essential functional objectives. The ease of use and the frequency with which the app would be used (questions U3 and U4) also received high ratings, emphasizing its importance for ensuring ongoing commitment and long-term adoption. Furthermore, the high willingness of users to recommend the app to others (question U5) reflects its perceived value and effectiveness in maintaining or achieving a HL. These findings underscore the importance of adhering to user-centered design principles and suggest good market potential and user acceptance, which are crucial for its widespread adoption. It should be noted that the discrete values of the Likert scale were interpreted as follows: 1–1.8: none; 1.9–2.6: scarce; 2.7–3.4: moderate; 3.5–4.2: high; 4.3–5: very high.

The proposed app shows similarities with other applications, as it includes PA recommendations, as demonstrated in 10 of the 13 apps identified in the literature for Sedentary Health (HS) (refer to Table 1). Like the majority, it implements assessment and monitoring through a wearable device. Additionally, Sedentary incorporates a chatbot, an essential element for facilitating natural dialogue with the user, although this feature only appears in two other applications: MedLiPal and EMERITI Fitness. On the other hand, all reviewed studies report positive outcomes, such as stress reduction in IMPACTap, increased PA in Exertime, and weight loss in MedLiPal, results that are consequences of PA and awareness of an HS. However, none of the studies address knowledge acquisition, goal achievement, or the usability of the app, which contribute respectively, to the awareness of an HS, the undertaking of PA, and the use of the app.

7 CONCLUSIONS

In this study, we introduced a model and a mobile app designed to raise awareness on HL practices among HOWs. The app facilitates interaction, sensitization, assistance, and recommendations regarding HEPA. Notably, the app is distinct because of the integration of a chatbot for sensitizing participants, a knowledge-assessment questionnaire, and tools for assessing and monitoring participants’ physical activity.

The model was implemented using a mobile app named Sedentary, using JAVA for the backend and C# for the frontend, and it was developed within the Microsoft Azure infrastructure. Database management was performed using Azure SQL. To enhance the chatbot’s capabilities, it was integrated using IBM Watson Assistant, thus leveraging its capacity for algorithm and logical structure management for artificial intelligence. Subsequently, 20 participants working from home used the app.

The results of the HL knowledge questionnaire revealed a 46% average increase in participants' knowledge following 15 days of app use. The results on PA show a beneficial effect, evidenced by the fact that, on average, 96% of the established PA goals were achieved during the four weeks of use. Additionally, results from the usability survey showed that participants strongly endorsed the app's utility for enhancing HL, commended its ease of use, and expressed their willingness to recommend it to others.

A limitation of this study is its short duration and the absence of a control group, which could affect the accurate attribution of results to the use of the app. Additionally, the lack of long-term follow-up prevents the assessment of the sustainability of the knowledge acquired and its impact on sustained behavioral changes. Future research should consider a longitudinal design that explores how specific features of the app, such as reminders and rewards, influence the achievement of activity goals and enduring behavioral changes. These studies would help identify potential declines in user commitment and the underlying causes, thus ensuring that high usability ratings translate into practical and ongoing benefits for users. Although the app currently focuses solely on PA, future research will also include activities aimed at mental health to address the negative consequences of remote work, including depression [54]. Additionally, additional sensors should be incorporated to monitor participants' physiological markers as they seek to improve their learning capacity.

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10 AUTHORS

David Mauricio has a PhD in Computer and Systems Engineering and a Master's degree in Applied Mathematics from the Federal University of Rio de Janeiro (Brazil). He has been a professor at the Universidad Estadual Norte Fluminense in Brazil (1994–1998), and since 1998 he has been a full professor at the Universidad Nacional Mayor de San Marcos in Peru. Areas of interest: Mathematical Programming, Artificial Intelligence, Software Engineering, Entrepreneurship (E-mail: dmauricios@unmsm.edu.pe; ORCID: https://orcid.org/0000-0001-9262-626X).

César Marcelo Flores-Cortegana is a graduate of the Information Systems Engineering program at the Universidad Peruana de Ciencias Aplicadas (UPC) (E-mail: u201622201@upc.edu.pe).

Anthony Jaimar Shuan-Arias is a graduate of the Information Systems Engineering program at the Universidad Peruana de Ciencias Aplicadas (UPC) (E-mail: u201721371@upc.edu.pe).

Pedro Castañeda has a PhD in Systems Engineering-UNMSM, a Master's Degree in Management and Information Technology Management – UNMSM and a Master's Degree in Business Administration (MBA)-ESAN. He currently leads projects of electronic brokering, software development, and process improvement, using agile and traditional methodologies. He has the following certifications: Project Management Professional (PMP), Scrum Certified Developer (CSD), IBM Certified Professional in Rational Unified Process, and ORACLE Certifications. Teacher of Project Management Methodologies and Software Development in public and private universities. Areas of Interest: Software Productivity, Business Intelligence, Machine Learning, Software Engineering (E-mail: pcsipcas@upc.edu.pe; ORCID: https://orcid.org/0000-0003-1865-1293).

Leonardo Rojas-Mezarina is a surgeon from the Universidad Nacional Mayor de San Marcos (UNMSM), a specialist in Health Administration and Management (UPCH), a Master (c) in Health Management (UPCH), a RENACYT Researcher, a Coordinator of the Health Information and Innovation Technologies research group, and an Associate Professor of the Academic Department of Preventive Medicine and Public Health (UNMSM). Former General Director of the General Office of Information and Systems of the National Institute of Health. He is currently Executive Director of the Telemedicine Directorate of the Peruvian Ministry of Health and Head of the Telehealth Unit of the UNMSM (E-mail: leonardo.rojas@unmsm.edu.pe).

José Luis Castillo-Sequera received the degree in computing from the National University of San Marcos, Peru, the master's degree in computer project management and the master's degree in university teaching in Spain, and the Ph.D. degree in information systems, documentation, and knowledge from the University of Alcalá, Spain. He is currently a full professor with the Department of Computer Science, University of Alcalá (Spain). He has multiple publications at the level of high-level indexed JCR journals and is the author of books and book chapters related to the field of artificial intelligence. His research interests include information retrieval, knowledge extraction and neural networks, data mining and big data, and machine learning. He also leads projects of technological innovation oriented to the use of ICTs in university research groups. His research interests include business technologies (E-mail: jluis.castillo@uah.es).