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ПРИНЯТИЕ МОБИЛЬНОГО ЗДРАВООХРАНЕНИЯ ПАЦИЕНТАМИ С СЕРДЕЧНО-СОСУДИСТЫМИ ЗАБОЛЕВАНИЯМИ: СТРУКТУРНАЯ МОДЕЛЬ ИСПОЛЬЗОВАНИЯ МЕДИЦИНСКИХ ПРИЛОЖЕНИЙ

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Acceptance of Mhealth by Patients with Cardiovascular Diseases: the Structural Model of Health Applications Use

Резюме

Многими исследователями отмечается проблема приверженности лечения лекарственными препаратами пациентов с сердечно-сосудистых заболеваний (ССЗ). Технологии мобильного здравоохранения (mHealth) могут оказывать существенное положительное влияние на изменение поведения пациентов, профилактику и предупреждение обострений сердечно-сосудистых заболеваний (ССЗ). Для внедрения в практику такого подхода прежде всего следует выяснить возможности использования mHealth для пациентов с ССЗ. **Цель.** Изучить принятие медицинских приложений пациентами с ССЗ, а также оценить отношение пациентов к личной ответственности за сохранение своего здоровья в контексте использования mHealth. **Материалы и методы.** Моделирование структурных уравнений методом частичных наименьших квадратов в программе «Smart-PLS» (производитель SmartPLS GmbH, Германия) использовали для реализации модели UTAUT (англ. the unified theory of acceptance and use of technology: Единая Теория Принятия и Использования Технологий), включающую 10 конструктов: «Использование приложений», «Намерение использовать приложения», «Ожидаемая производительность», «Социальное значение», «Поддерживающие условия», «Отношение к использованию приложений», «Тревога», «Роль пациента», «Роль профилактики» и «Значение информации». В исследование включили 437 пациентов с ССЗ, которые имели опыт использования медицинских приложений: 253 женщины и 184 мужчин, средний возраст 47,95±5,22 лет. **Результаты.** Конструкты «Ожидаемая производительность», «Социальное значение», «Поддерживающие условия» и «Значение информации» оказывали прямое положительное влияние на конструкт «Намерение использовать приложения», объясняя 59,3 % дисперсии этого конструкта. Положительное влияние конструкта «Намерение использовать приложения» и «Отношение к использованию приложений» объясняло 61,2 % дисперсии конструкта «Использование приложений». Конструкт «Тревога» косвенно, через «Отношение к использованию приложений», оказывала негативное влияние на конструкт «Использование приложений». 41,4 % дисперсии конструкта «Значение информации», то есть понимание необходимости медицинской грамотности, зависело от конструкта «Социальное значение» и понимания роли личной ответственности за здоровье и профилактику ССЗ. **Заключение.** Пациенты с ССЗ понимают значимость личного участия в сохранении своего здоровья и готовы использовать mHealth для профилактики заболеваний и снижения модифицируемых факторов риска ССЗ. Барьером внедрения mHealth может быть страх пациентов перед самостоятельным использованием приложений. Принятие mHealth пациентами с ССЗ для повышения эффективности лечения будет возможно при наличии соответствующих технических условий, социальной поддержки, а также понятного и профессионального образа mHealth.

Ключевые слова: сердечно-сосудистые заболевания; мобильное здравоохранение; UTAUT; PLS-SEM; профилактика; роль пациента; медицинская грамотность

Конфликт интересов

Авторы заявляют, что данная работа, её тема, предмет и содержание не затрагивают конкурирующих интересов

Источники финансирования

Авторы заявляют об отсутствии финансирования при проведении исследования

Соответствие принципам этики

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Abstract

Many researchers have noted the problem of adherence to drug treatment in patients with cardiovascular diseases (CVD). Mobile health (mHealth) technologies can have a significant positive impact on changing patient behavior, preventing and preventing exacerbations (recurrences) of cardiovascular diseases (CVD). To put this approach into practice, first of all, it is necessary to find out the possibilities of using mHealth for patients with CVD. **Aim.** To study the acceptance of medical applications by patients with CVD, and also to assess patients' attitudes towards personal responsibility for maintaining their health in the context of using mHealth. **Materials and Methods.** Partial least squares structural equation modeling in the Smart-PLS environment was used to implement the UTAUT model (the unified theory of acceptance and use of technology), which included 10 constructs: Use of Applications, Intention to Use, Performance Expectancy, Social Influence, Facilitating Conditions, Attitude towards the use of Applications, Anxiety, Patient's Role, Role of Prevention and Value of Information. The study included 437 patients with CVD who had experience using medical applications: female (253) and males (184), average age 47.95±5.22 years. **Results.** Constructs Performance Expectancy, Social Influence, Facilitating Conditions, and Value of Information had a direct positive effect on construct Intention to use of health Applications and explained 59,3 % of the variance this construct. The positive influence of the construct Intention to use of Applications and Attitude towards the use of Applications explained 61,2 % of the variance in the construct Use of Applications. The construct Anxiety indirectly, through Attitude towards the use of Applications, had a negative impact on the construct Use of Applications. 41,4 % of the variance of construct the Value of Information, that is, an understanding of the need for medical literacy, was determined by the Social Influence construct, as well as an understanding of the role of personal responsibility for health and CVD prevention. **Conclusion.** Patients with CVD understand the importance of personal participation in maintaining their health and are ready to use mHealth to prevent the disease and develop behavior aimed at reducing modifiable risk factors for CVD. One of the barriers to mHealth adoption may be patients' fear of using medical applications on their own. Acceptance of mHealth technologies by patients with CVD to improve the effectiveness of treatment will be possible if there are appropriate technical conditions and social support that creates a trusting, professional, understandable and attractive image of mHealth.

Key words: cardiovascular diseases; mHealth; UTAUT; PLS-SEM; prevention; patient role; health literacy

Conflict of interests

The authors declare no conflict of interests

Sources of funding

The authors declare no funding for this study

Conformity with the principles of ethics

The study was approved by the local ethics committee of the Federal State Budgetary Educational Institution of Higher Education Siberian State Medical University of the Ministry of Health of Russia (No. 9628 of December 15, 2023). Participation in the study was voluntary, anonymous, non-interventional, and did not contain potentially harmful or burdensome questions. Survey participants provided informed consent, which is typical for online surveys

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mHealth — mobile health, PLS-SEM — Partial Least Squares Structural Equation Modelling, CVD — cardiovascular diseases, UTAUT — unified theory of acceptance and use of technology, IT — information technology

Introduction

Cardiovascular diseases (CVD), such as arterial hypertension, ischaemic heart disease and myocardial infarction, that are associated with the lifestyle, are the leading cause of deaths among employable population in any country. Prevention of exacerbations of these

diseases and development of serious complications bears a significant component: reduction of mortality rates and incapacitation among employable population.

An economic analysis of the use of non-drug and drug therapies in patients with cardiovascular diseases (CVD) demonstrates the advantage of using non-drug

measures for improvement of health and survival rates in such patients [1]. Cardiologists believe that prevention [2] and innovative strategies in medical institutions and non-clinical settings [3] are the keys to solution of this problem.

However, despite convincing facts on the need for prevention, people with a high risk of CVD are exposed to modified risk factors and inadequate drug therapies. For instance, Kotseva K. et al. (2016) [4] found out that 48.6% of CVD patients continued smoking, were barely active or inactive at all; 37.6% were obese; in 42.7% of patients, blood pressure was above 140/90 mm Hg; and 80.5% of patients did not achieve the target low density lipoprotein cholesterol values, etc.

This situation is a result of health-related decision-making outside the healthcare facilities. This demonstrates the need to search for tools, which allow taking sound decisions at home. A majority of experts agree that mHealth (mobile health) technologies can become a driving force in health improvement for patients with CVD [5].

This opinion is supported by experts from the World Health Organisation (WHO), who define mHealth as “the medical practices and public health practices supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices” [6]. The possibility of using mobile medical programs is supported by the public interest to such applications: in 2022, the estimated value of the global mobile health market was 8.9 billion US dollars; by 2030, it is expected to reach 72.10 US dollars, with an average annual rate of growth of 29.89% over the period from 2022 to 2030 [7].

It is assumed that systems supporting clinical decision-making with the help of mHealth allow reducing the number of medical errors and boost both quality and efficiency of healthcare [8]. Medical applications modify users' behaviour: they reduce the risk of CVD development and exacerbations [9]. Moreover, studies by Donovan G. et al. (2022) showed that the automation of bilateral doctor/patient communication and drug medication monitoring can facilitate reflexive motivation to take medications and comply with therapy regimens [10].

Nevertheless, the actual use of such systems is currently limited [11]. One of the obstacles is a subjective attitude of users regarding both clinical and economic efficiency of mHealth in use. Not all people are ready to embrace information technology (IT). For instance, irrespective of age, users may face some challenges due to personal characteristics, lack of knowledge, technical resources, etc. [12].

In a majority of cases, introduction of innovations is resource-intensive, and the use of smart solutions requires active public participation. In other words, introduction and efficient use of such technologies require an evaluation of the possibility of their acceptance by the target groups: doctors, patients and other interested parties. It necessitates the study of the factors affecting intention to use communication technologies, especially in healthcare.

Thus, this study was conducted to evaluate the public attitude to health-related applications in general, as well as to analyse the public attitude to the personal responsibility for health and use of applications to prevent CVD.

Mobile healthcare, including CVD management, is discussed in a number of publications, e.g. Belenkov Yu.N. and Kozhevnikova M.V. (2022) [13], Simenyura S.S., Sizova Zh.M. (2021) [14], Arshed M. et al. (2023) [15], etc. This study differs, as its main perspective is the idea of personal role in health support, factors which are essential for CVD prevention and adequate awareness of the mobile healthcare use. To this end, the UTAUT model used has been updated with new healthcare-specific constructs, namely “Patient's role”, “Role of prevention”, and “Significance of information”.

Materials and Methods

Justification of the model selection

There are wide array of models to study the acceptance of technologies. e.g. the Theory of Reasoned Action (TRA) the Theory of Planned Behavior (TPB), the Social Cognitive Theory (SCT), and the Extended Technology Acceptance Model (TAM2). However, these theories have significant limitations, and they are unable to describe the multidimensionality of technology acceptance by people. An attempt to create a single model combining various theories [16] resulted in the emergence of the unified theory of acceptance and use of technology (UTAUT), which was able to explain up to 77% of differences in user intents and 52% of dispersion in the use of technologies [17]. Later, in order to dismiss any doubts as to its ability to explain acceptance of technologies by some people, for the purpose of a more accurate explanation of user behaviour, the authors developed UTAUT2 [18], a model which explained up to 74% of differences in user intents and 52% of dispersion in the use of technologies [17]. The UTAUT2 model contains nine main constructions: intent to use and actual use of technologies, expected performance, expected effort, social significance, facilitating conditions, cost, hedonist motivation and habits, as well as three moderating variables:

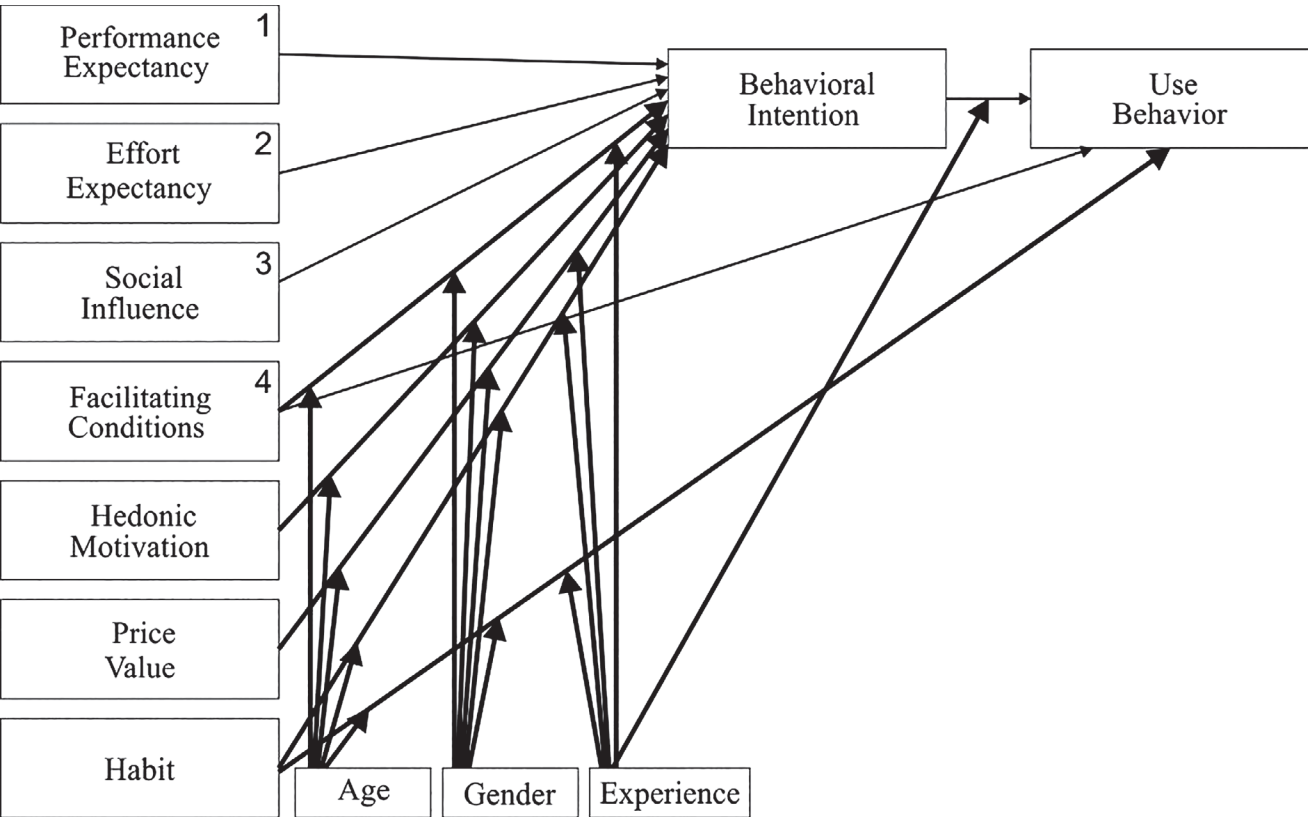


Figure 1. Модель UTAUT 2. Source: Venkatesh, Thong and Xu, 2012.
Note: 1. Moderated by age and gender. 2. Moderated by age, gender, and experience. 3. Moderated by age, gender, and experience. 4. Effect on use behavior is moderated by age and experience. 5. New relationships are shown as darker lines

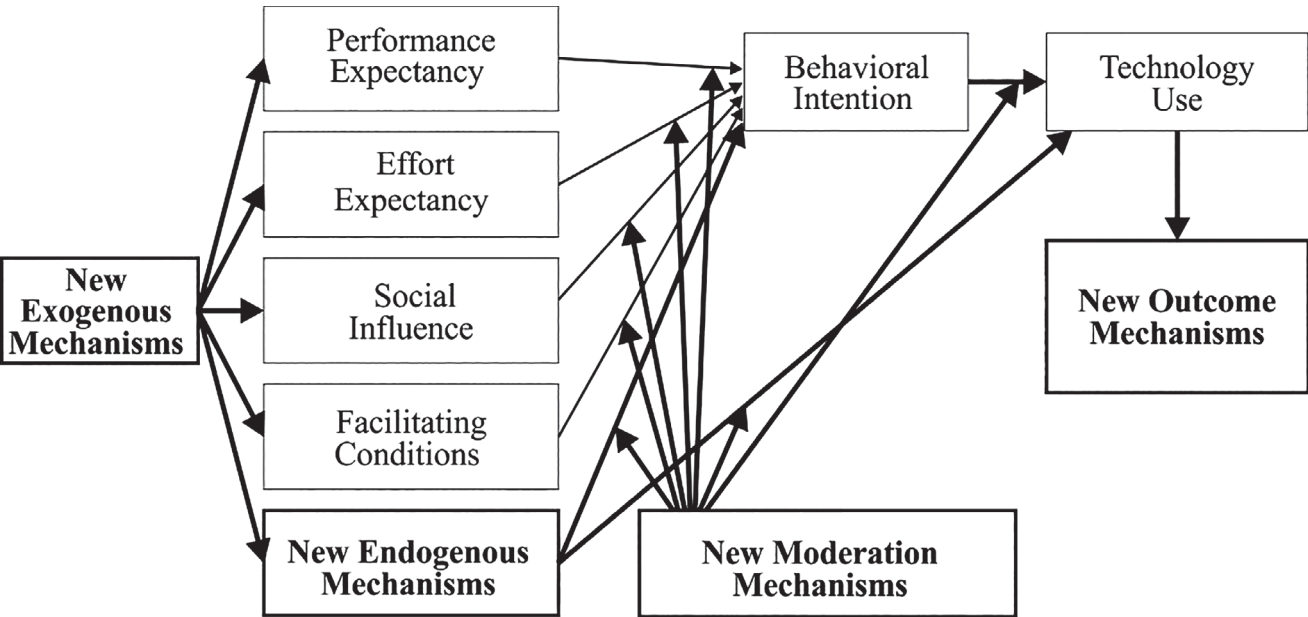


Figure 2. Four types of UTAUT extensions: new endogenous and exogenous mechanisms, new outcome and moderation mechanisms. Source: Venkatesh, Thong and Xu, 2016

sex, age and experience, which can impact the relations between constructs (Fig. 1).

There are various extensions of this model, which include new variables, e.g. attitude to the use of technologies, ease of use, perceivable risk and benefit, satisfaction, self-efficiency, etc. [19]. To account for all modifications made by researchers and not to set limits, the authors proposed to be guided by the four types of expended UTAUT studies described in publications, which include new endogenous and exogenous mechanisms, new mechanisms of moderation and result achievement (Fig. 2). The theory has been widely applied in the study of the use of information technology in healthcare [20], including introduction of mHealth, where additional constructs can include health consciousness and motivation, etc. [21]. Successful application of UTAUT in various areas and the possibility to add new essential constructs were the reasons for the use of this model in this study.

Selection of constructs and research hypotheses

In this study, the UTAUT model used both standard constructs (constructs 1–5) and additional constructs (constructs 6–10), introduced for the purposes of the study objective:

1. Construct “Use of technologies”: actual use of technologies. In this study, it means use of any health-related applications, the final construct of the model. Of note, the final construct in the UTAUT model is “Use of applications”, so this model is unable to study potential users’ interest in non-existing applications. Thus, in this study, the public opinion was evaluated in regard to the use of any health-related applications. This construct is defined by three questions ($\alpha = 0.79$): 1) Use of applications to monitor health (I have experience in using applications for health monitoring). 2) Use of applications to receive health-related information (I’m using applications to receive information on health support, healthy lifestyle). 3) Use of applications to assess physical activity (I sometimes use applications to assess my physical activity).

2. Construct “Intent to use applications”: in the UTAUT model, the actual use of a technology is dependent on the intent to use applications, which also depends on other key constructs [17]. In this study, it is use of medical and recreational applications. This construct is defined by three questions: 1) Intent to use medical applications in the future (I’m planning to use medical applications in the future). 2) Intent to use medical applications more regularly to monitor health (I’m planning to use medical applications more regularly in the future).

3) Intent to use medical applications more often for prevention and therapy (I’m planning to use medical applications in the future for prevention and therapy).

3. Construct “Expected performance”: in this study, it is the importance of applications to prevent CVD. This construct is defined by three questions: 1) Benefit (I think that health applications can be beneficial in my daily life). Performance (Use of health applications will facilitate health support). 3) Enhancement of efficiency (Health applications will make prevention more efficient).

4. Construct “Social significance”: it is the extent, to which an individual perceives that other people think that he/she should use the application, public opinion on the use of the application. This construct is defined by three questions: 1) Attitude to the use of applications (The general public should use health application functionality as much as possible). 2) Social role of applications (Health applications are essential in the social role of health support). 3) Need in applications for communication (Efficient communication with medical institutions is impossible without special applications).

5. Construct “Facilitating conditions”: it is the extent, to which an individual thinks that there is an organisational and technical infrastructure to facilitate use of the system, adequate technical equipment, as well as sufficient knowledge to use applications and availability of support where necessary. This construct is defined by four questions: 1) Sufficiency of technical devices (I have sufficient technical resources to use applications). 2) Knowledge (I have knowledge required for the use of electronic applications). 3) Adequacy of knowledge (I have sufficient knowledge to use applications). 4) Help with the use (I have someone to help me if I have questions on the use of applications).

6. Construct “Attitude to the use of applications”: attitude to similar applications in general, desire to have medical applications, readiness to explore new applications and enjoy it. This construct is defined by four questions: 1) Unwillingness for the applications to stop working (I wish health application did not stop working). 2) The ability of applications to make life more interesting (Health applications make life more interesting). 3) Need in medical applications (Applications for prevention and therapy are necessary for the general public). 4) Enjoyment from exploring new applications (I like exploring new mobile and computer apps).

7. Construct “Anxiety”: the intent and actual use of applications can be impacted by the fear to use any applications, fear to make an error, lose information, and reluctance to accept any types of technologies. This construct is defined by four questions: 1) Fear to use

applications (There are applications which I'm afraid to use (for various reasons). 2) Fear to lose information (I'm afraid that during the use of some applications I may lose a lot of information if I press a wrong button). 3) Fear of an error (I don't dare to use some applications because of the fear to make an error, which I won't be able to undo). 4) Fear to use (I'm a bit afraid of any applications).

Also, the model was updated with three new constructs, which characterised the overall attitude of respondents to information support, CVD prevention and the patients' role in this matter:

8. Construct "Patient's role": the role of the patient in CVD development, the need to engage the patient in CVD prevention and therapy, patient's readiness to act in case of a heart attack and their active participation in medical decision-making, i.e. implementation of one of the most important aspects of the patient-oriented approach. In this study, this construct is essential for understanding the possibility of engagement with CVD prevention and management. This construct is defined by four questions: 1) Overall role of the patient (The patient has an important role to play in CVD development). 2) Patient's engagement in prevention and therapy (The healthcare provider should try to engage the patient in CVD prevention and therapy). 3) The role of patient's knowledge (Each individual should be aware of CVD prevention and cardiovascular health). 4) An active position of the patient (Successful CVD prevention and therapy is impossible without active engagement of patients in medical decision-making).

9. Construct "Role of prevention": understanding of the need to prevent CVD exacerbations (relapses), avoidance of CVD risk factors, cholesterol level monitoring, participation in prevention in general, as well as the impact of the lifestyle, including smoking and obesity, and irreversibility of cardiovascular disorders. This construct allows assessing the attitude to the need to modify patients' behaviour to mitigate modifiable risk factors of CVD. To determine this construct, answers to the following eight statements were used: 1) Everyone needs CVD prevention. 2) It is important to avoid any factor triggering CVD. 3) Damaged heart cannot be repaired. 4) Heart diseases are associated mainly with the person's lifestyle. 5) The lifestyle should facilitate CVD prevention. 6) Monitoring of cholesterol levels is essential for CVD prevention. 7) Diabetes prevention reduces cardiac problems. 8) Smoking promotes CVD.

10. Construct "Significance of information": understanding that professional medical information should be available, and understanding the role of medical literacy for CVD therapy and prevention. Assessment of the need in highly available medical information on

measures to prevent CVD, the role of diet in CVD development, physical exercises, etc. This construct is defined by four questions: 1) Medical literacy (Medical literacy is crucial for prevention of cardiac disorders). 2) Information on prevention (Highly available professional information on measures to prevent CVD is required). 3) Information on the role of the diet (Reliable professional information should be available on the role of the diet in CVD). 4) Information on the role of physical exercises (Reliable professional information on physical exercises in prevention of CVD and exacerbations is essential).

Study hypotheses

The conceptual model of the study included testing of 17 hypotheses:

H1: The use of medical applications by CVD patients is positively impacted by the intent to use them

H2 (a, b): Construct "Expected performance" has positive impact on the intent of CVD patients to use applications (a) and the use of applications (b).

H3 (a, b): Construct "Social significance" has positive impact on the intent of CVD patients to use applications (a) and the use of applications (b).

H4 (a, b): Construct "Facilitating conditions" has positive impact on the intent of CVD patients to use medical applications (a) and the use of these applications (b).

H5 (a, b): Construct "Attitude to the use of applications" has positive impact on the intent of CVD patients to use applications (a) and the use of applications (b).

H6 (a, b): Construct "Anxiety" has negative impact on the intent of CVD patients to use applications (a) and the use of applications (b).

H7 (a, b): Construct "Significance of information" has positive impact on the intent of CVD patients to use applications (a) and the use of applications (b).

H8 (a, b): Construct "Role of prevention" has positive impact on the intent of CVD patients to use applications (a) and the use of applications (b).

H9 (a, b): Construct "Patient's role" has positive impact on the understanding of the need in available professional medical information (a) and preventive measures (b).

Data gathering

The study design corresponded to a cross-sectional observational sampling study. Data were collected from 15 December 2023 to 15 February 2024 using a questionnaire in Yandex Forms. This exploratory study used convenient sampling, where an electronic questionnaire was distributed like a "snowball" in social networks and

Table 1. Presence of arterial hypertension (AH), coronary heart disease (CHD), myocardial infarction (MI) and their combinations in male and female respondents

Cardiovascular diseases	Number of respondents, n (%)		
	Male	Female	Total
AH	160 (36,68)	214 (48,98)	374 (85,66)
AH + CHD	21 (4,74)	38 (8,68)	59 (13,43)
CHD + MI	3 (0,69)	1 (0,23)	4 (0,92)
Total	184 (42,11)	253 (57,89)	437 (100)

messengers: the authors of the article sent requests to their contacts (total: 120 people, including 67 men and 53 women), asking to send a link to the questionnaire to their 4–5 contacts of various ages and ask them to distribute the link as well. The request stated that of interest were subjects with a confirmed cardiovascular disease.

This study was approved by the Local Ethics Committee at the Siberian State Medical University of Russia (No. 9628 dated December 15, 2023). Participation in the study was voluntary, anonymous, non-interventional and did not involve any potentially dangerous or burdensome questions. Participants of the survey provided their informed consent typical for online surveys: the study objective was described in the chat inviting to participate, and its anonymous nature was mentioned; a person willing to participate could follow the link to complete the questionnaire. Users had two tiers to agree or refuse to take part: 1) they could not agree to take part in the survey in the chat, 2) they could refuse to send the electronic questionnaire to the researchers.

The questionnaire consisted of three parts:

- **Part 1.** Personal information (age, sex, education), experience in the use of any mobile applications and an idea of medicinal mobile applications, CVD status of the respondent.
- **Part 2.** Seven questions to implement the UTAUT model, i.e. to identify components of the following constructs: 1) “Use of applications”, 2) “Intent to use applications”, 3) “Attitude to the use of applications”, 4) “Expected performance”, 5) “Social significance”, 6) “Facilitating conditions”, and 7) “Anxiety”. Questions defining UTAUT components were taken from published studies with a minor adjustment [17].
- **Part 3.** Three questions related to constructs of the study area: “Patient’s role”, “Role of prevention”, and “Significance of information”.

A 5-point Likert-type scale was used to evaluate the statements in parts 2 and 3 of the questionnaire; the total score for the model elements was calculated by adding up answers to respective questions [22, 23].

So that all questions and answers were adequately clear to respondents, the questionnaire was pre-tested in 17 subjects of various age and educational background; the questionnaire was then improved and modified.

In this study, of interest were respondents who had experience in the use of medical applications and who were diagnosed with one or several of the following CVDs: ischaemic heart disease (IHD), myocardial infarction (MI), arterial hypertension (AH) (Table 1).

All in all, 793 answers by respondents were received, including 437 answers of “a cardiovascular disease diagnosed by a healthcare provider”. All respondents were cis-genders: 253 (57.89 %) women and 184 (42.11 %) men. 170 (38.90 %) respondents had secondary or vocational education, 267 (61.10 %) subjects had higher education. The mean age of respondents was 47.95 ± 5.22 years old, including 124 (28.38 %) respondents under 35 years of age, 170 (38.90 %) respondents — 35 to 55 years of age, and 143 (32.72 %) respondents — 56 to 71 years of age.

Since the survey was based on an electronic questionnaire on the Internet, the survey did not include users who did not use Internet technologies in their daily life.

Data analysis and software

The correlations were analysed using structural equation modelling with the use of partial least squares (PLS-SEM). PLS-SEM is widely used as a method to assess correlations between hidden (latent) variables [24] including in the use of UTAUT. Hidden variables cannot be measured directly, they are impacted by a number of measurable parameters, which are combined to form constructs. PLS-SEM does not require normally distributed data, because it is a non-parametric methodology, where a recommended measurement scale is ordinal, while the Likert-type scale is one of the most optimal.

The use of PLS-SEM allows quantifying correlations between constructs and identifying the most relevant parameters for the model, most significant

Table 2. Cronbach’s alpha (α) coefficient values for model constructs

Constructs of model	α
Performance Expectancy	0,85
Attitude Towards the Use of applications	0,77
Social Influence	0,73
Facilitating Conditions	0,75
Behavioral Intention	0,83
Use Behavior	0,79
Anxiety	0,72
Role of Patient	0,81
Role of Prevention	0,87
Value of Information	0,75.

recommendations and suggestions. PLS-SEM is focused on identification of the key constructs and is recommended not for testing of existing theories, but for exploratory studies [25], which was an additional reason to select this approach.

Calculations for UTAUT under the PLS-SEM model were performed with 3.3.3.Smart PLS software. p-Values, which equalled to 0.0000 in SmartPLS, were presented as $p < 0.001$. The statistical significance threshold α was $p < 0.05$. Also, statistical data were processed in MS Excel 2010 and Statistica 8.0. StatSoft. Inc.

Hypothesis testing

To confirm or reject suggested hypotheses, the study includes analysis of 17 correlations. According to the rule of ten [24], which is a rough, but a simple method to determine the sample size, for meeting the representativity requirements, this study requires 170 valid results, which is smaller than the resulting sample size.

The internal consistency of the questionnaire scales in Statistica 8.0. StatSoft. Inc. was determined using the Cronbach’s alpha, where the values were above the recommended 0.7 (Table 2).

Results

Usually, the use of PLS-SEM includes two steps: assessment of measurement validity and reliability and then structural model interpretation [24].

Assessment of model measurements

First, we deleted parameters (questions in the questionnaire) with the factor weight of less than 0.60, i.e. one question in construct “Facilitating conditions”. All other questions in the questionnaire had the factor weight of

over 0.7 [26], in other words, they were significant for the model.

The reliability and confidence of the construction variables were assessed using composite reliability (CR) and average extracted dispersion (AVE) (Table 3). All CR values were above the recommended level of 0.700 and AVE 0.500, confirming convergent confidence Factor dispersion inflation for each indicator to evaluate multicollinearity was < 5.0 [27]. Discriminant validity was assessed using cross-loads and the heterotrait-monotrait ratio of correlations (HTMT) method. All factor weights exceeded their cross-loads, and HTMT was below 0.85, it being a sign of discriminant validity [27]. The obtained results demonstrated sufficient reliability and confidence of measurements. This fact allows continuing with the analysis of technology acceptability using the UTAUT model to test the suggested hypotheses.

Hypothesis testing

Hypothesis testing resulted in a structural model of patients’ attitude to the use of medical applications for prevention, therapy and avoidance of CVD relapses (Fig. 3).

Correlations between elements were described with path coefficients (β) and the coefficient of determination (adjR^2) as a predicative value of the model (Table 3, Fig. 3).

The resulting model is able to explain **59.3 %** of dispersion in intent to use medical applications and **61.2 %** of dispersion in the use of medical applications. Data analysis fully confirmed only 6 out of 17 hypotheses suggested in this study (Fig. 3):

H1: Construct “Intent to use applications” (medical applications) directly correlated with their use ($\beta = 0.51$, $p < 0.001$)

Table 3. Average variance extracted (AVE), composite reliability (CR), and coefficient of determination (adjR²) of model constructs.

Конструкты	AVE t / p	CR t / p	adjR ²
Performance Expectancy	0,701 9,014/<0,001	0,813 17,365/<0,001	0,332
Attitude Towards the Use of applications	0,721 12,024/<0,001	0,837 15,249/<0,001	0,174
Social Influence	0,758 14,083/<0,001	0,862 22,271/<0,001	0,223
Facilitating Conditions	0,601 9,616/<0,001	0,816 17,936/<0,001	
Anxiety	0,73 16,45 /<0,001	0,892 36,960 /<0,001	
Behavioral Intention	0,750 10,599/<0,001	0,875 23,798/<0,001	0,593
Use Behavior	0,771 13,205 /<0,001	0,849 15,752/<0,001	0,612
Value of Information	0,775 11,433/<0,001	0,832 22,521/<0,001	0,41
Role of Patient	0,750 10,607/<0,001	0,857 15,303/<0,001	
Role of Prevention	0,698 7,021/<0,001	0,704 7,002/<0,001	

Note: t — t-test value, p — level of statistical significance

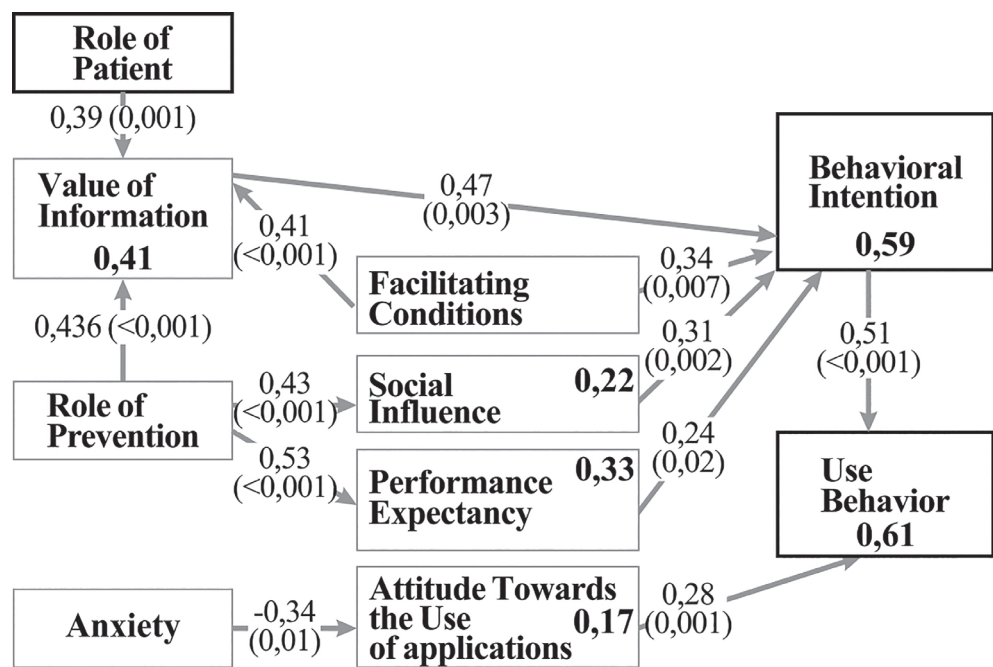


Figure 3. Structural model of patients' attitudes towards the use of medical applications for the prevention, treatment and prevention of exacerbations (recurrences) of CVD

Note: inside the rectangles is the coefficient of determination — adjR², the arrows indicate the path coefficients β and the p values in parentheses

H2 (a): Construct “Expected performance” directly correlated with the intent to use medical applications ($\beta = 0.24$, $p = 0.02$), but not with their use.

H3 (a): Construct “Social significance” directly correlated with construct “Intent to use applications” ($\beta = 0.31$, $p = 0.002$), but not with the use of medical applications.

H4 (a, b): Construct “Facilitating conditions” directly correlated with construct “Intent to use applications” ($\beta = 0.34$, $p = 0.007$), but not with the use of medical applications.

H5 (b): Construct “Attitude to the use of applications” directly correlated with construct “Use of applications” ($\beta = 0.28$, $p = 0.001$), but not with construct “Intent to use applications”.

H7 (a): Significance of professional medical information directly correlates with construct “Intent to use applications” ($\beta = 0.47$, $p = 0.003$), but not with the use of medical applications.

H9 (a): Understanding the patient’s role in health support directly correlates with construct “Significance of information”, i.e. with the understanding of the need in availability of professional medical information ($\beta = 0.44$, $p < 0.001$), but not with construct “Role of prevention”.

Construct “Role of prevention” is not directly associated with “Intent to use applications” and “Use of technologies”. At the same time, construct “Role of prevention” directly correlates with construct “Intent to use applications” via construct “Significance of information” ($\beta = 0.30$, $p < 0.001$), “Social significance” ($\beta = 0.29$, $p = 0.02$) and “Expected performance” ($\beta = 0.19$, $p = 0.03$).

“Anxiety” was inversely associated only with “Attitude to the use of applications” ($\beta = -0.34$, $p = 0.01$) and, via it, with “Use of medical applications” ($\beta = -0.12$, $p = 0.03$).

All mentioned constructs had statistically significant indirect impact on “Use of technologies” via “Intent to use applications”.

Discussion of Results

Results demonstrated that, on the one hand, the use of medical applications is impacted by construct “Intent to use applications” and, on the other hand, by construct “Attitude to the use of applications”, i.e. the extent, to which the user is generally willing to use such information technologies and considers them essential for prevention and therapy of cardiovascular diseases.

Predictably, “Expected performance”, i.e. the benefit of using mHealth, greatly impacted the intent to use the application. Expected performance can be a factor,

which is more important for acceptance and rejection of mHealth, as in case of chatbots in healthcare [28]. Also, our data confirm the UTAUT theory, suggesting that a significant factor of intention to use or the actual use of applications is “Facilitating conditions”. Acceptance and introduction of IT in healthcare is more likely, when patients have required resources and support [28].

For the implementation of the mHealth technologies, it is essential to take into account that one of the most important factors of the wide-scale implementation of information and communication technologies is anxiety associated with their use. It is assumed that a lot of people are still anxious when pushed to use computer technologies [29]. In this model, anxiety during the use of applications (construct “Anxiety”) had negative indirect and minor impact on the use of medical applications via “Attitude to the use of applications”. These results do not contradict other studies; moreover, they correspond to the statement that the attitude to acceptance of applications fully mediates the negative correlation between user’s anxiety and the attitude to the use [30]. At the same time, it has been demonstrated that anxiety has negative impact on perceived usefulness and perceived easy to use, therefore, it can reduce in the interest in the use of IT [31]. It is highly likely that implementation of mHealth will require special measures to eliminate fear to use applications, so that patients have positive attitude to these technologies and willingness to explore them.

“Social significance” of information and communication technologies is also essential to ensure their acceptance. That is why wide use of medical applications will require proof of their social significance. It is assumed that these correlations can be impacted by the social and economic status of the population [32], which should be taken into account during development and promotion of applications. To form a favourable attitude to mobile healthcare, it is advisable to efficiently use influencers’ opinion in order to eliminate obstacles in the use of applications; these should be close people and healthcare providers rather than famous persons.

The readiness of patients with cardiovascular disorders to use medical applications is impacted by availability of professional information on the measures to prevent CVD, the role of the diet and physical exercises in CVD development (construct “Significance of information”). Such correlations are discussed in other studies [33], where respondents are happy about information and communication technologies, if they can see that technologies are able to provide necessary and reliable information. Users feel they can trust and are in control when they are sure that services provided by mobile

health applications are reliable and meet their expectations [20].

The number one priority in the development of this structural model was to study respondents' opinion about the role of the patient in preservation of their own health and the role of prevention, which is one of the most pressing problems in healthcare. Surprisingly, constructs "Role of prevention" and "Patient's role" had only direct correlations with the intent to use applications via constructs "Significance of information" and "Facilitating conditions". The results show that the understanding of the role of prevention leads not only to the intent to use medical applications, but, what is most important, to understanding of the significance of professional medical information.

Of note, among the participating patients with cardiovascular diseases, there were no patients who fully denied the patient's role. It might have been associated with the fact that patients gave socially desired answers. However, on the plus side, patients with cardiovascular diseases think that this idea is correct, and they need some help in putting this idea into action. Results showed that the patients' understanding that successful prevention and management of cardiovascular diseases is impossible without their active involvement ensures acceptance of medical information. It means that patients need quality professional information, which should be provided to them. It can be one of the significant factors to attract patients to mobile healthcare. This idea is indirectly supported by studies, where the knowledge of health, health support and attitude to health were directly associated with intents to use innovative IT [34, 35]. On the other hand, such correlations are not always relevant. For example, Yang M. et al. (2024) [21] published data, where, according to the authors, specific behaviour of the Indonesians was responsible for a minor correlation between the intent to use m-Health and constructs "Conscious health" and "Motivation of health", i.e. readiness to take responsibility and undertake actions, which are beneficial for the health, or their motivation to engage into activities to facilitate good health.

Also, an important factor is that understanding of the role of cardiovascular disease prevention (indirectly) impacts the intent to use medical devices. It is clear that efficient measures to prevent cardiovascular recurrences are impossible without introduction of relevant IT (user applications); for example, to boost compliance of cardiovascular patients [13, 15]. Lack of full-scale comprehensive use of information and communication technologies in healthcare is inefficient not only medically, but also economically, because non-use of technologies results in low efficiency of healthcare [1].

Conclusions

Analysis of the structural model UTAUT of the use of mobile healthcare by patients with CVD allows making a number of general conclusions. CVD patients realise the significance of their personal involvement in preservation of their health and are ready to use mobile healthcare to prevent the disease and form habits focused on minimisation of the modifiable risk factors of CVD. One of the obstacles for the introduction of mHealth can be that patients fear to use medical applications on their own. Also, acceptance of mobile healthcare solutions by CVD patients for more efficient therapy will be possible if there are required technical conditions and social support, forming a trusted, clear and attractive image of mHealth. Therefore, some patients may require special training sessions to be able to use mobile applications.

An important task of the healthcare system is involvement of all populations in technological information processes. The practical value of this study is to study the factors impacting decisions to use applications and take an active part in support of own health, bringing about economic benefits for the society. On the other hand, the UTAUT model was updated with new healthcare-related constructs, which were tested for the significance for patient integration in the processes of CVD prevention and therapy using medical information technologies.

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QUESTIONNAIRE

The questionnaire consists of three parts:
Three variants of answers on the 5-point Likert-type scale and modified 5-point Likert-type scale were used to evaluate the statements in parts 2 and 3 of the questionnaire [Golubkov EP, 1998; Sandakov YaP et al., 2019].

Part 1. Personal information (age, sex, education), experience in the use of any mobile applications and CVD status of the respondent.

1. Choose your sex:

☐ Male

☐ Female

2. Choose your age group:

☐ Below 35 years old

☐ 35–55 years old

☐ Over 55 years old.

3. Choose your education

☐ Primary

☐ Secondary

☐ Vocational training

☐ Incomplete higher

☐ Higher

4. Have you had any EXPERIENCE IN USING any mobile applications to track your health? These are applications used to track your physical exercises, health status, calorie intake; they can remind you to take medications or drink water; you can use them to record blood pressure, blood glucose, etc. (e. g. Apple Health, Wellory, FatSecret, MyTherapy, Tide, Water Meter, Daylio, etc.):

☐ Yes

☐ No

5. Do you have any diagnosed cardiovascular disease? If yes, please specify:

☐

Part 2: Questions about the main constructs of the UTAUT model

1. Construct “Use of applications”:

1) I use a medical application to track my health status:

☐ Almost always

☐ Often

☐ Sometimes

☐ Rare

☐ Never

2) In my daily life, I use information on the Internet to support my health:

☐ Almost always

☐ Often

☐ Sometimes

☐ Rare

☐ Never

3) I use mobile applications to record my physical activity:

☐ Almost always

☐ Often

☐ Sometimes

☐ Rare

☐ Never

2. Construct “Intent to use applications” (medical applications):

4) I am planning to use medical applications in the future:

☐ Completely agree

☐ Partially agree

☐ Neither agree nor disagree

☐ Partially disagree

☐ Completely disagree

5) I will be using medical applications to monitor my health status more regularly in the future:

☐ Completely agree

☐ Partially agree

☐ Neither agree nor disagree

☐ Partially disagree

☐ Completely disagree

6) In the future, I will be using medical applications for prevention and therapy:

☐ Completely agree

☐ Partially agree

☐ Neither agree nor disagree

☐ Partially disagree

☐ Completely disagree

3. Construct “Expected performance”:

7) I think that medical applications can be beneficial in my daily life:

☐ Completely agree

☐ Partially agree

☐ Neither agree nor disagree

☐ Partially disagree

☐ Completely disagree

8) Using medical applications will benefit my health:

☐ Completely agree

☐ Partially agree

☐ Neither agree nor disagree

☐ Partially disagree

☐ Completely disagree

9) Medical applications will ensure more efficient preventive healthcare more me:

☐ Completely agree

☐ Partially agree

☐ Neither agree nor disagree

☐ Partially disagree

☐ Completely disagree

4. Construct “Social significance”

10) The public should use mobile health functionality as much as possible:

☐ Completely agree

☐ Partially agree

☐ Neither agree nor disagree

☐ Partially disagree

☐ Completely disagree

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- 11) Medical applications are essential for the social role in health support:
- ☐ Completely agree
 - ☐ Partially agree
 - ☐ Neither agree nor disagree
 - ☐ Partially disagree
 - ☐ Completely disagree
- 12) Efficient cooperation with medical organisations is impossible without special web-based applications:
- ☐ Completely agree
 - ☐ Partially agree
 - ☐ Neither agree nor disagree
 - ☐ Partially disagree
 - ☐ Completely disagree
5. Construct “**Facilitating conditions**”:
- 13) I have technical resources to use mobile applications:
- ☐ Completely wrong
 - ☐ Partially wrong
 - ☐ Neither true nor wrong
 - ☐ Partially true
 - ☐ Completely true
- 14) I have knowledge required for the use of mobile applications:
- ☐ Completely wrong
 - ☐ Partially wrong
 - ☐ Neither true nor wrong
 - ☐ Partially true
 - ☐ Completely true
- 15) I have sufficient knowledge to efficiently use mobile applications:
- ☐ Completely wrong
 - ☐ Partially wrong
 - ☐ Neither true nor wrong
 - ☐ Partially true
 - ☐ Completely true
- 16) I have someone to support me if I have questions about the use of mobile applications:
- ☐ Completely true
 - ☐ Partially true
 - ☐ Neither true nor wrong
 - ☐ Partially wrong
 - ☐ Completely wrong
6. Construct “**Attitude to the use of applications**”:
- 17) I would not like that mobile health applications stopped working:
- ☐ Completely agree
 - ☐ Partially agree
 - ☐ Neither agree nor disagree
 - ☐ Partially disagree
 - ☐ Completely disagree
- 18) Mobile health applications make life more interesting:
- ☐ Completely agree
 - ☐ Partially agree
 - ☐ Neither agree nor disagree
 - ☐ Partially disagree
 - ☐ Completely disagree

- 19) Mobile applications for prevention and therapy are essential for the public:
- ☐ Completely agree
 - ☐ Partially agree
 - ☐ Neither agree nor disagree
 - ☐ Partially disagree
 - ☐ Completely disagree
- 20) I like exploring new mobile applications:
- ☐ Completely true
 - ☐ Partially true
 - ☐ Neither true nor wrong
 - ☐ Partially wrong
 - ☐ Completely wrong
7. Construct “**Anxiety**”:
- 21) There are mobile applications I don’t dare to use (due to various reasons):
- ☐ Completely true
 - ☐ Partially true
 - ☐ Neither true nor wrong
 - ☐ Partially wrong
 - ☐ Completely wrong
- 22) I fear that I can lose a lot of information if I do something wrong while using some applications:
- ☐ Completely true
 - ☐ Partially true
 - ☐ Neither true nor wrong
 - ☐ Partially wrong
 - ☐ Completely wrong
- 23) I don’t dare to use some mobile applications because of the fear to make irreversible mistakes:
- ☐ Completely true
 - ☐ Partially true
 - ☐ Neither true nor wrong
 - ☐ Partially wrong
 - ☐ Completely wrong
- 24) I’m a bit afraid of any applications:
- ☐ Completely true
 - ☐ Partially true
 - ☐ Neither true nor wrong
 - ☐ Partially wrong
 - ☐ Completely wrong

Part 3. Three questions related to constructs of the study area: “Patient’s role”, “Role of prevention”, and “Significance of information”.

8. Construct “**Patient’s role**”:
- 25) Patients themselves have an important role to play in development of cardiovascular diseases:
- ☐ Completely agree
 - ☐ Partially agree
 - ☐ Neither agree nor disagree
 - ☐ Partially disagree
 - ☐ Completely disagree

26) Doctors should strive to **engage patients in prevention and therapy** of cardiovascular diseases:

- ☐ Completely agree
- ☐ Partially agree
- ☐ Neither agree nor disagree
- ☐ Partially disagree
- ☐ Completely disagree

27) Each and every one should possess **knowledge on measures to prevent** cardiovascular diseases and support cardiovascular health:

- ☐ Completely agree
- ☐ Partially agree
- ☐ Neither agree nor disagree
- ☐ Partially disagree
- ☐ Completely disagree

28) Successful prevention and therapy of cardiovascular diseases are impossible without **active engagement of patients** in medical decision-making:

- ☐ Completely agree
- ☐ Partially agree
- ☐ Neither agree nor disagree
- ☐ Partially disagree
- ☐ Completely disagree

9. Construct "Role of prevention":

29) Each person **needs prevention** of cardiovascular diseases:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

30) It is essential that everyone avoids any factor, which causes cardiovascular diseases:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

31) A damaged heart cannot be repaired:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

32) Heart diseases are mostly associated with the person's lifestyle:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

33) **The lifestyle** should promote prevention of cardiovascular diseases:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

34) **Cholesterol levels should be monitored** in order to prevent cardiovascular diseases:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

35) Diabetes prevention reduces the risk of heart conditions:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

36) Smoking increases the risk of cardiovascular diseases:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

10. Construct "Significance of information":

37) **Medical literacy** is **essential for prevention** of cardiovascular diseases:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

38) It is essential to ensure high availability of reliable professional **information on prevention** of cardiovascular diseases:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

39) It is essential to ensure availability of reliable professional **information on the role of diet** in the development of cardiovascular diseases:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong

40) It is essential to ensure availability of reliable professional **information on the role of physical exercises** in prevention of cardiovascular diseases and prevention of relapses:

- ☐ Completely true
- ☐ Partially true
- ☐ Neither true nor wrong
- ☐ Partially wrong
- ☐ Completely wrong