A Bot-Based Self-Report Diagnostic Tool to Assess Post-Traumatic Stress Disorder

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Abstract. This paper discussed using a bot-based self-report diagnostic tool to identify post-traumatic stress disorder. The authors present information technology for assessing the psychological state of individuals who have experienced traumatic events in a stressful environment. The technology uses the International Trauma Questionnaire (ITQ) and additional questions describing the current psychological environment. The study employed data analysis techniques to identify significant dependencies between respondents' answers to additional questions about the current environment and their ITQ scores. The bot interface provides a user-friendly platform for respondents to complete the questionnaire. The analytical system, which includes data collection, storage, and processing, allows for flexibility in modifying the questionnaire based on ongoing research.

Keywords: Post-Traumatic Stress Disorder, International Trauma Questionnaire, Bot, Data Analysis, Database Structure.

1 Introduction

The full-scale invasion has caused irreparable damage to the people and economy of Ukraine. Observable damage includes dead and maimed people, destroyed infrastructure, mined areas, etc. But equally threatening is the unobservable damage, particularly the impact on people's mental health.

According to current estimates, 30% of Ukraine's population suffers from post-traumatic stress disorder (PTSD). This figure will increase over time. Stress affects health, and there is already talk of an explosive increase in heart attacks, strokes, and cancer.

PTSD is a mental disorder that can develop after exposure to exceptionally threatening or terrifying events. PTSD can occur after a single traumatic event or because of prolonged exposure to trauma. Individuals cannot recover from exposure to trauma [1].

In [2], it was explained how PTSD was first recognized and defined in DSM-III after pressure to acknowledge the psychological effects of war on Vietnam veterans and concentration camp survivors. Diagnostic categories are commonly used to study and treat mental illness, helping researchers identify those with the disorder based on specific symptoms. PTSD includes four clusters of symptoms: intrusive memories, avoidance

of trauma-related triggers, adverse changes in mood and thoughts, and changes in reactivity. The DSM-5 added new criteria for changes in mood and cognition seen in PTSD. Assessing trauma and correctly attributing symptoms to a specific event is essential, but multiple factors can influence response and recovery. Military personnel may experience trauma from combat duties or be in dangerous conditions, while civilians can be traumatized by witnessing others' suffering. However, no clear rules exist for determining when an event causes injury [3].

Unfortunately, people hide psychological problems and do not seek medical help. This is why we need a point-of-care diagnostic tool that is always at hand and against which there is no prejudice. The solution could be to use a bot.

As the ground for the bot, we propose to use the International Trauma Questionnaire (ITQ), which is a self-report diagnostic measure of PTSD and complex PTSD (CPTSD) [4]. However, the ITQ research was conducted under "stable" conditions. The current conditions of Ukrainians cannot be classified as stable. On the contrary, a challenging, stressful situation can lead to a disorder without a single traumatic event. Therefore, there is a need to investigate the properties of the ITQ for people on the home front living under stressful conditions but not sharply traumatized.

We formulated a working hypothesis: the ITQ retains the properties of PTSD recognition in the stressful environment of the home front of military conflict. The hypothesis can be tested using data analysis techniques.

The work aimed to propose an information technology approach for investigating the sensitivity of the ITQ in diagnosing PTSD and to conclude whether the questionnaire should be used to momentarily diagnose a person's mental condition in a stressful environment on the home front.

The paper is structured as follows. Section 2 provides an overview of the critical research on which our work is based. In section 3, we described the information technology of ITQ properties studying. Section 4 describes the application of the proposed information technology. Finally, the general conclusions of the work are collected in Section 5.

2 Related Works

An inevitable outcome of information technology development became the development of medical software applications. The software for diseases diagnosing or predicting changes in patient’s conditions has particular importance. Such software’s results can directly impact a person's life.

The diagnostics are based on the study of the person’s condition indicators. The primary task is to define a set of diagnosis indicators and decide whether to analyze the indicators statistically or dynamically.

In [5] overviewed such a category of software for diagnosis and prognosis of the patient as the various systems for EWS (Early Warning Scores), e.g., the Royal College of Physicians National Early Warning Scale (NEWS), Modified Early Warning System (MEWS), supplemented by other assessments, Pediatric Early Warning System. (PEWS).

Let us take the NEWS system, developed by researchers at the University of Portsmouth, as an example of software for predicting changes in a patient's condition—the development aimed to recognize a patient's deteriorating condition early to respond to it. The early warning assessment initiates a formal evaluation by the responsible clinician. NEWS is based on a fixed number of parameters and gives a cumulative score within certain limits. Patients are categorized into risk groups depending on the value of the cumulative score [5].

The system has evolved over a long period. The system processes' scheme and development are shown in Figure 1, where *TS* describes the set of indicator values *PV* for patient *pt* at time *t*, and *pd* is the measurement period. The number and composition of the indicators remain unchanged. In the initial version [6], the integrated assessment was calculated without considering the disturbances in the values of the individual extreme indicators. In [7], the methodology was corrected to reduce additional work for the bedside nurse and treating physician, which was disproportionate to the benefit of more frequent detection of adverse outcomes.

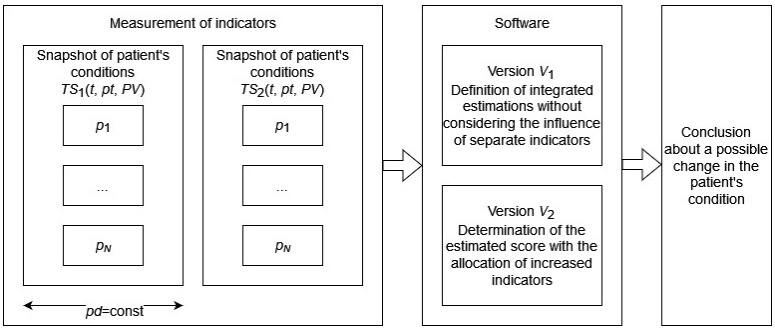

Fig. 1. Schema of NEWS system

A group of authors investigated the extent to which the results of commonly measured laboratory tests collected shortly after admission can be used to distinguish between in-hospital mortality [9].

The researchers also conducted a study applying this approach to surgical versus therapeutic patients. They showed that the developed EWS differentiated deterioration in surgical patients at least as much as in medicinal patients [10].

In [11], the application of the developed system was investigated in COVID-19 patients. It showed that adding new covariates or changing the weight of existing parameters is unnecessary when assessing patients with COVID-19.

The features of the considered systems are listed below:

- patients were hospitalized;
- measurements of parameters were made using appropriate tools and are objective;
- the frequency of measurements was guaranteed.

The issue may be caused by the short measurement period, which does not allow prediction before the patient's critical condition occurs.

Each mental illness has its characteristics. Diagnosis can be made using symptoms that are defined in different guidelines. In [11], the DSM-5 and ICD-11 (International Classification of Diseases) were compared. There was shown that different approaches to symptom management are used, “the DSM-5 encompassing a broad definition, and the ICD-11 instead proposing a narrow PTSD construct and introducing the new diagnosis complex PTSD (CPTSD), comprising PTSD in conjunction with ancillary symptoms.” The DSM-5 diagnosis of PTSD consists of twenty symptoms, grouped into four groups: re-experiencing, avoidance, negative changes in cognition and mood, and changes in arousal and reactivity. The ICD-11 describes PTSD with six symptoms grouped into three groups: re-experiencing, avoidance, and heightened feelings of threat. Tools for assessing PTSD are highlighted in [12]: the PCL-5 post-traumatic stress checklist and the International Trauma Interview (ITI).

The PCL-5 is a 20-item self-assessment that assesses 20 symptoms of PTSD according to the DSM-5. The goals of the PCL-5 are to monitor symptom change during and after treatment, to screen people for PTSD, and to make a preliminary diagnosis of PTSD [13, 14].

In [2], there was estimated that 636,120 combinations of symptoms are possible for the DSM-5. As a result, it could be that DSM diagnoses do not include people for whom the "right" combination of symptoms is missing or those for whom the diagnosis does not fit. The conclusion is that “the desire for a diagnosis to encompass the broad spectrum of posttraumatic presentations led to a diagnosis in DSM-5 that was complex, even compared with other DSM disorders.”

The International Trauma Interview (ITI) with Physician Assessment and the International Trauma Questionnaire (ITQ) were designed according to general ICD-11 principles; that is, a limited number of core characteristics (12 symptom indicators plus indicators of functional impairment) are used to identify the disorder [12, 15]. The ITQ is a self-report measure of diagnostic PTSD and complex PTSD (CPTSD) [4].

In [16], the need to simultaneously consider the type of trauma and severity of PTSD symptoms when studying emotion regulation in trauma survivors was investigated. The relationship between PTSD and difficulties in emotion regulation was confirmed.

Studies show that the language of implementation of surveys initially written in English and translated into 25 languages does not affect diagnostic results (e.g., [12] for Swedish, [17] for Chinese, [18] for Dari).

In [19], the application of machine learning (ML) and the evaluation of induction modeling approaches are reviewed. Hypotheses are considered as to whether ML can be used to see a statistical correlation between observed symptoms and PTSD exacerbation, whether the relevance of early symptoms used by medical professionals to predict PTSD, whether the period needed to predict PTSD exacerbation can be determined, and whether ML-induced models can be used to predict PTSD exacerbation. All this when considering the situation one month after injury: the authors showed that using ML methods unambiguously brings results for all hypotheses. Also, an essential finding of the study is that surveys using smartphones to self-report symptoms can be simplified. However, the features of the study are that a rigid period of one month after an injury is set and that people with an already confirmed diagnosis participated in the study.

The outcome of the published work analysis was the hypothesis that the ITQ translated into Ukrainian could be used to diagnose PTSD in the current context. However, it makes sense to examine the influence of external factors on the components of the integral assessment under ITQ.

3 Information Technology of Significant Dependencies Identification

The proposed information technology is based on the use of an ITQ. We must consider that the ITQ properties were investigated in a stable environment. How the stressful environment affects the findings of the questionnaire as a whole and the values of individual indicators, have not been studied before. Information technology, therefore, should analyze the properties of ITQ under continuous stress conditions.

3.1 Identification of Significant Dependencies

The ITQ is a brief, simply worded measure of the core features of PTSD, which is consistent with maximizing clinical utility and international applicability through a focus on a limited but central set of symptoms [4]. In our research, we used an 18-item version of ITQ. Two-factor Second-Order Model of ITQ, which is used in the study, includes two second-order latent symptoms of PTSD, explaining the covariation between re-experiencing (RE), avoidance (AV), and perceived threat (TH), and DSO (Disturbances in Self-Organization), explaining covariation between affective dysregulation (AD), negative self-concept (NSC) and relationship disturbances (DR).

The analysis of the Second-Order Model supports two types of results. The first one is binary and is based on the Boolean logic. For this purpose, each response Q_i is labeled as True or False based on the condition $Q_i \geq 2$. Disjunctions of respective question labels provide the labels for symptoms, and conjunctions of respective symptom labels provide the labels for PTSD and DSO diagnosis. The second one is numerical and is based on dimensional scoring. Scores are calculated for each symptom and summed in clusters to produce PTSD and DSO scores.

Published studies of the ITQ properties had been conducted on the condition that the inclusion criteria for the sample selection contained screened positive for at least one lifetime traumatic event. Usually, the list of traumatic events is provided by Life Events Checklist, which has only one item, “Combat or exposure to a war zone (in the military or as a civilian),” connected with war conditions.

In the current situation, describing the environment in detail is advisable. Practicing psychologists have been brought in to identify questions that might reflect a military conflict environment. This question set was added after the primary ITQ questions. The basic assumption for identifying significant dependencies was that a significant factor splits the responses set into classes with considerable differences.

The input data for the study are the answers to the questions in the questionnaire. The first block of responses corresponded to the items in the ITQ questionnaire; the

second block of responses corresponded to questions about the factors whose influence is being studied. Figure 2 shows the scheme of the multi-block questionnaire using.

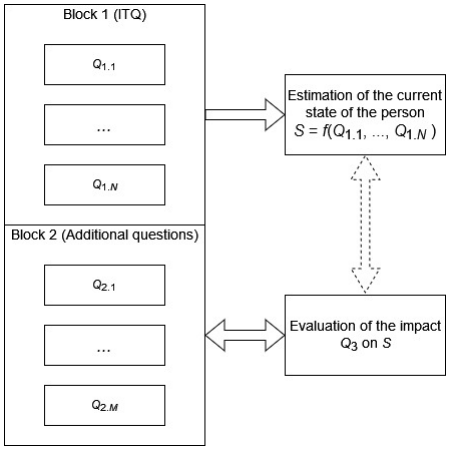

Fig. 2. Scheme of using the multi-block questionnaire

Let us describe the proposed technology for identifying significant dependencies.

1. Move from answers to questions $Q_{1,1}$–$Q_{1,N}$ to integral estimates of indicators PTSD, RE, AV, TH, DSO, AD, NSC, and DR. In other words, object descriptions are moved from 18 features space to eight features space.

2. For each question from the set $Q_{2,1}$–$Q_{2,M}$

2.1. Classify the objects represented by integral features by the variants of answers to the related question.

2.2. Calculate the percentage distribution of the responses corresponding to high and low anxiety.

3. Analysis of the consistency of percentage distributions with ITQ results (integral estimations of PTSD and DSO).

Suppose the results of the analysis at step 3 agree with the results of the ITQ processing. In that case, it can be assumed that the ITQ is applicable for analyzing the condition of people in a stressful home front environment.

Figure 3 shows the activity diagram for the work process for information technology.

The work process begins with the experts, who supplement the ITQ questions with questions about the current environment to form the questionnaire. The questionnaire is then handed over to the data analysts, who prepare the software tool and data structures to efficiently handle the raw survey results. A link to the bot is sent out to potential respondents. After the respondent finishes answering the questionnaire, the bot displays an instant diagnostic result obtained with a standard algorithm for the ITQ. The data analysts prepare the collected data and aggregate the results for the questions in block 3. The results of the calculations are transmitted to the experts for review and semantic interpretation.

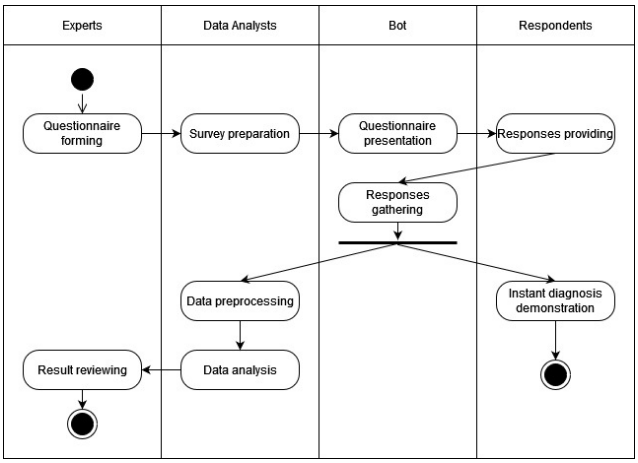

Fig. 3. Activity diagram for work process

3.2 Bot Description

A survey bot is an automated tool that engages in interactive conversations with survey respondents to collect data and feedback.

To provide a user-friendly interface, the bot should have a clean and intuitive interface that guides respondents through the survey process. The bot follows a logical conversation flow, presenting questions to respondents with respect to the questionnaire's order. As the base of the questionnaire, we used the Ukrainian translation of the 18-item version of ITQ. Figure 4 shows the screenshots of the questionnaire.

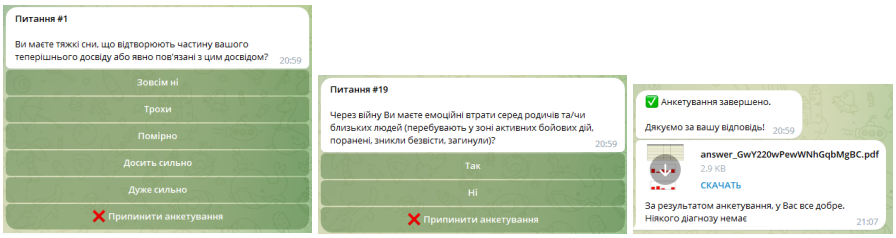

Fig. 4. Screenshots of the bot interface

The bot supports only the multiple-choice question type. Responses to the questions on the ITQ can be unambiguously translated into the Likert scale. The bot's algorithm was constructed so the participant could interrupt the interview at any time. This feature protects against the risk of discomfort for participants when asking about potentially traumatic events and psychological symptoms [11].

We focus attention on the sensitivity of gathered responses. So, the bot complies with relevant data protection regulations, ensures secure data transmission and storage, and provides clear information on how the collected data will be used and protected at the first run.

The developed bot is encapsulated in the analytical system.

3.3 Analytical System for Dependencies Identification

The development process of the analytical system can be represented as the set of activities shown in Figure 5.

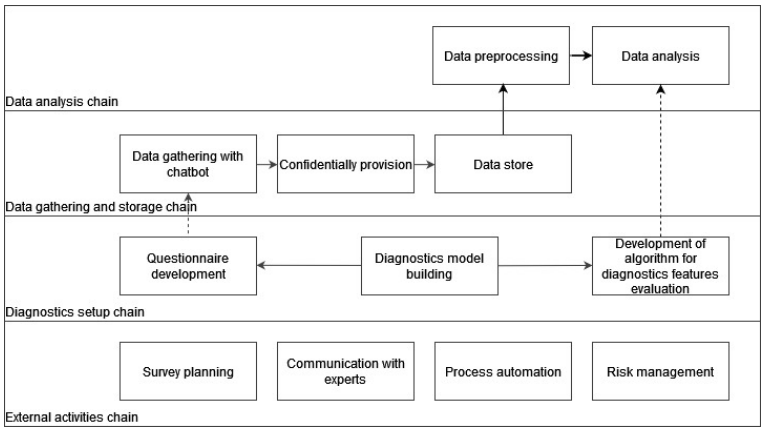

Fig. 5. Block diagram of the analytical system

The external activities chain includes survey planning, communication with experts, process automation, and risk management.

Survey planning consists of the following sub-activities:

- Defining the purpose of the survey: studying the psychological state of a person during the war, which is accompanied by intense stress and traumatic events for the population.
- Defining the target audience: people participating in the survey can be divided into separate categories (e.g., war veterans, those who were not directly affected by the military conflict but still experienced its impact, etc.). The civilians' category can be subdivided into subcategories: women, children, older adults, people with disabilities, etc.
- Setting up survey parameters: determining the time parameters, possible modes and deadlines for completing the survey, the number of questions, etc.

Communication with experts should include such sub-activities as:

- Finding professional psychologists who have a high level of knowledge, experience, and qualifications in the field of PTSD and can provide authoritative advice and recommendations on issues related to this field.
- Involvement of experts in the development of the questionnaire content.
- Involvement experts (if necessary) in consulting and decision-making based on the survey results.

- Ensuring effective communication implies clarity, mutual understanding, two-way interaction, trust, transparency, regular contacts, and reports to determine progress in resolving issues.

Automation of processes in PTSD diagnosis involves the use of various technologies and tools for automatic data collection and analysis, including the Telegram API, which reduces the time and cost of diagnosis, improves the accuracy and reliability of results, and increases the efficiency of resource use.

Risk management includes the identification, assessment, control, and minimization of possible risks associated with inadequate qualifications of experts, errors in the diagnostic methodology, errors in the structure of the questionnaire, algorithms for calculating diagnostic indicators, insufficient number of questions, and errors in the software.

Questionnaire development activity is closely connected with the development of database structure. Because we planned the questionnaire modification based on the result of the research, we should have provided flexibility in the data storage structure. We used the database structure, which made it possible to reconfigure the questionnaire "on the fly" and continue collecting data. For example, the fourth additional question in the first version of the questionnaire was phrased as "Do you hide during an air raid?" Then it was decided to change the question's wording and offer five possible answers.

The implemented analytical system was used to study the ITQ properties.

4 Case Study

The study was conducted on a non-clinical sample of 286 people between the ages of 16 and 60 who were in Ukraine at the start of the war. It was realized as an anonymous Internet survey using a Telegram bot. The link was distributed in a friend-to-friend way. We sent the link to the groups of students and refugees and colleagues and acquaintances. As well we asked our contacts to spread the link further. At the time of the survey, respondents were living both in the territory of Ukraine and abroad.

After removing the records with missing values, a final dataset consisted of n=212 records. In the final set, 137 entries corresponded to respondents who manifested PTSD and disturbances in self-organization (DSO).

Initially, the number of questions in block 1 was N=18, and in block 2 was M=9. The data analysis showed that the personal feelings or circumstances revealed by the questions in block 2 correlated with the results determined by the standard algorithm for the ITQ, probably reinforcing the manifestations of PTSD.

We studied the relationship between the PTSD status identified using the standard algorithm for ITQ and the answers to questions in block 2. We can distinguish all responses in block 2 into two categories: K_1 is the category of responses for high anxiety, K_2 is the category of responses for low anxiety. We modeled the relevancy of the category responses as

K_j = {$Q_{2.1}$ <"Answer1", "Answer2", ...>, …, $Q_{2.9}$ < "Answer1", "Answer2", ...>},
where $Q_{2.i}$, i=1...9 are the question numbers in block 2.

Figure 6 shows the percentage contributions of the two response categories.

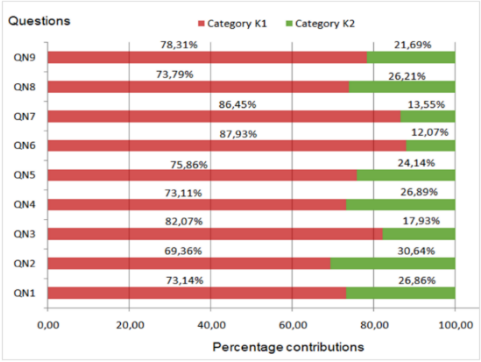

Fig. 6. Distribution of answers to questions in block 2 in the presence of PTSD

As we can see, the answers to category K_1 are expressively dominant in all questions. As the survey results demonstrate the consistency of blocks 1 and 2, we can conclude that the ITQ is relevant when used in a stressful home front environment.

The list of questions in block two or options for answering individual questions could change as the Ukraine war situation changes. The proposed mechanism for obtaining raw data and subsequent calculations makes it possible to adjust the form of the questionnaire. The data obtained are helpful for psychologists to identify entry points for working with people who are potentially at risk of PTSD.

5 Discussion

Developing a bot as part of the proposed information technology for diagnosing PTSD holds significant potential. The bot provides a user-friendly interface that engages in interactive conversations with survey respondents, facilitating data collection and feedback. This section of the discussion focuses on the role and benefits of the bot in the diagnostic process.

One of the main advantages of using a bot is its accessibility and habituality. A bot is accessed through Telegram messenger, allowing respondents to conveniently engage with the diagnostic tool in a well-known environment. This is particularly important in diagnosing PTSD, as individuals may be hesitant or unable to seek traditional in-person medical help. The bot provides a non-judgmental and convenient avenue for individuals to assess their mental health and seek support.

Furthermore, the bot creates a comfortable space for respondents to share their experiences and symptoms. Many individuals may feel more at ease disclosing sensitive information to a bot than a healthcare professional in a face-to-face setting. The anonymity provided by the bot encourages respondents to be honest in their responses, leading to more accurate diagnostic results.

Additionally, the bot provides instant diagnostic results to respondents. This real-time feedback can be valuable for individuals seeking immediate insights into their mental health status. The instant results can also catalyze individuals to take proactive steps toward seeking appropriate treatment or support.

However, it is essential to note some limitations and considerations associated with using a bot for diagnosing PTSD. While the bot can provide valuable insights and initial diagnostic results, it should not replace a comprehensive assessment conducted by a qualified healthcare professional. The bot can serve as a screening tool to identify potential cases of PTSD, but a formal diagnosis and treatment plan should always be confirmed and provided by a trained professional.

6 Conclusion

The use of the bot in the messenger environment, familiar to many residents of Ukraine, is promising, as it allows to cover a large audience with surveys and supplement the standard questionnaire with questions that will enable considering the changes over time circumstances, tracking the dynamics of change in the mental mood of the person over time.

The ITQ is relevant in a stressful environment. It can be used to identify the psychological state of individuals who have been exposed to traumatic events. The proposed information technology makes it possible to adjust the questionnaire's list of questions and answers to reflect the current environment and obtain relevant data for diagnostics. The proposed method for assessing the psychological state of individuals can be seen as an effective way to help people suffering from PTSD and other mental disorders.

In the future, we can expand the bot with feedback to accept respondents' suggestions for changes to various additional questions. Also, over time, the data collected will allow us to predict the mental state of regular respondents.

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