Mobile Application: For Anxiety and Cardiovascular Depression Monitoring Using a Smartwatch Based on Cognitive Behavioral Therapy

Lucero Huaroto
Universidad Peruana de Ciencias Aplicadas
Lima, Perú
h.c.luceriio@gmail.com

Lenis Wong
Universidad Peruana de Ciencias Aplicadas
Lima, Perú
lwongpuni@gmail.com

Vanessa Alvarado
Universidad Peruana de Ciencias Aplicadas
Lima, Perú
amvanessa59@gmail.com

***Abstract*—In recent years, medical care for mental health has been affected by the confinement situation due to COVID-19. Access to these services has been strongly affected, becoming virtual to avoid close contact. However, this change brought other problems to starting conversations with the patient and monitoring their mental health since the description of events reported by the patient is not entirely accurate and can be biased. For this reason, an approach is proposed for monitoring anxiety and cardiovascular depression by applying the cognitive behavioral therapy (CBT) technique, also considering levels of the patient's physiological variables using a *smartwatch*. This approach consists of choosing the type of CBT technique as the basis of the mobile application, the selection of physiological variables, choosing the *smartwatch* model applying benchmarking, and the design of the mobile application. Two scenarios were used for the experimentation: (a) without the proposal and (b) with the proposal. Results of real-life environment validation experimentation showed an increase of more than 80% of the events discussed in therapy using the proposed solution, in addition to an average rating of 4.75 by the psychologist. Lastly, the results of the surveys show specialists and patients consider the proposal useful.**

I. Introduction

Mental health is related to the psychological and mental well-being of people and their good condition helps prevent mental illness [1]. However, medical care for mental health in the world has been affected by the coronavirus situation. A study the WHO carried out in 130 countries indicates that 67% of the observed disturbances in psychological counseling and psychotherapy services are due to the COVID-19 context [2]. On the other hand, mental health care has become virtual, but this change brought other problems to start conversations with the patient to monitor their mental health [3]. This issue is because the specialist's direct contact with the patient is essential to monitor their mental health status, but it also has a limit. A study indicates that the current diagnosis of mental illness depends entirely on the partial description of the symptoms reported by the patient [4]. However, a more objective diagnosis could be done by monitoring the physiological responses of the patients in specific situations, since a study reveals that the changes caused in the physiology of the human body in response to stress can be observed and used as a stress indicator [5].

To mitigate this problem, some studies have emerged that use smartwatches or sensors to detect or monitor certain diseases, such as Parkinson's and epilepsy [6]. The authors in [7] found a relationship between physiological variables and mental health. More specifically, they found that blood pressure and heart rate may be related to stress. Also, the case of the Motherly application [8] was revised, which applies behavioral therapy to monitor women in the maternity stage. But, although these studies are focused on monitoring mental health from the measurement of physiological variables and some consider certain kinds of therapy, this is additionally applied as an informative model and is not considered within the solution.

Therefore, this study proposes an approach to monitoring anxiety and cardiovascular depression by applying the cognitive behavioral therapy (CBT) technique in conjunction with measurements of the patient's physiological variables using *smartwatches*. The proposition consists of four activities: (1) choosing the type of CBT technique; (2) selection of physiological variables; (3) choosing the *smartwatch* model, and (4) design of the mobile application.

The paper is organized in this way. Section 2 presents the background of the study. Related works are mentioned in Section 3. The details of the proposed system architecture are presented in Section 4. Section 5 presents the validation protocol and its execution. The results of the validation are presented in Section 6. Finally, the conclusions and future work are presented in Section 7.

II. Background

A. Mental health

According to the World Health Organization, "mental health is a state of well-being where the person is aware of their abilities, copes with daily stress and can work productively contributing to society" [9]. Also, in Peru, the entity in charge of this matter is the MINSA. This entity defines mental health as something more than the absence of a mental illness, relating it to how the person socializes in their family, work, social environment, etcetera. [10]. On the other hand, mental illness can manifest from childhood and adolescence, some of these

signs being depression or anxiety. In addition, Blanchet points out that mental health also refers to the person's psychic state at a given time depending on three factors: (1) Biological Factors: characteristics related to the person's genetics and physiology. (2) Psychological Factors: cognitive, relational, and affective characteristics of the person. (3) Contextual Factors: social characteristics of the person, so that all the positive or negative factors that happen in the person's environment will cause an impact on their mental health, becoming an obstacle for it in some cases [11].

B. Cognitive behavioral therapy

Cognitive-behavioral therapy (CBT) consists of a set of techniques that are part of a psychological treatment focused on the behavior and stimuli of a person that occurs in a situation [14]. This type of therapy focuses on the problems that the person currently has and originated from cognitive therapy and behavioral therapy, which results in practices that help the person change their way of thinking and their behavior, allowing the person to feel better [15]. On the other hand, cognitive-behavioral therapy applies different techniques to treat the patient, such as the following:

The technique called "dysfunctional thought recording" is used for patients to record their automatic thoughts in a situation and emotions they felt, so the therapist provides alternative responses to the thoughts described by the patient [16]. The second technique of "relaxation" allows the patient to control her negative emotions, such as anxiety or anger [17]. The third technique of "emotional regulation" refers to the processes that allow the monitoring, evaluation, and modification of the person's emotional reactions, in such a way that they can help achieve a specific objective [18]. The fourth technique of "spectator and distant observer" consists of making direct observations of the external behaviors of the patient in the situation in which he finds himself [19].

III. Related works

In various studies, intervention methods have emerged for patients with symptoms of stress or anxiety. In [5], the authors built a classification model and statistical analysis of data collected from healthy people where the result was that the respiratory rate and heart rate are the main factors that help us identify if a person is in a state of stress or not. Likewise, in [20], a group metacognitive therapy is applied to address symptoms of depression and anxiety in patients undergoing cardiac rehabilitation.

Physiological variables monitoring has been used in studies to detect and prevent disorders. In [21], the authors considered the changes in heart rate variability in healthcare workers to identify if they are at risk of experiencing stress when exposed to counteracting events, such as emotional support and quality of life. On the other hand, in [22], a study was carried out on patients hospitalized due to Covid-19, whose authors considered the oxygen saturation levels to identify the risk of anxiety or depression. Also, in [23], stress levels are obtained from the measurements of physiological variables, such as heart rate and oxygen saturation.

Anxiety and cardiovascular depression monitoring have considered the use of technological devices. In [24], the Fitbit *smartwatch* allows the measurement of heart rate and a monitor for blood pressure, being these indicators of stress. Likewise, in [25], a *smartwatch* is used to measure the resting heart rate of law enforcement officers and stress levels. Also, it offers short meditation exercises to help relieve the stress levels that arise. On the other hand, in [26], an Empatica bracelet is used to track sleep, a monitor is also used to measure heart rate and blood pressure and develop a mobile application to detect signs of stress in academic computers.

There are several types of therapies to treat depression, anxiety, or some other disorder. In [27], they applied metacognitive therapy to carry out a twelve-week follow-up in patients with heart disease to evaluate the presence of symptoms of depression and anxiety. In addition, in [8], CBT is applied to treat depression in pregnant women through a mobile application, thus obtaining a favorable change in the level of maternal depression. Likewise, in [28], the authors developed an application based on CBT to carry out interventions in the mental health of healthcare workers on the front line due to the Covid-19 pandemic, where the results showed a reduction of mental health problems by two weeks in workers who received medication.

IV. Proposed model

Fig. 1 describes the proposed model. This model consists of monitoring the state of a person's mental health by considering their physiological variables through a *smartwatch*. Likewise, Cognitive Behavioral Therapy (CBT) has been selected for this research because it obtained viability in other studies [8][28]. The phases of this model are the following: (1) choosing the type of CBT technique, (2) selection of physiological variables, (3) choosing the *smartwatch* model, and (4) mobile application design.

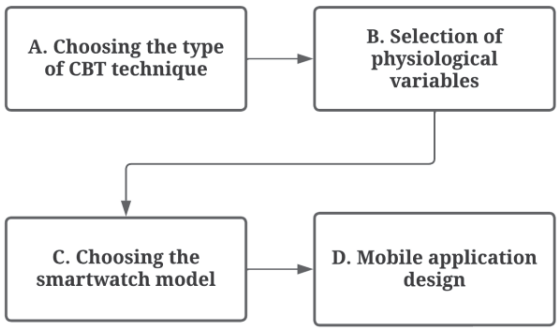


Fig. 1. Proposed model

A. Choosing the type of CBT technique

The choice of the type of CBT technique was carried out through benchmarking, where 4 CBT techniques were considered, selected from the literature review: Register of dysfunctional thoughts, relaxation techniques, emotional regulation techniques, and bystander or distant observer.

The measurement of these techniques considered four aspects: adaptability, scope, automation, and registration, considering the limitations and aim of the solution.

The first aspect to evaluate the CBT technique is *Adaptability* (T1), refers, for example, to whether the CBT technique can be applied virtually. The second aspect *Scope* (T2) considers the application of the technique within the scope of the investigation. For example, the proposed duration time for the development of the study. The third aspect is *Automation* (T3), which considers the implementation of the technique in a mobile application. Finally, the fourth aspect is *Registry* (T4), which involves if the technique uses data captured by the *smartwatch* for its development.

Then, in Table I, the *confrontation matrix* [19] was applied, where "1" is assigned if the row aspect is more or equally important to the column aspect and "0" if it is less important, excluding the case where both the row and column aspects are the same. The results show that the "Scope" aspect obtained a greater weight, with a value of 43%.

TABLE I. CONFRONTATION MATRIX OF ASPECTS

	T1	T2	T3	T4	Total	Weighted average
T1		0	1	0	1	14%
T2	1		1	1	3	43%
T3	1	0		0	1	14%
T4	1	0	1		2	29%
Totals					7	100%

Finally, Table II shows the benchmarking summary of the four CBT techniques, with their respective score (S) and average (A), where "emotional regulation" obtained the highest score (5). Therefore, the technique applied to this research was "emotional regulation".

TABLE II. BENCHMARKING OF CBT TECHNIQUES

Aspect	Weighted average	Register of dysfunctional thoughts technique		Relaxation technique		Emotional regulation technique		Bystander or distant observer technique	
		S	A	S	A	S	A	S	A
T1	14%	4	0,57	2	0,29	5	0,71	1	0,14
T2	43%	3	1,29	3	1,29	5	2,14	1	0,43
T3	14%	4	0,57	2	0,29	5	0,71	1	0,14
T4	29%	1	0,29	3	0,86	5	1,43	3	0,86
Total	100%		2,71		2,71		5,00		1,57

B. Selection of physiological variables

The physiological variables considered in this study are "heart rate" [2][23] and "blood oxygenation" [22][23] for monitoring anxiety and cardiovascular depression, since they are the most frequently used in the scientific articles identified in the literature.

There are cases where patients with cardiac or reparative diseases feel shortness of breath, making them think they had a heart attack. But this is also because they are having a panic attack, which produces a variation in their oxygen saturation, which makes them have shortness of breath (dyspnea) [30].

C. Choosing the smartwatch model

The six *smartwatch* models considered are the following: Samsung Watch 4 (W1), Huawei Band 6 (W2), Fitbit Sense (W3), Fitbit Versa 3 (W4), Apple Watch Series 6 (W5), Xiaomi Band 6 (W6), as shown in Table III.

TABLE III. SMARTWATCH MODELS

ID	Model	Description
W1	Samsung Watch 4	Shows muscle and body fat data. Also, has electrocardiogram (ECG) sensors and blood pressure [31].
W2	Huawei Band 6	Does daily blood oxygen (SpO2) checks and monitors frequently heart rate 24 hours a day [32].
W3	Fitbit Sense	Allows stress management, has ECG and SpO2 sensors, and the user can register their mood [33].
W4	Fitbit Versa 3	Measures SpO2 levels and alerts when it detects irregular values in heart rate [34].
W5	Apple Watch Serie 6	Measures blood oxygen levels and heart rate [35].
W6	Xiaomi Band 6	Measures heart rate and SpO2 and tracks stress [36].

The seven aspects selected for the evaluation are the following: Heart Rate Sensor (A1), Blood Oxygen Sensor (A2), Price (A3), Compatibility (A4), Accuracy (A5), Battery (A6), and Connection (A7), considering the nature of the study and connectivity with the mobile device.

The *A1* aspect considers if the model has a heart rate sensor and *A2* if it has a blood oxygenation sensor. Aspect *A3* refers to the model price. The *A4* aspect considers the model's compatibility with Android and iOS operating systems. Then, *A5* is about the accuracy of data capture. The *A6* refers to battery life. Finally, *A7* considers the types of connections of the model.

The confrontation matrix was also applied to evaluate the aspects. Table IV shows aspects *A1* (Heart rate sensor) and *A2* (Blood pressure sensor) obtained the highest weighted average of 27%.

TABLE IV. CONFRONTATION MATRIX OF ASPECTS

	A1	A2	A3	A4	A5	A6	A7	Total	Weighted average
A1		1	1	1	1	1	1	6	27%
A2	1		1	1	1	1	1	6	27%
A3	0	0		1	0	1	1	3	14%
A4	0	0	0		0	1	0	1	5%
A5	0	0	1	1		1	1	4	18%
A6	0	0	0	0	0		1	1	5%
A7	0	0	0	1	0	0		1	5%
Totals								22	100%

Finally, Table V shows the benchmarking summary of the seven *smartwatch* models along with their respective score (S) and average (A). The weights were obtained in the confrontation matrix, where the *W6* model (Xiaomi Band 6) got the highest score (3.71). Therefore, the *smartwatch* model used for the present investigation was *W6*.

TABLE V. BENCHMARKING OF SMARTWATCHES

Aspect	Weighted Average	W1		W2		W3	
		S	A	S	A	S	A
A1	27%	3	0,81	3	0,81	3	0,81
A2	27%	3	0.81	3	0,81	3	0,81
A3	14%	2	0,28	4	0,56	3	0,42
A4	5%	5	0,25	5	0,25	5	0,25
A5	18%	5	0,91	1	0,18	5	0,91
A6	5%	3	0,14	5	0,23	3	0,14
A7	5%	3	0,14	1	0,05	5	0,23
Total	100%		3,33		2,88		3,56
Aspect	**Weighted Average**	**W4**		**W5**		**W6**	
		S	**A**	**S**	**A**	**S**	**A**
A1	27%	3	0,81	3	0,81	3	0,81
A2	27%	3	0,81	3	0,81	3	0,81
A3	14%	4	0,56	1	0,14	5	0,70
A4	5%	5	0,25	1	0,05	5	0,25
A5	18%	5	0,91	5	0,91	5	0,91
A6	5%	3	0,14	1	0,05	4	0,18
A7	5%	3	0,14	3	0,14	1	0,05
Total	100%		3.61		2,90		3,71

D. Mobile application design

We applied the C# programming language along with .NET Core framework (for the backend development) and the Android Kotlin programming language (for the frontend) in the mobile application development. To obtain physiological data from the smartwatch we used the Google Fit API, and this data was later stored in the database of the mobile application along with the day and hour. To register the emotions of the patients, they had to manually register their mood and events that happened through the day that impacted them, this data is also stored with the day and hour of registration. Finally, the data that was previously saved (physiological data and emotions data) is shown in the stats view to the specialist divided in the sections of mood, heart rate and blood oxygenation. In addition, the mobile application was developed in the Spanish language and is available for Android devices. Also, the name given to the app is *WeCare*.

Fig. 2 shows the physical architecture of the application, in which there is a user layer, devices, connection, front-end, and back-end. First, the "user layer" represents the users that interact with the application. The users are patient, specialist, and administrator. On the other hand, the "device layer" consists of the Xiaomi Band 6 *smartwatch*, which sends data to the smartphone via Bluetooth. The "connection layer" considers the technologies used to access the application wirelessly, such as Wi-Fi connection and 4G mobile telephony. Likewise, in the "front-end layer", there is a graphical visual environment of the App's functionalities. Finally, the "back-end layer" starts with an API for the connection of the App with the services AWS, such as S3 for media file storage and RDS, which is a relational database.

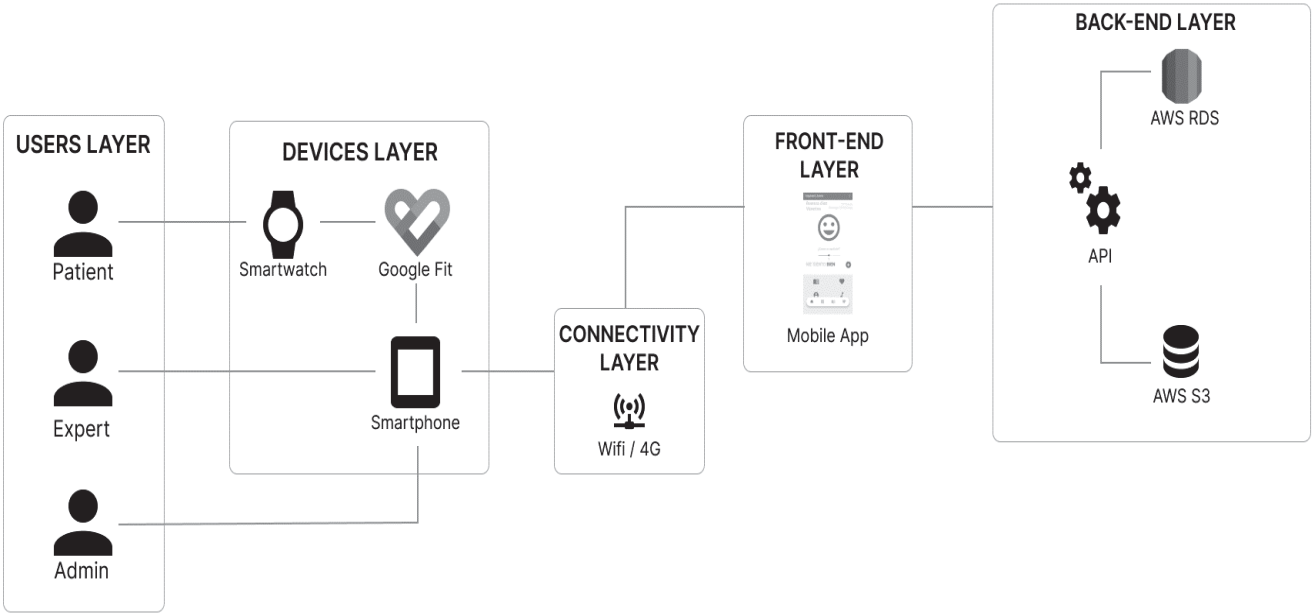
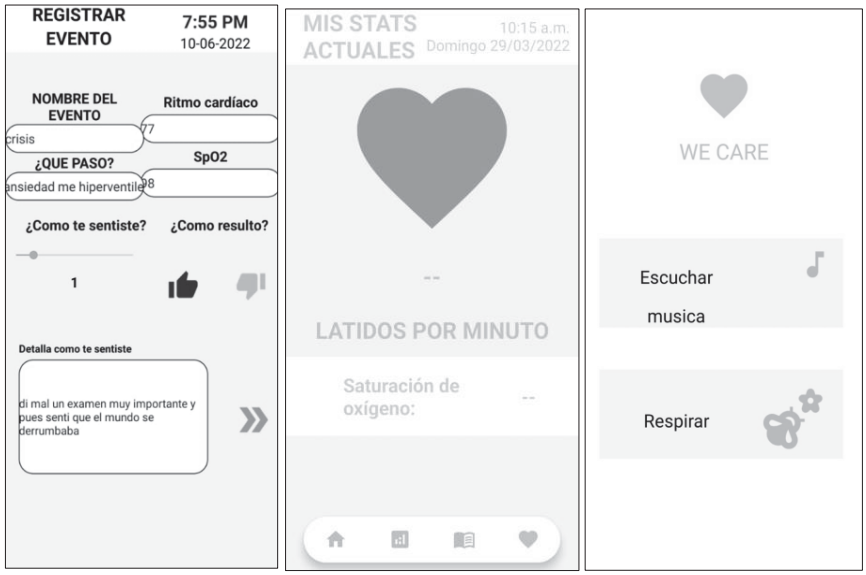


Fig. 2. Physical architecture



(a) (b) (c)

Fig. 3. Main user interfaces of *WeCare* for the patient

(a) (b) (c)

Fig. 4. Main user interfaces of *WeCare* for the specialist

In addition, the mobile application has the following features: 1) the Main menu, which is the home screen of the application and where the user can enter their mood. 2) Register an event where the patient details how they felt in a situation and what the result was. 3) My current stats, in which the patient can view their heart rate and blood pressure and take the measurement 4) Statistics, where the specialist can view the summary of the patient's heart rate and blood pressure measurements, as well as the patient's state of mind.

V. Validation

To validate the system, an experiment followed through in a real-life environment during the therapy sessions involving the patient and the psychologist. In addition, the judgment of experts was done by both: the specialists (psychiatrists and psychologists) and the patients who attend therapy.

A. Real-life environment experimentation

The validation of the system occurred during two therapy sessions between the patient and psychologist with an approximate duration of one hour for a period of two weeks (Table VI). This therapy was given virtually in a video conference with Google Meet.

TABLE VI. Experimentation scenarios

Scenario	Duration	Participants
Without proposed solution	1st week	1 patient 1 psychologist
Using *WeCare*	2nd week	1 patient 1 psychologist

In the first week, the therapy followed through traditionally without using the solution, while in the second week, the *smartwatch*, and the proposed mobile application (*WeCare*) were used. Because of this, the following activities were conducted before the study: (i) explanation of the use of the system, (ii) download the *WeCare* application on the mobile devices of the patient and specialist, (iii) account creation, (iv) pairing of the *smartwatch* with the patient's mobile application and (v) synchronization of the patient and specialist account.

During the second week, the patient registered events in the diary of emotions section (Fig. 3(a)), took measurements of his heart rate and oxygen saturation (Fig. 3(b)), and, if considered, performed relaxation exercises (Fig. 3(c)). At the end of the week, the psychologist (Fig. 4(a)) reviewed the report of the events registered by the patient (Fig. 4(b)), as well as the summary graphs of the measurements of his physiological variables: heart rate and oxygen saturation (Fig. 4(c)).

On the other hand, the quality characteristic "usability" was considered to evaluate the system because it obtained the highest score in the prioritization study by [37]. For the same reason, the sub-characteristics of "learning" were considered. Therefore, the following metrics were defined: 1) Number of events registered in the diary of emotions on the first day of the experiment, and 2) Heart rate and oxygen saturation measurement time (in seconds) using traditional devices and the *smartwatch*.

Then, the psychologist answered questions regarding the *smartwatch's* usefulness, Diary of emotions, and Relaxation sections, as shown in Table VII. The sections follow the emotional regulation technique of CBT.

TABLE VII. QUESTIONS ASKED AT THE END OF THE EXPERIMENTATION

Category		Question	Type
Usability	Q1	Do you think that the proposed app is easy to use?	Close-ended
Mental health monitoring	Q2	Do you think that the use of *smartwatches* improves the follow-up of mental health?	Close-ended
	Q3	Do you think the app helps with mental wellness monitoring?	Close-ended
Therapy technique tool	Q4	Do you think the "Diary of emotions" section helps achieve better monitoring of a person's emotional well-being?	Close-ended

B. Expert judge validation

In the expert judgment validation, five specialists and four patients from Lima, Peru were contacted. This experiment consisted of 3 activities: (i) remote demonstration of the system, (ii) development of a survey for the experts (psychologists and psychiatrists), and (iii) development of a survey for the patients.

The specialists consisted of three psychologists and two psychiatrists who work from both clinics and hospitals. On the other hand, the patients were between 18 and 21 years old. They also attend therapy to treat anxiety, depression, or post-traumatic stress syndrome.

For the validation, each participant was invited to a videoconference through the Google Meet platform according to their availability. The participants were explained the functionalities they can perform in the system according to the type of user. For psychiatrists and psychologists, they were described the periodic reports of physiological variables measurements of the patients and their registers in the "Diary of emotions" section. On the other hand, we explained to patients about recording their physiological variables measures using the *smartwatch*, the "Diary of emotions" section, and the relaxation exercises. This experiment lasted approximately 50 minutes for each participant.

Finally, a Google Forms survey [12][13] was sent to every participant. Table VIII shows the eight closed questions asked to experts, and Table IX shows the five closed questions for the patients. For both surveys, the Likert scale was applied (1=totally disagree, 2=disagree, 3=do not agree and neither disagree, 4=agree, 5=totally agree).

TABLE VIII. SURVEY QUESTIONS FOR SPECIALISTS

Category		Question	Type
Physiology	Q1	Do you think that the mental state of the person impacts their physiology?	Close-ended
	Q2	Do you think that heart rate and blood oxygen saturation as variables could help improve monitoring of mental well-being?	Close-ended
Reaching the solution's goal	Q3	Do you think the proposed app helps with mental wellness monitoring?	Close-ended
	Q4	How willing would you be to implement the use of the application in therapy?	Close-ended
Therapy technique tool	Q5	Do you think that a breathing excersices section would help patients in a state of crisis?	Close-ended
	Q6	Do you think that the diary of emotions section achieves a better follow-up of the mental health of your patients?	Close-ended
Usability	Q7	Do you think that the proposed app is easy to use?	Close-ended
	Q8	Are the graphics with the patient's results useful to improve the follow-up of the patient in a more detailed way?	Close-ended

TABLE IX. SURVEY QUESTIONS FOR PATIENTS

Category		Question	Type
Usability	Q1	Do you think that the proposed app is easy to use?	Close-ended
Smartwatch	Q2	Do you think that the use of *smartwatches* improves the follow-up of your mental health?	Close-ended
Therapy technique tool	Q3	Do you think that the diary of emotions section achieves a better follow-up of your mental health?	Close-ended
	Q4	Do you think that a breathing exercises section would help you in a state of crisis?	Close-ended
Reaching the solution's goal	Q5	How willing would you be to use the application to monitor your mental health?	Close-ended

VI. RESULTS AND DISCUSSION

A. Experimentation

Table X shows the results of the Usability metrics defined concerning the number of registered events and time taken to measure the physiological variables in both scenarios (without the solution and with the solution).

TABLE X. RESULTS OBTAINED IN BOTH SCENARIOS

Scenarios	The number of events discussed in the therapy session	The time it takes to measure the physiological variables (In minutes)
Without the solution	2 events that the patient remembered	Heart rate: 60 seconds Oxygen saturation: 10 seconds
With the solution	4 events the specialist decided to address during the therapy session (+10 events registered in the app)	Heart rate: 10 seconds Oxygen saturation: 3 seconds

The specialist addressed a significant number of events in the therapy session. Previously, the specialist reviewed these events using the solution to choose the ones appropriate for the session. On the other hand, the time required to measure heart rate and blood oxygenation was approximately 10 seconds with the *smartwatch*. Then, using the traditional method, the manual heart rate measurement took 1 minute, and the oxygen saturation using an oximeter took 10 seconds.

Fig. 5 shows the results obtained from the questions asked to the specialist after completing the development of the two scenarios.

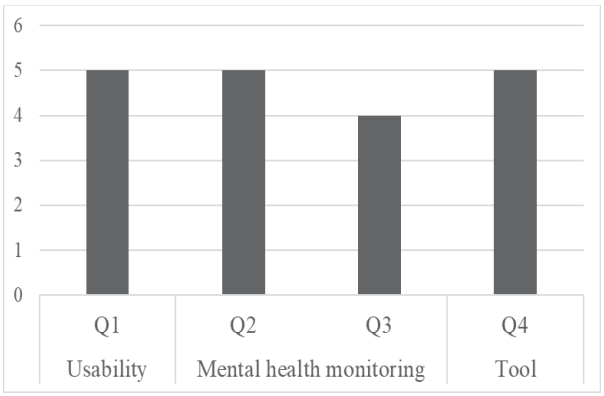


Fig. 5. Summary of responses from the psychologist

The results showed the specialist rated 5 for the "Usability" and "Tool" of the therapy technique categories. In addition, she gave an average score of 4.5 in the "Mental Health Monitoring" category.

The registered events in the remainder of the week were discussed with the psychologist during the therapy session. The psychologist reviews these results and comments that, although the oxygenation level is normal, the heart rate is not. Likewise, revising the registered events, the psychologist mentions the events are related to negative feelings and, if they continue like this for a month, she will consider the option of starting medication with psychiatric help.

For this reason, although the patient has events of shortness of breath and agitation during an anxiety crisis, it doesn't reflect on their physiological variables, so there is a difference between what the patient tells and their physiological behavior.

B. Expert judge

Fig. 6 shows the survey results obtained from the five experts (E), grouped by four categories (physiology, study objective, tool, and usability) and the eight questions.

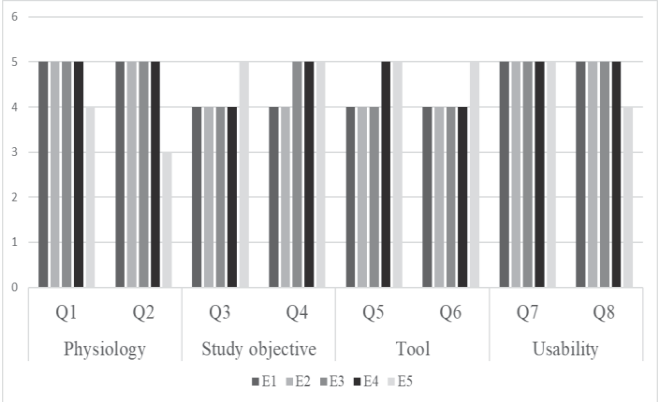


Fig. 6. Summary of survey responses from experts

On average, the "usability" of the system had a value of 4.9. The consideration of the "physiological" variables of 4.8. The fulfillment of the "study objective" of 4.4. And the use of the "tool" as a technique therapy of 4.3.

On the other hand, Fig. 7 shows the survey results obtained from the four patients (P), grouped by the four categories: usability, *smartwatch*, tool, and study objective.

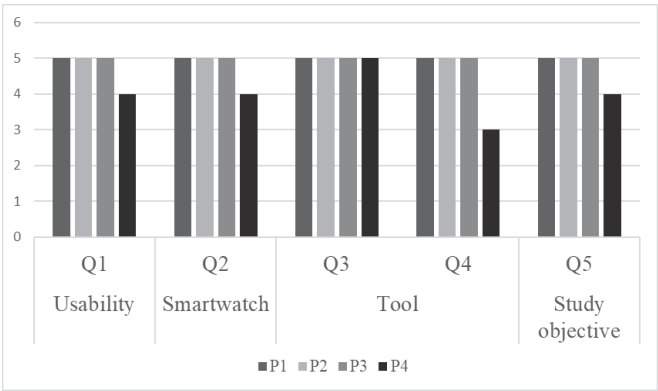


Fig. 7. Summary of survey responses from patients

On average, the "usability" of the System, use of the "*smartwatch*" for monitoring mental health, use of the therapy technique "tool", and compliance with the "objective of the study" obtained 4.75 each.

VII. CONCLUSION AND FUTURE WORK

In the literature, different works use physiological variables, techniques, and devices for monitoring anxiety and cardiovascular depression. However, they don't consider therapy techniques as the basis of the solution but as an extra section of information.

In the present study, the proposal is an approach to monitor anxiety and cardiovascular depression by applying the cognitive

behavioral therapy (CBT) technique in addition to measurements of the patient's physiological variables using *smartwatches*. It was done through the development of a mobile application (*WeCare*) carried out in 4 activities: choosing the type of CBT technique, selection of physiological variables, choosing the *smartwatch* model, and mobile application design.

Experimentation was carried out in a real-life environment and validated by expert judgment. It lasted for two weeks of therapy sessions between the patient and psychologist. In the first week, the therapy session was carried out traditionally. In the second week, the solution was applied.

The results of the real-life environment experiment showed that using the mobile application, the patient and psychologist discussed twice the number of events registered by the patient. In addition, the time required to measure heart rate and blood oxygenation levels using the *smartwatch* was, on average, 83% and 70% shorter, respectively, compared to using traditional methods. At the end of the scenarios, the psychologist rated an average of 4.75. On the other hand, the results of the expert judge validation showed the patients gave a rating of 4.75 and specialists 4.58. These values are close to the maximum score of 5 (completely agree).

For future work, it's proposed to consider other physiological variables such as blood pressure and respiratory rate, which can also be measured using *smartwatches* or other devices like sensors or monitors to complement the detection reports of their variations.

ACKNOWLEDGMENT

We want to thank the experts and patients who participated in the experimentation of the real-life environment and the expert judgment validation. Likewise, we thank the Research Department of the Universidad Peruana de Ciencias Aplicadas for the support provided to carry out this research work.

REFERENCES

[1] OMS official website, Salud Mental, Web: https://www.who.int/es/news-room/facts-in-pictures/detail/mental-health

[2] OMS official website, Los servicios de salud mental se están viendo perturbados por la COVID-19 en la mayoría de los países, Web: https://www.who.int/es/news/item/05-10-2020-covid-19-disrupting-mental-health-services-in-most-countries-who-survey

[3] Salud con Lupa, Consultas virtuales: cuando te desahogas con tu terapeuta a través de una pantalla. Salud con lupa, Web: https://saludconlupa.com/salud-mental/consultas-virtuales-cuando-te-desahogas-con-tu-terapeuta-a-traves-de-una-pantalla/

[4] M. Sheik, M. Qassem, & P. Kyriacou, "Wearable, Environmental, and Smartphone-Based Passive Sensing for Mental Health Monitoring", *Frontiers in Digital Health*, vol.3, April 2021.

[5] T. Iqbal, P. Redon-Lurbe, A.J. Simpkin, A. Elahi, S. Ganly, W. Wijns, & A. Shahzad, "A Sensitivity Analysis of Biophysiological Responses of Stress for Wearable Sensors in Connected Health", *IEEE Access*, vol. 9, May 2021, pp. 93567–93579.

[6] A. Ozanne, D. Johansson, U. Hällgren Graneheim, K. Malmgren, F. Bergquist, & M. Alt Murphy, "Wearables in epilepsy and Parkinson's disease-A focus group study", *Acta Neurologica Scandinavica*, vol. 137, July 2017, pp. 188–194.

[7] L. W. H. Lehman, R. G. Mark, & S. Nemati, "A Model-Based Machine Learning Approach to Probing Autonomic Regulation From Nonstationary Vital-Sign Time Series". *IEEE Journal of Biomedical and Health Informatics*, vol.22, Jan. 2018, pp. 56–66

[8] P. F. Zuccolo, M. O. Xavier, A. Matijasevich, G. Polanczyk, & D. Fatori, "A smartphone-assisted brief online cognitive-behavioral intervention for pregnant women with depression: a study protocol of a randomized controlled trial", *Trials*, vol. 22, March 2021, pp. 1–19.

[9] OMS official website, Salud mental: fortalecer nuestra respuesta, Web: https://www.who.int/es/news-room/fact-sheets/detail/mental-health-strengthening-our-response

[10] MINSA, Salud Mental, Web: https://www.minsa.gob.pe/portalweb/06prevencion/prevencion_76.asp

[11] J. Gagné, "L. Blanchet, M.-C. Laurendeau, D. Paul et J.-F. Saucier, La prévention et la promotion en santé mentale: préparer l'avenir, Boucherville, Gaëtan Morin Éditeur", *Nouvelles pratiques sociales*, vol. 7, 1994, pp. 257–261.

[12] Survey Google Form for experts. Available in: https://forms.gle/kHC95Vaxi2VK7Gz67

[13] Survey Google Form for patients. Available in: https://forms.gle/4QnkuBpYKK2w6nzW7

[14] D. Moragón, Ventajas y Desventajas de la Terapia Cognitivo Conductual. Psiky, Web: https://www.psiky.es/practica-clinica/terapia-cognitivo-conductual/ventajas-desventajas/

[15] Royal College of Psychiatrists, La terapia cognitivo conductual (TCC), Web: https://www.sepsiq.org/file/Royal/LA%20TERAPIA%20COGNITIVO-CONDUCTUAL.pdf

[16] S. Quinto, El modelo cognitivo conductual, Web: http://www.apalweb.org/docs/manualtcc.pdf

[17] C. Ibáñez, & R. Manzanera, "Técnicas cognitivo-conductuales de fácil aplicación en atención primaria (I)". *SEMERGEN - Medicina de Familia,* vol. 38, Sept. 2012, pp. 377–387.

[18] R. Thompson, "Emotion regulation: A theme in search of definition", *Monographs of the Society for Research in Child Development*, vol. 59, Feb. 1994, pp. 25–52.

[19] Psicología Online, La Observación Conductual, Web: https://online-psicologia.blogspot.com/2007/11/la-observacin-conductual.html

[20] A. Wells, D. Reeves, L. Capobianco, C. Heal, L. Davies, A. Heagerty, P. Doherty, & P. Fisher, "Improving the Effectiveness of Psychological Interventions for Depression and Anxiety in Cardiac Rehabilitation: PATHWAY—A Single-Blind, Parallel, Randomized, Controlled Trial of Group Metacognitive Therapy", *Circulation*, vol. 144, June 2021, pp. 23–33.

[21] R. P. Hirten, M. Danieletto, L. Tomalin, K. H. Choi, M. Zweig, E. Golden, S. Kaur, D. Helmus, A. Biello, R. Pyzik, C. Calcagno, R. Freeman, B. E. Sands, D. Charney, E. P. Bottinger, J. W. Murrough, L. Keefer, M. Suarez-Farinas, G. N. Nadkarni & Z. A. Fayad, "Factors Associated With Longitudinal Psychological and Physiological Stress in Health Care Workers During the COVID-19 Pandemic: Observational Study Using Apple Watch Data". *Journal of Medical Internet Research*, vol. 23, Sept. 2021.

[22] I. Saidi, P. P. Koumeka, S. Ait Batahar, & L. Amro, "Factors associated with anxiety and depression among patients with Covid-19", *Respiratory Medicine*, vol. 186, Sept. 2021.

[23] N. C. Basjaruddin, F. Syahbarudin & E. Sutjiredjeki, "Measurement Device for Stress Level and Vital Sign Based on Sensor Fusion", *Healthcare Informatics Research*, vol. 27, Jan. 2021, pp. 11–18.

[24] T. Chalmers, B. A. Hickey, P. Newton, C. T. Lin, D. Sibbritt, C. S. McLachlan, R. Clifton-Bligh, J. Morley, & S. Lal, "Stress Watch: The Use of Heart Rate and Heart Rate Variability to Detect Stress: A Pilot Study Using Smart Watch Wearables", *Sensors*, vol. 22, Dec. 2021.

[25] K. K. Jetelina, R. Molsberry, L. Malthaner, A. Beauchamp, M. B. Cannell, T. Hall, E. Fowler, & L. Anderson, "Acceptability of a real-time notification of stress and access to self-help therapies among law enforcement officers", *BMC Public Health*, vol. 22, Jan. 2022.

[26] L. Bolliger, J. Lukan, M. Luštrek, D. de Bacquer, & E. Clays, "Protocol of the STRess at Work (STRAW) Project: How to Disentangle Day-to-Day Occupational Stress among Academics Based on EMA, Physiological Data, and Smartphone Sensor and Usage Data", *International Journal of Environmental Research and Public Health*, vol. 17, Nov. 2020.

[27] A. Wells, K. McNicol, D. Reeves, P. Salmon, L. Davies, A. Heagerty, P. Doherty, R. McPhillips, R. Anderson, C. Faija, L. Capobianco, H. Morley, H. Gaffney, G. Shields & P. Fisher, "Improving the effectiveness of psychological interventions for depression and anxiety

in the cardiac rehabilitation pathway using group-based metacognitive therapy (PATHWAY Group MCT): Study protocol for a randomised controlled trial", *Trials*, vol. 19, April 2018.

[28] M. A. Fiol-DeRoque, M. J. Serrano-Ripoll, R. Jiménez, R. Zamanillo-Campos, A. M. Yáñez-Juan, M. Bennasar-Veny, A. Leiva, E. Gervilla, M. E. García-Buades, M. García-Toro, P. Alonso-Coello, G. Pastor-Moreno, I. Ruiz-Pérez, C. Sitges, J. García-Campayo, J. Llobera-Cánaves & I. Ricci-Cabello, "A Mobile Phone–Based Intervention to Reduce Mental Health Problems in Health Care Workers During the COVID-19 Pandemic (PsyCovidApp): Randomized Controlled Trial". *JMIR mHealth and uHealth*, vol. 9, May 2021.

[29] A. Chacaltana & P. Damián, "Inteligencia de mercados internacionales: método de evaluación de localización aplicado a los negocios internacionales", 2018, Web: https://repositorio.ulima.edu.pe/handle/20.500.12724/6647

[30] B. Sadock, V. Sadock & P. Ruiz, *Kaplan & Sadock's synopsis of psychiatry, 2015.*

[31] Samsung, Samsung Galaxy Watch 4 Classic, Web: https://www.samsung.com/es/watches/galaxy-watch/galaxy-watch4-classic-black-bt-sm-r890nzkaphe/

[32] Huawei, HUAWEI Band 6, Web: https://consumer.huawei.com/pe/wearables/band6/

[33] Fitbit, Fitbit Sense, Web: https://www.fitbit.com/global/es/products/smartwatches/sense

[34] Fitbit, Fitbit Versa 3, Web: https://www.fitbit.com/global/es/products/smartwatches/versa3

[35] Apple, Apple Watch Series 6, Web: https://www.apple.com/la/apple-watch-series-6/

[36] Xiaomi, Mi Smart band 6 Negro, Web: https://xiaomioficial.pe/band-xiaomi-mi-smart-band-6

[37] P., Del Aguila, D. Roque, L. Wong, "Quality Model for Educational Mobile Apps Based on SQuaRE and AHP", *Information Management and Big Data*, vol. 1577, pp 174–186.