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Mobile information and communication system to support building of therapy groups in addiction treatment using a trust mechanism

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***Abstract*—Addiction is a physiological or emotional dependence on a substance, activity, or mode of action that is so severe that it causes harmful physical or emotional effects and prevents the individual from coping effectively with life and interacting with society. The most effective method of treating addiction is group therapy. However, the traditional building of a therapy group, based solely on periodic meetings and discussions, is a time-consuming, labour-intensive, and costly process. We propose a method and tools to support the therapist in building an effective therapy group. This support is based on the use of a mechanism of mutual trust. Our proposed use of information and communication solutions and the machine learning method reduces the time-consumption of the whole process and, thus, the workload and costs of building a therapy group. We use mobile applications to collect the necessary data from therapy participants. This data, via wireless networks, is sent to a data center. There, they are processed using machine learning. The method presented, and the information and communication environment prepared for it can be applied to a specific substance and behavioural addictions, as well as mixed addictions.**

***Keywords*—mHealth; Information and Communications Technology; trust; mobile application; addiction treatment; decision tree**

I. Introduction

OUR proposed solution fits into the concept of mobile health (mHealth). Mobile health techniques are defined as using mobile and wireless Information and Communications Technology (ICT) for health promotion. This technology offers a promising approach to the following barriers: seeking and receiving help, cost, burden, and limited treatment availability [1]. It should also be noted that mobile devices are widely used. In the last decade, mobile devices, and especially smartphones, have played an increasingly important role in our daily lives. We can observe that people's time interacting with a smartphone is increasing. This is because smartphones can now handle more tasks, helping us with our daily activities. One area of use of the latest ICT is in support of addiction treatment. Addiction is a physiological or emotional dependence on a substance, action, or course of action that is so strong that it causes harmful physical or emotional effects and prevents the individual from coping effectively with their life and interacting with society. Addictions have a strong negative impact on the health of the addict, as well as on the functioning of their environment, from the patient's family to society. The multi-featured ICT solution and smartphone application may significantly benefit patients in continuing care for addictions. We can find many free or low-cost addiction recovery support software applications, e.g., I Am Sober, Sober Grid, I Am, Q Sense, Pear reSET-O, SoberWorx, 24 Hours a Day, Recovery Box, Nomo, WEconnect, SoberTool, Quitzilla, SMART Recovery Cost Benefit Analysis [2].

Most are based on helping patients track the number of sober days and send notifications and daily motivational messages. It allows the patient to find treatment providers, including sober living homes, therapists, and counselors. These applications designed to reduce addiction needed more evidence base. More comprehensive and sophisticated applications are A-CHESS and LBMI-A [3]. Alcohol – Comprehensive Health Enhancement Support System (A-CHESS) has a well-developed evidence base. A-CHESS is the application for patients in recovery from alcohol dependence. This application is based on a computerized system developed at the University of Wisconsin-Madison for managing various diseases. A-CHESS's primary function is to diminish heavy drinking days post-treatment. Many services were designed and included in A-CHESS to promote patients' autonomous motivation and coping competence. A-CHESS is focused on identifying and preventing high-risk relapse situations. The application uses Global Position System-enabled location tracking to identify high-risk locations. Application A-CHESS provides social support via anonymous discussion forums and a text-messaging feature for pre-approved friends and family. In addition, it utilizes regular surveys to assess alcohol use and craving. Location-Based Monitoring and Intervention System for Alcohol Use Disorders (LBMI-A) is based on several theoretical perspectives, including relapse prevention, community reinforcement, and motivational enhancement. The LBMI-A was composed of psychoeducational modules: motivational enhancement through assessment and feedback, identification of high-risk drinking locations and strategies to avoid them, selection of a social support network, managing cravings, problem-solving skills, pleasurable alternatives to

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drinking, and assertive communication and drink refusal skills [4]. Many researchers are optimistic about the prospect of online relationships to build social ties based on "networked individualism" and the creation of virtual community groups (social networking). With the rise of modern technology, many treatment participants have begun to use the Internet to share their recovery experiences through both commercial and non-commercial digital platforms in support of sobriety. Many internet recovery sites include platforms ranging from passive general recovery and www addresses to interactive sites offering opportunities to create social networks with other abstinence individuals [5]. Online recovery networks can give patients a sense of belonging, purpose, and support. Social networks provide additional sources of information and support for those who find self-disclosure challenging. Authors [6] show that online social networks should be considered a valuable resource to supplement standard therapeutic approaches supporting sustained recovery from addictive behaviours.

However, these are usually individual initiatives. The use of these solutions is an individual choice of the therapy participants.

To our knowledge, there is a lack of ICT solutions to intentionally and comprehensively support the building of therapy groups, including all therapy participants. The ICT tools, including machine learning methods and the trust mechanism, have not been used in the process of setting up addiction therapy groups to date.

II. BUILDING OF A THERAPY GROUP

In general, we distinguish between individual and group therapy. While in individual therapy, the patient meets with only one therapist, in group therapy, the meeting is with the entire group and one or two therapists. It turns out that the most effective method of treating addiction is group therapy. Empirical research on the therapy group dynamic shows that the altruism promoted by regular meeting attendance and fellowshipping can result in better long-term abstinence outcomes, increased self-esteem, personal relationships, and motivation [7]. The four stages of building a therapy group can be distinguished [8]. The first stage is the stage of orientation, dependence, threat, and search for meaning. The second stage is the stage of confrontation, competition, rebellion, and exploration of differences. The third stage is characterized by mutual closeness, care, and safety. This integration, cohesion, and cooperation stage should be based on mutual trust. The fourth stage is the stage of intentional and conscious therapeutic action. This stage lasts until the end of therapy. The first three stages are an introduction to the stage of proper therapy. However, the traditional building of a therapy group is only based solely on periodic meetings and discussions. Reaching the fourth stage is usually time-consuming and, therefore, labour-intensive and costly. Building a motivated and mutually supportive therapy group ready to participate in the fourth stage takes several weeks to several months and depends on the group [9].

We have developed a method and tools to support the therapist in effectively building an effective and treatment-determined therapy group. This support relates to the first three stages of building a therapy group and is based on calculating trust values between individuals and ICT tools, including machine learning. Our idea is to isolate a group of mutually trusting people from among the therapy participants who can start the therapy work typical of the fourth stage of a therapy group. The use of ICT solutions significantly simplifies the process of establishing trust between therapy participants. Thus, it significantly speeds up the process of building up the therapy group. Fig. 1 schematically shows the proposed change in building a therapy group.

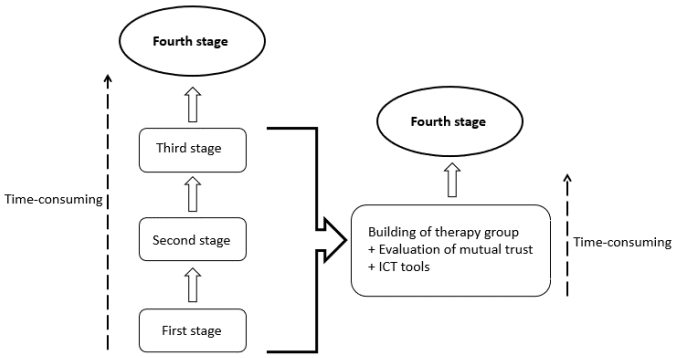

Fig. 1. Traditional and proposed methods of building a therapeutic group; ICT – Information and Communications Technology

This is a completely new and innovative approach to building a therapy group. Our solution should reduce the time consumption of the whole process of building an effective addiction-focused therapy group. It thus should reduce the workload and costs of building a therapy group.

III. PROPOSED TRUST EVALUATION MODEL

The term trust is being used with a variety of meanings. Among them, we can distinguish two widely accepted, standard definitions of trust: reliability and decision trust [10]. Reliability trust is the subjective probability by which an individual, A, expects that another individual, B, performs a given action on which its welfare depends. Decision trust is the extent to which one party is willing to rely on something or somebody in a given situation with a feeling of relative security, even though negative consequences are possible. Trust can mean reliance on an entity's integrity, ability, or character. Trust can be explained in terms of confidence in the truth or worth of an entity [11]. In general, trust describes the personal experiences one gathers about another based on interactions with that interaction partner [12]. Trust is the belief that the behaviours of a trusted community member are up to the expectation level [13].

Trust is known in the social sciences, philosophy, and economics [11, 12, 13, 14]. It is increasingly used in modern ICT systems. These include the use of trust in social networks [14], the Internet of Things [15], human-machine interactions [16] or cloud computing management [17].

In our case, the trust is used to build a therapy group. Trust is necessary for a therapy group to function properly because its members are not convinced that all group members have the same positive intentions. Mutual trust accelerates the building of a therapeutic group and ensures its coherence. Characteristics of a trusting group: group members dare to ask each other for help, they appreciate each other, members' skills and

experiences are helpful and put into practice, and commitment is invested in important issues. We can assume that patients who trust each other have the same treatment targets and course of treatment preferences.

Trust between participants in therapy is determined by assessing the direct experience (relationship) between individuals forming a group and recommendation. The direct experience is evaluated based on the two metrics of trust, namely honesty and cooperativeness [18]. Honesty may be seen as individuals' willingness to communicate what they think or feel, even when it is uncomfortable or unpopular. The cooperativeness trust property represents whether the individual is socially cooperative with others [18]. On the other hand, a recommendation is an opinion or suggestion regarding the reliability of an entity given by other entities [13]. In this case, the recommendation is associated with an opinion from parties not interacting with the assessed individual.

We determine the value of the trust (between trustor u and trustee v) by the following relationship:

$$T_{u,v}(t+dt)=a((1-w_{u,v})T_{u,v}(t)+w_{u,v}DE_{u,v}(t+dt))+(1-a)R_v(t+dt) \quad (1)$$

When trustor u interacts with trustee v at time t+dt, trustor u updates its trust assessment $T_{u,v}(t+dt)$ toward trustee v, $T_{u,v}(t)$ is the previous trust value at time t. The factor $DE_{u,v}(t+dt)$ represents direct experience at time t+dt i.e., the direct relation between the individuals (trustor and trustee) at time t+dt. Parameter a determines the relative importance of direct experience in relation to non-direct experience, i.e., recommendation. The parameter a takes values from 0 to 1. The factor R_v (t+dt) is the recommendation for trustee v at time t+dt. The higher value of the weighting factor $w_{u,v}$ indicates that current, direct experience ($DE_{u,v}(t+dt)$) between individuals has more influence than past trust ($T_{u,v}(t)$). Fig. 2 illustrates the idea of determining the confidence value.

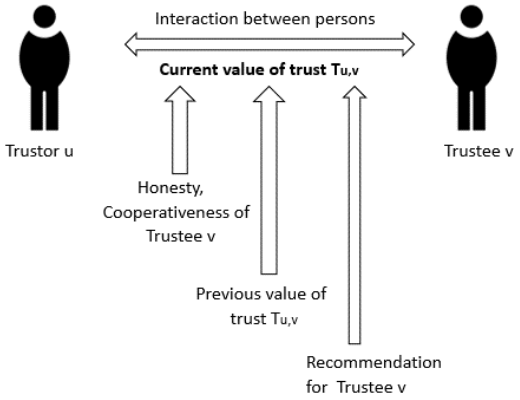

Fig. 2. Diagram of the method for determining trust $T_{u,v}$

The factor $DE_{u,v}(t+dt)$ is calculated using honesty (h) and cooperativeness (c).

$$DE_{u,v}(t+dt)=bh_{u,v}(t+dt)+(1-b)c_{u,v}(t+dt) \quad (2)$$

where b is a parameter defining the relative importance of honesty versus cooperativeness. Parameter b takes values from 0 to 1.

Honesty (h) is defined as follows [18]:

$$h=\frac{N_p}{N_T} \quad (3)$$

where N_p is the number of positively assessed interactions between trustor u and trustee v, and N_T is the number of all interactions between trustor u and trustee v

Cooperativeness (c) is defined as follows [18]:

$$c=\frac{f_u \cap f_v}{f_u \cup f_v} \quad (4)$$

where f_u denotes the set of individuals with whom trustor u interacted, f_v denotes the set of individuals with whom trustee v interacted. For example, trustor u interacts with A, B, and C individuals, and trustee v interacts with C, D, and E individuals. Then, the numerator in (4) has the value 1, and the denominator has the value 5.

The weighting factor w depends on the specific characteristics of the experience between the trustor and trustee. Here, we consider the number of interactions and age of interactions [12]. The value of the weight w is equal to:

$$w=dw_n+(1-d)w_a \quad (5)$$

where w_n is the weight for the number of experiences, and w_a is the weight for the age of interactions. Parameter d determines the relative importance of w_n in relation to w_a. Parameter d takes values from 0 to 1.

Number of interactions. More interactions mean that the trust value tends to describe the expected observable behaviour more precisely. We expect the function $w_n(k)$ to increase monotonically with the number of interactions (k). In detail, the function $w_n(k)$ is defined as follows:

$$w_n(k)=\begin{cases} 0, & k=0 \\ \frac{1}{1+\exp(-(\alpha k+\beta))}, & 0<k<k_{max} \\ 1, & k \geq k_{max} \end{cases} \quad (6)$$

The parameter k_{max} defines how many interactions at least have to be made to be able to be maximum confident in a trust value. The parameter α influences the rate of change of the w_n-weight value depending on the number of interactions, parameter β is dependent on the value of k_{max}. These parameters are chosen to suit the specific case.

Fig. 3 shows the course of the function $w_n(k)$.

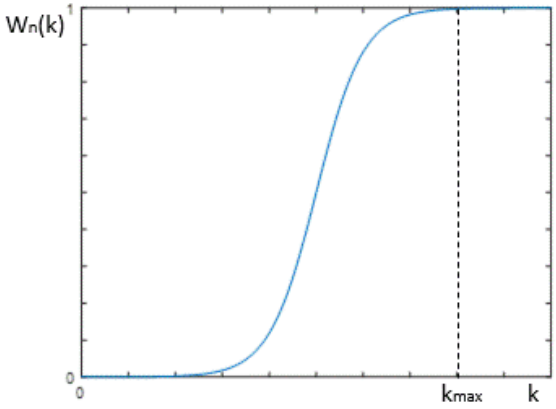

Fig. 3. Illustration of an example $w_n(k)$

Age of interactions. Individuals may change their behaviour between two interactions. Recent interactions should be considered more than older interactions. We expect the function

$w_a(l)$ to decrease monotonically with the age of interactions (l). In detail, the function $w_a(l)$ is defined as follows:

$$w_a(l) = \begin{cases} 1, & l \le l1 \\ 1 - \left(\frac{1}{1+\exp(-(\gamma l+\delta))}\right), & l1 < l < l2 \\ 0, & l \ge l2 \end{cases} \quad (7)$$

The parameter l1 denotes the point in time, to when interactions are considered as recent, parameter l2 indicates the point in time, from when interactions are regarded as completely out of date. The parameter γ influences the rate of change of the w_a-weight value depending on the age of interactions, parameter δ is dependent on the value of l1 and l2. These parameters are chosen to suit the specific case.
Fig. 4 shows the course of the function $w_a(l)$.

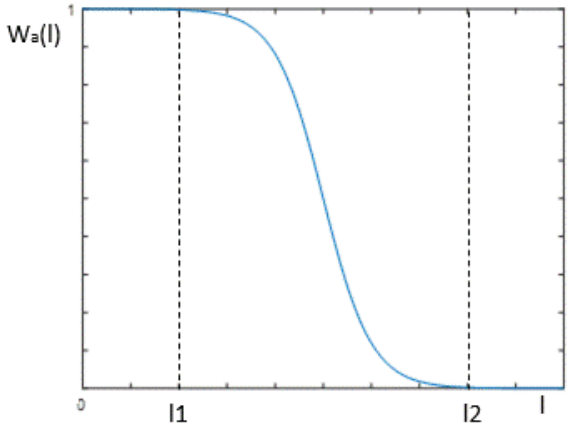

Fig. 4. Illustration of an example wa(l)

The recommendation R_v is a prediction of a trustee's behaviour as determined by the questionnaires. Machine learning in the form of a decision tree algorithm is used to implement the prediction.
Two types of questionnaires are used - an intrapersonal questionnaire and an interpersonal questionnaire. The intrapersonal questionnaire is filled in by those participating in therapy and in the process of building a therapy group. It is a modified form of the Brief Addiction Monitor questionnaire, which is often used in addiction therapy [19]. This questionnaire contains 14 questions. The 7-value scale is used in it. Questions in the questionnaire include assessment of health, problems with falling asleep and sleeping, feelings of depression, anxiety, anger, and nervousness, the impact of thinking about addiction on daily activities, attitude to maintaining abstinence, participation in therapy, the emergence of situations that pose a danger to therapy, involvement in work, school social activities, income to provide for the patient and his family, the impact of problems in relationships with family and close friends, support of therapy from family and close friends. This questionnaire also asks whether there has been a relapse into addiction. The interpersonal questionnaire is filled in by people who have contact with the participant in therapy but do not themselves participate in the therapy and do not take part in the formation of the therapy group, e.g., spouse, relatives, or friends. This questionnaire assesses the behaviours of the specific individual that may indicate a threat to their therapy; it contains 10 questions. The 7-value scale is used in it. Such behaviours include quarrelsomeness, aggression, chaotic behaviour, escaping into solitude, and provoking contact with or inciting addictive behaviour. The cooperating therapist prepared the interpersonal questionnaire. The questionnaires are completed every certain, strictly defined period of time.

IV. INFORMATION AND COMMUNICATION SYSTEM

The main components of our information and communication system are physical units, protocols, and applications. The physical layer includes mobile devices (smartphones) and the wireless communication infrastructure, and the server acts as a back-end for storing, processing, and accessing data. The wireless communication infrastructure is based on 4G/LTE (Long Term Evolution) or 5G mobile system standards. Fig. 5 shows the physical infrastructure of the information and communication system.

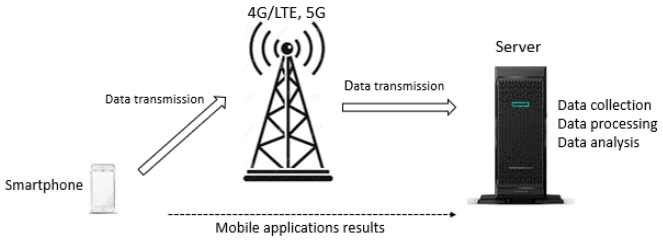

Fig. 5. Diagram of the physical infrastructure of the information and communication system

From the point of view of the protocols and applications used, i.e., the application layer, the system architecture looks as follows (Fig. 6).

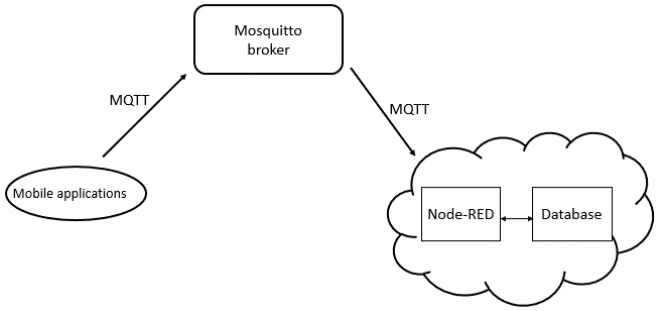

Fig. 6. System architecture at the application layer

We distinguish between the following components of the application layer: mobile applications, Mosquitto broker, database, and Node-RED application. The MQTT (Message Queue Telemetry Transport) protocol in the TLS (Transport Layer Security) standard was used to transmit data between the smartphone applications and the Mosquitto broker and between the Mosquitto broker and the Node-RED application [20]. This solution guarantees the security of the transmitted data.
The Paho MQTT Client Libraries and Android Service were used to implement the functionality of the MQTT protocol. Smartphone application is the interface between the patient and the information and communication system. Application framework Flutter and the Programming language Dart are used to create the applications for the Android platform [21]. Flutter is a free, open-source toolkit for creating compiled applications. The therapy participant smartphone applications include a simple tool for individual interaction assessment and questionnaires used in intrapersonal assessment. The

application containing the implementation of the interpersonal questionnaire is possessed only by those completing it. Fig. 7a shows the screen of the application used to assess the interaction between therapy participants. Fig. 7b and 7c show an extract from the intrapersonal and interpersonal questionnaires, respectively.

The data sink consists of two elements. The first is the Mosquitto broker, which is the intermediary for data transmission. The second element is the database, where all the data processed during the communication between the smartphone and the server is stored.

Mosquitto is a broker provided by the Eclipse Foundation that supports the MQTT protocol. In the MQTT architecture, messages sent by senders do not go directly to the recipient - the MQTT broker is the intermediary. The broker's task is to receive messages from publishing clients and forward them to subscribing clients. With communication defined this way, mobile applications do not always have to be active. Both publishers and subscribers can only be active when they want to send or receive information. The only requirement is that the broker is constantly active. Such a mechanism saves much energy on smartphones. In the implemented system, the Mosquitto broker is the intermediary between the mobile and Node-RED applications, which process the data.

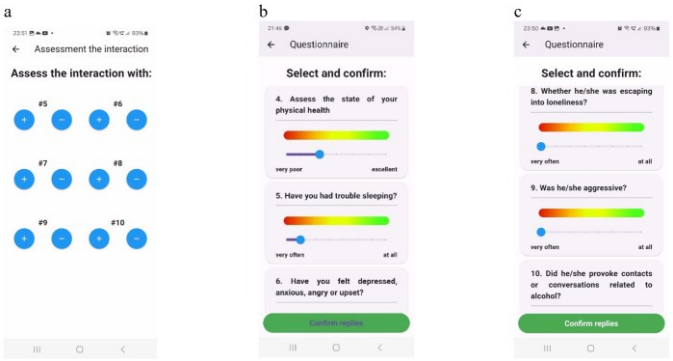

Fig. 7. Screenshots of mobile applications: a -interaction assessment (+ positive assessment, - negative assessment), b - intrapersonal questionnaire, c - interpersonal questionnaire

The mobile applications operating as publishing clients and the Node-RED application as a subscribing client connect to the server. Another element of the architecture is the database. A MySQL (Structured Query Language) database is used, which stores all the data processed during the research. All smartphone data is linked to a specific system user in the database. Each data transfer from the mobile applications is assigned a timestamp to associate the acquired data with time. The processing unit consists of applications written in the Node-RED environment. Node-RED is a development tool that connects the various devices and APIs (Application Programming Interface) needed for Internet of Things solutions [22]. The entire environment runs on Node.js. Applications are created using programmable nodes, and data flows between these nodes. Programmed functions and data flows are saved as JSON (JavaScript Object Notation) standard files. The basic Node-RED package has built-in nodes to support the MQTT protocol. The relevant flows in the Node-RED environment are implemented to capture the data sent by mobile applications and process the data accordingly. The main nodes are the blocks that connect to the broker and subscribing/publishing messages on a given topic. The data is passed on to the nodes where the defined actions related to the SQL database are executed. The data extracted from the mobile applications and processed in the Node-RED application is used to determine the values: honesty and cooperativeness, weight w, and recommendation. Using data from the tool for assessing interactions between individuals (Figure 7a), the following are determined: the number of positively evaluated interactions between trustor and trustee, the number of all interactions between trustor and trustee, and the time at which the interaction was assessed. These data allow the calculation of honesty, weight w_n, and weight w_a, according to equations (3), (6), and (7), respectively. By selecting the individuals with whom the application user has interacted in this application, it is possible to designate cooperativeness, according to equation (4). The recommendation is a prediction of an individual's behaviour based on extracted data from an intrapersonal questionnaire (Figure 7b) and a related interpersonal questionnaire (Figure 7c). A machine learning algorithm as a decision tree is used for prediction. It assigns an individual's predicted behaviour to one of two classes: ”Sobriety” and “Relapse to addiction”. Decision trees are a graphical method of decision support. The choice of the decision tree algorithm was based on its main advantages. The main advantage of decision trees is that they can represent arbitrarily complex concepts. Besides, they have low memory complexity compared to other hypothesis representations. Also, the computational complexity is linearly limited by the number of attributes. In addition to the advantages associated with the machine-processable structure representing hypotheses, decision trees are also human-readable, and a possible switch to a rule-based representation does not pose a problem.

V. Results of Field Study

Below is an example of the application of our method. The research was carried out on a relatively small number of cases. But nevertheless, results were obtained that allow us to evaluate the method and determine its potential confidently.

Therapy participants from one of the local alcohol therapy center took part in a field study. The team starting the therapy consisted of 10 people. Scheduled therapy group meetings were held once a week. Person-to-person interactions took place in and out of meetings. All participants had smartphones with applications containing tool for interaction assessment (Fig. 7a) and an intrapersonal questionnaire (Fig. 7b). Each participant nominated an individual not in therapy, whose task it was to complete the interpersonal questionnaire (Fig. 7c). Such an individual had the relevant applications installed. Therapy participants used the tool (Fig. 7a) each time they interacted (meeting) with another therapy participant. The intra- and interpersonal questionnaires were filled in once a week every Sunday and concerned the evaluation of the passing week. Therapy participants for the duration of the study were labeled as participants #1, #2, #3, #4, #5, #6, #7, #8, #9, and #10. The research was conducted over a period of five weeks. The trust value was determined at each week's end, i.e., every Sunday. Due to the small size of the treatment team and thus the small number of questionnaires, the inclusion of recommendations was only accepted after the fifth week of the research. This was because as the amount of learning data increased, the reliability

of the decision tree created increased. It was assumed that 50 intrapersonal questionnaires and 50 interpersonal questionnaires would be sufficient. The same individuals completed questionnaires at the end of each week. Their analysis indicated that, for specific individuals, they could vary significantly from week to week. The results of the questionnaires are, in a way, a reflection of the state and the behaviour of the individual participants in therapy. Therefore, e.g., changes in mood, changes in attitude towards therapy, family or professional life, and variability in attitude towards addiction are typical in the first stages of forming a therapy group. The results of questionnaires completed by the same individuals were treated as independent of each other. To reinforce the independence of questionnaires completed by the same individuals at different times, the order of the questions was changed, and the individuals completing them did not have access to their previous answers.

It should be emphasised that if a subsequent therapy group is built, the available database of completed questionnaires can be used. Then, the recommendation can be included in the trust determination at individual control time points, i.e., at the end of each week. Fig. 8 shows the timetable for completing the questionnaires and calculating the trust.

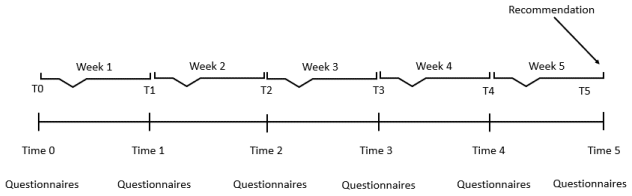

Fig. 8. Time diagram of the research course

At Time 0, intrapersonal and interpersonal questionnaires about the previous week were completed. Based on consultation with therapy participants, initial T0 trust values were randomly set as values between 0.0 and 0.2. At time points Time 1, Time 2, Time 3, and Time 4, trust values were determined using relationship (1) without taking into account recommendation:

$$T_{u,v}(t+dt)=(1-w)T_{u,v}(t)+wDE_{u,v}(t+dt) \quad (8)$$

In our case, e.g., for T3, relation (8) takes the form of:

$$T3_{u,v}=(1-w3_{u,v})T2_{u,v}+w3_{u,v}DE3_{u,v} \quad (9)$$

Where $T3_{u,v}$ is the value of trust between trustor u and trustee v at Time 3, $T2_{u,v}$ is the value of trust between trustor u and trustee v at Time 2, $DE3_{u,v}$ is the value of direct experience between trustor u and trustee v at Time 3. The $DE3_{u,v}$ value is calculated from honesty and cooperativeness values, according to the relationship (2), (3), and (4), determined from the data collected in Week 3, i.e., between Time 2 and Time 3. The value of weight $w3_{u,v}$ is determined according to a relationship (5), (6), and (7), based on the data collected in Week 3, i.e., between Time 2 and Time 3. The application shown in Figure 7a was used to determine $DE3_{u,v}$, and the $w3_{u,v}$.

At Time 5, the trust value of T5 is determined by relationship (1), i.e., considering the recommendation. In our case, relation (1) takes the form of:

$$T5_{u,v}=a((1-w5_{u,v})T4_{u,v}+w5_{u,v}DE5_{u,v})+(1-a)R5_v \quad (10)$$

Where $T5_{u,v}$ is the value of trust between trustor u and trustee v at Time 5, $T4_{u,v}$ is the value of trust between trustor u and trustee v at Time T4, $DE5_{u,v}$ is the value of direct experience between trustor u and trustee v at Time 5. The $DE5_{u,v}$ value is evaluated from honesty and cooperativeness values, according to the relationship (2), (3), and (4), determined from the data collected in Week 5, i.e., between Time 4 and Time 5. The value of $w5_{u,v}$ is determined according to a relationship (5), (6), and (7), based on the data collected in Week 5, i.e., between Time 4 and Time 5. The application shown in Figure 7a is used to determine $DE5_{u,v,}$ and the $w5u,_v$ weight.

To determine the value of the trust, the following were assumed:

1. Parameter a=0.8 in equation (1).
2. Parameter b=0.5 in equation (2).
3. Parameter d=0.5 in equation (5).
4. Parameter k_{max}=10, α=1, β=-0.5kmax in equation (6).
5 Parameter l1=1 and l2=7, δ=1, γ=-0.5(l1+l2) in equation (7).

Recommendation $R5_v$ is a prediction of the state of trustee v in terms of two behavioural classes, “Sobriety” and “Relapse to addition.” To build the decision tree, questionnaires completed by trustee v at Time 0, Time 1, Time 2, Time 3, and Time 4 were used to describe trustee v state and behaviour in the week preceding Time 0, Week 1, Week 2, Week 3 and Week 4 respectively. The application shown in Figures 7b and 7c was used to complete the questionnaires. The intrapersonal questionnaire also asks whether there was behaviour “Sobriety” or behaviour “Relapse to addition”. We predict the class “Sobriety” or “Relapse to addition” reported in the next predicted intrapersonal questionnaire (Figure 9). We link the responses from the intrapersonal and intrapersonal questionnaire completed in the previous week (e.g., at Time 2 for Week 2) to the response relating to “Sobriety” or “Relapse to addition” contained in the intrapersonal questionnaire completed in Time 3 describing Week 3. This is shown schematically in Fig. 9.

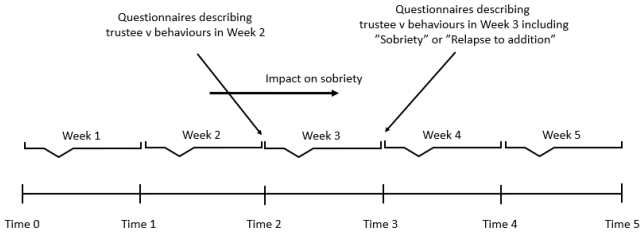

Fig. 9. Conceptual model for predicting weekly sobriety

A decision tree was built based on 50 intrapersonal and 50 interpersonal questionnaires. Figure 10 shows the resulting decision tree.

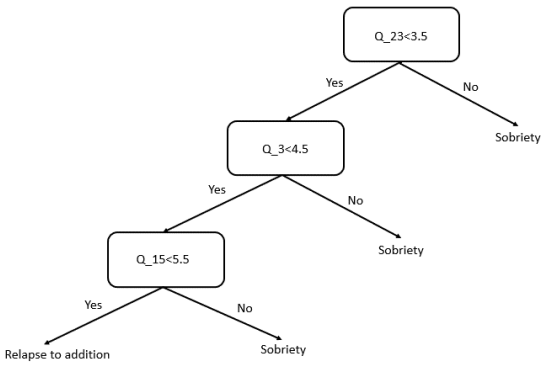

Fig. 10. The resulting decision tree based on intrapersonal and interpersonal questionnaires

An estimation of the classification error determined by the cross-validation procedure was carried out. This error was estimated to be 0.09.

In the decision tree from Figure 8, attribute Q_23 is associated with a question from the interpersonal questionnaire about provoking alcohol-related contacts and conversations. Attribute Q_3 is associated with a question from the intrapersonal questionnaire regarding physical health. In contrast, attribute Q_15 is related to a question about getting angry and upset quickly and unprovoked.

The decision tree constructed was used to assign therapy participants to the class “Sobriety” or “Relapse to addition” based on the questionnaires completed at Time 5.

The following result was obtained: individuals #1,#2, #4, #7,#8, #9, and #10 were assigned to the "Sobriety" class. While #3, #5 and #6 were assigned to the "Relapse to addiction" class.

It was then assumed that the recommendation takes the value -1 for the class "Relapse to addiction" and the value 1 for the class "Sobriety".

Table 1 shows the trust value T5 at time point Time 5. The threshold value for trust was set at 0.5. If $T_{u,v} > 0.5$, then trustor u trusts trustee v. In our case, mutual trust is important. Therefore, a selection of participants was made taking into account mutual trust, i.e., $T_{u,v} > 0.5$ and $T_{v,u} > 0.5$.

A result indicated that the mutual trust group consists of individuals #1, #2, #4, #7,#8 and #10.

The result suggests to the therapist that a consolidated and therapeutically goal-oriented group can be formed with individuals #1, #2, #4, #7, #8, and #10. A group of mutually trusting people has been identified from among the therapy participants who can begin the therapeutic work typical of the fourth stage of a therapy group. For the therapist, the result is an aid in determining which individuals are ready for the fourth stage of therapy. This should reduce the time to set up a conscious therapy group. In addition, the prediction in the form of assigning therapy participants to class “Sobriety” or class ”Relapse to addiction” is a clue for the therapist on which individuals (#3, #5, and #6) to pay attention to when meeting the therapy group. This information should also be communicated to the concerned individuals so they know the risks.

Fig. 11 shows an example of how trust value changes as a function of time. The changes in trust value over time for trustor #2 and trustee #1, #4, #5 and #9 are shown.

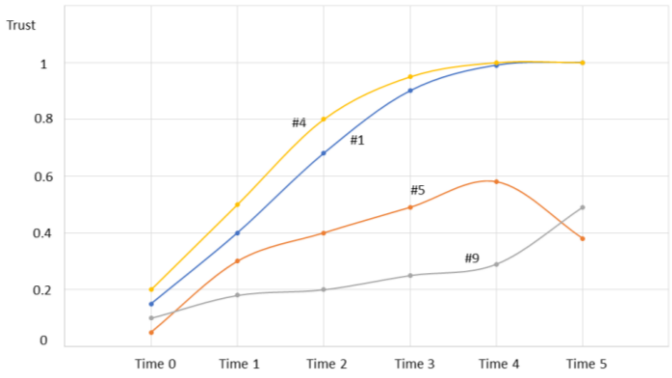

Fig. 11. Change in trust value for trustor # 2 and trustee #1, #4, #5 and #9

For #1 and #4, a steady and strong increase in trust value is evident, quickly exceeding the threshold value. For #5 the trust value increases and exceeds the threshold value, but the recommendation value causes the trust value to fall below the threshold value at Time 5. In contrast, in the case of #9 the increase in trust value is weaker and, despite the increase caused by the recommendation, does not reach the threshold value at Time 5. There is a strong influence of the recommendation through the value of the parameter a on the trust value. The therapist should choose the value of this parameter carefully based on the observation of the therapy participants.

The trust building process should be monitored by the therapist. The duration of the trust building between therapy participants is up to the therapist. The therapist decides when to end this process. This can be due, for example, to reaching the assumed size of the trusting group ready to start the fourth stage of therapy, or when observing that certain individual are not likely to exceed the trust threshold.

It should be emphasised that using passively collected digital data raises many privacy and security issues. Our privacy management ensures that participants have as much control over their data as possible. Solutions were applied to ensure data security in terms of procedural safety and technical security. Participants were informed about what data was collected about them, how long it would be used, who would use it, and why. The data obtained was anonymised, i.e., transformed so that specific information cannot be attributed to a particular or identifiable individual.

TABLE I
TRUST VALUES T5 AT TIME 5

		Trustee									
		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
T	#1	X	1	0.36	1	0.39	0.42	1	0.85	0.63	1
r	#2	1	X	0.41	1	0.38	0.37	1	1	0.49	1
u	#3	0.61	0.64	X	0.60	0.26	0.32	0.62	0.64	0.54	0.63
s	#4	1	1	0.36	X	0.31	0.37	1	1	0.57	1
t	#5	0.64	0.62	0.24	0.59	X	0.29	0.61	0.66	0.50	0.63
o	#6	0.66	0.63	0.36	0.61	0.28	X	0.64	0.65	0.47	0.66
r	#7	1	1	0.37	1	0.37	0.40	X	1	0.57	1
	#8	1	1	0.38	1	0.42	0.40	1	X	0.47	1
	#9	0.84	0.74	0.11	0.57	0.31	0.27	0.82	0.67	X	0.64
	#10	1	1	0.39	1	0.38	0.41	1	1	0.62	X

CONCLUSION

A method and ICT tools for assisting the therapist in setting up an addiction therapy group was presented. The method is based on the use of a trust mechanism. This made it possible to isolate from the therapy participants those who could form a consolidated and effective team participating in the actual therapy phase. Moreover, the use of ICT tools facilitates the assessment of interactions taking place between participants in addiction therapy groups. As a result, it can in some cases even significantly reduce the time it takes to build conscious therapy groups. It should be emphasized that the method presented should be considered only as a support to the therapist and as a complement to the traditional method. Due to the relative complexity of the method, it can only be practically realized with ICT tools, including machine learning methods dedicated to it. The idea of using smartphones with appropriate applications and ICT infrastructure with applications and protocols specific to the Internet of Things to realise the presented method was presented. The developed mobile applications allowed the realisation of a simple and intuitive human - ICT system interface. The applied technical solutions related to the creation of the application, the realisation of data transmission and the processing and analysis of the acquired data guarantee data security and low implementation costs of the developed method of addiction therapy support. We realise that a single research campaign may not be sufficient to prove the thesis of accelerating the formation of a treatment group using our method and the prepared ICT environment. Nevertheless, the results obtained are promising and confirm the sensibility of our solution. Moreover, the method developed and the ICT environment prepared for it can be applied to specific substance and behavioural addictions, as well as mixed addictions (i.e., alcohol, drugs, nicotine, caffeine, eating disorders and gambling). We will further develop our product. We plan to develop application modules for the analysis of behaviour in dangerous situations for therapy by on-line health monitoring.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Krzysztof Perlicki: Writing – original draft, Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. Tomasz Mrozek: Data curation, Software, Writing – review & editing.

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