Organization of Information Flows in Preventive Health Screening System

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Abstract **– This report relates to e-medicine. The authors offer a new Mobile Telemedicine Screening Complex (MTSC) allowing implementing preventive health screening of adult population. This screening complex is recommended for family doctors' practices, outpatient departments, preventive centres and for examinations of people outside medical service offices.**
MTSC has several functions:

- **to obtain subjective and objective information about the individual's health;**
- **to make a decision about the individual's health;**
- **to provide wireless transmission of all information to the analysis centre in order to confirm the final conclusion of screening results and to develop database of each individual.**

These functions are carried out by a portable computer supplied with specially developed software. The article deals with the organization of subjective and objective information flows and their influence on a decision-making process.

Keywords **– E-medicine, interactive questionnaire, objective measurements, preventive health screening.**

I. Introduction

Public health is one of the main priorities in any European Union (EU) member state. The comparative studies of mortality rates in Latvia and other EU member states show that the disease specific mortality rates differ in Latvia, but in all cases they are higher than in the EU. The data of World Health Organization (WHO) show that the mortality rate from cardiovascular system diseases in the population group aged 0-64 years in Latvia is four times higher than in the EU and exponentially increases after age 35. The second reason of frequent mortality in Latvia is malignant tumours; however, the morbidity with tumour in Latvia is lower than in the EU. One of the main factors determining a high mortality rate from malignant tumours is the late diagnostics – the incidence of distant-stage diseases in Latvia is very high [1-7].

The most common strategy in medicine for reducing the mortality is preventive health screening – the early diagnostics of the disease. Screening is used in a population to identify an unrecognized disease in individuals without signs or symptoms. Screening can also include individuals with pre-symptomatic or unrecognized symptomatic disease or condition. As such, screening tests are somewhat unique in that they are performed on persons apparently in good health [8-12].

There are several types of screening tests:

1) universal screening involves screening of all individuals in a certain category, for example, screening of the whole population of a certain age;
2) case finding involves a smaller group of people based on the presence of risk factors, for example, mammography to detect breast cancer or PSA test to detect cancer of prostate.

Medical equipment used in screening tests is usually different from equipment used in diagnostic tests. Screening tests are used to indicate the likely presence or absence of a disease or condition in people not presenting symptoms, while diagnostic medical equipment is used to confirm a suspected disease or condition. Medical screening equipment must be capable of fast processing of many cases, but may not need to be as precise as diagnostic equipment [13].

The task of our project was to produce a universal health diagnostic screening system that could be used by doctors in regular preventive examinations of adult population. It has been developed as a Mobile Telemedicine Screening Complex (MTSC) that includes an interactive questionnaire about 12 organ systems and 7 risk factors and 14 measurement modules allowing for objective measurements. The screening conclusion about patient's health is made by MTSC.

The functioning of MTSC is provided by the embedded computer, whose functions can be subdivided into two parts. The first part contains a questionnaire and measurement management, measurement value calculations, digitization of the results and wireless transmission to the analysis centre, indication of the measurement results. The second part contains the function concerning the decision making on person's health status and subsequent recommendations (to eliminate risk factors or to consult a specialist). The screening conclusion about the patient's health is made by MTSC. This article focuses on the organization of information flows for a successful decision-making process.

II. Results

A. Interactive Questionnaire

The interactive questionnaire comprises questions about person's chronic diseases, subjective sensations or discomfort, ill-disposed heredity and different risk factors. The questionnaire consists of 126 questions that are subdivided into four compartments:

S compartment, the largest group of questions, comprising 90 questions about signs and symptoms that characterize a disease or syndromes of 12 organ systems;

R compartment, including 20 questions about different risk factors – ill-disposed heredity, smoking, increased arterial blood pressure, weight, blood cholesterol and glucose level, low physical activity and increased psychological stress;

H compartment, containing 14 questions about patient's chronic diseases;

P compartment contains 2 questions about previously performed prophylactic examinations.

The answers to 126 questions ensure all subjective information flow that must be compared and linked together with the findings of objective individual measurements by MTSC.

Questioning of the person is performed with the help of a computer. Every question appears on the monitor screen and the examined person must choose and tick off the right response from 3 available responses– "yes" in the case of confirmation, "no" in the case of negation or "I cannot say" in the case of uncertainty. The dialogue form between the examined person and a computer determines an interactive mode of questionnaire.

S Compartment of Interactive Questionnaire

The subjective information flow included in S compartment of interactive questionnaire is subdivided into 12 parts, each comprising complaints from 12 organ systems, correspondingly:

S1 – cardiovascular system,
S2 – respiratory system,
S3 – kidney and urine elimination system,
S4 – suspected tumours,
S5 – bones and joints,
S6 – endocrine system,
S7 – vision,
S8 – hearing,
S9 – digestive system,
S10 – nervous system,
S11 – psycho-emotional status,
S12 – reproductive system.

The subsequent Tables 1, 2, 3 demonstrate examples of questions about the cardiovascular system (S1), bones and joints (S5) and nervous system (S10).

TABLE 1

QUESTIONS ABOUT THE CARDIOVASCULAR SYSTEM

S1.1	Do you feel a pain or smarting, pressure sense, unpleasant sensation, discomfort behind the breastbone during physical work?	yes no go to S1.6
S1.2	Do you feel a pain or unpleasant sensation behind the breastbone at rest?	yes no go to S1.6
S1.3	Does the pain (unpleasant sensation) behind the breastbone disappear after stoppage or taking nitroglycerin?	yes no
S1.4	Does the pain (unpleasant sensation) behind the breastbone disappear in 10 minutes or more rapidly?	yes no
S1.5	Does the pain irradiate to the left shoulder, neck, hand or left shoulder-blade?	yes no
S1.6	Do you feel a pain in the calves and feet going quickly or walking upstairs or uphill?	yes no go to S1.8
S1.7	Does the pain in the calves and feet disappear after stopping or going more slowly?	yes no I can't say
S1.8	Do you feel marked shortness of breath during easy physical work?	yes no
S1.9	Do you feel marked fatigue after physical load?	yes no
S1.10	Do you have swelling legs in the evening even during cool weather?	yes no
S1.11	Do you sometimes feel rhythm disturbances of the heart (the heart "turn somersaults", stoppage, "misfire" and pulse is irregular, accelerated or rather slow)?	yes no
S1.12	Do you have varicose veins in your legs?	yes no

TABLE 2

QUESTIONS ABOUT BONES AND JOINTS

S5.1	Do you feel a backache in the neck, chest or waist region?	yes no
S5.2	Do you feel a pain in the hip and knee joints during physical work?	yes no
S5.3	Do you feel a pain in the palms and feet joints during physical work?	yes no
S5.4	Do you have morning stiffness in the joints, which disappears after moving?	yes no
S5.5	Do you have any deformations of the joints?	yes no
S5.6	Did you have any trauma of backbone or joints?	yes no

TABLE 3

QUESTIONS ABOUT THE NEUROLOGICAL CONDITION

S10.1	Do you have frequent headaches?	yes no go to S10.6
S10.2	Does the headache is concerned with the changes in the blood pressure?	yes no I can't say
S10.3	Does the headache is concerned with emotional or mental stress?	yes no
S10.4	Does the headache is concerned with physical load?	yes no
S10.5	Do you have the headache more frequently in the morning?	yes no
S10.6	Do you have disturbances of the balance?	yes no
S10.7 S10.8 S10.9	Do you have dizziness: - changing body position; - turning the head; - in supine position.	yes no
S10.10	Do you have difficulties to remember past events, to keep in mind new things and to concentrate attention on one thing?	yes no
S10.11	Do you ever lose the consciousness?	yes no

R Compartment of Interactive Questionnaire

The subjective information flow included in R compartment of interactive questionnaire comprises questions about 7 risk factors:

R1 – unfavourable heredity,
R2 – smoking,
R3 – low physical activity,
R4 – increased arterial blood pressure,
R5 – psychological stress,
R6 – increased blood cholesterol and glucose level,
R7 – overweight and obesity.

The subsequent Tables 4, 5, 6 demonstrate examples of questions about ill-disposed heredity (R1), physical activity (R3) and psycho-emotional stress (R5).

TABLE 4
QUESTIONS ABOUT ILL-DISPOSED HEREDITY

R1.1	Does any of your first degree relatives (your mother, father, brother, sister) have an increased blood pressure?	yes no I cannot say
R1.2	Does any of your first degree relatives (your mother, father, brother, sister) have myocardial infarction and/or stroke?	yes no I cannot say
R1.3	Does any of your first degree relatives (your mother, father, brother, sister) have diabetes?	yes no I cannot say
R1.4	Does any of your first degree relatives (your mother, father, brother, sister) have cancer?	yes no I cannot say
R1.5	Does any of your first degree relatives (your mother, father, brother, sister) have glaucoma or cataract?	yes no I cannot say

TABLE 5
QUESTIONS ABOUT THE PHYSICAL ACTIVITY

R3.1	Is your physical activity low (sedentary job, leisure time without physical activities)?	yes no
R3.2	Is your physical activity moderate (job connected with walking, leisure time with regular physical activities at least two times in a week, working in the garden etc.)?	yes no
R3.3	Is your physical load heavy (hard physical job or sports training)?	yes no

TABLE 6
QUESTIONS ABOUT THE PSYCHO-EMOTIONAL STATUS

R5.1	Is your job related to haste, stress and misunderstandings with a boss, colleges or clients?	yes no
R5.2	Is your family life disquiet or unsatisfied?	yes no
R5.3	Are you worried about social and economic circumstances?	yes no
R5.4	Have you recently met with misery, disease, death of your close person?	yes no

H Compartment of Interactive Questionnaire

Subjective information flow included in H compartment of interactive questionnaire comprises questions about person's chronic diseases, see Table7

TABLE 7
QUESTIONS ABOUT CHRONIC DISEASES

H.1	Have you ever been ill or do you just now suffer from the heart disease – stenocardia or myocardial infarction?	yes no
H.2	Have you ever suffered from stroke?	yes no
H.3	Do you suffer from diabetes?	yes no
H.4	Have you ever suffered from tumour?	yes no
H.5	Do you suffer from an increased blood pressure?	yes no
H.6	Do you have any renal disease?	yes no
H.7	Do you have any disease of digestive tract?	yes no
H.8	Do you suffer from any disease of the respiratory system?	yes no
H.9	Do you have disease of liver or bile ducts?	yes no
H.10	Do you suffer from osteochondrosis?	yes no
H.11	Have you ever had trauma of the head?	yes no
H.12	Do you have any disease of brain arteries, legs or hands?	yes no
H.13	Do you suffer from bronchial asthma?	yes no
H.14	Do you suffer from allergy?	yes no

P Compartment of Interactive Questionnaire

The information included in P compartment of interactive questionnaire comprises questions about prophylactic examinations.

TABLE 8
QUESTIONS SHOWING THE REGULARITY OF PROPHYLACTIC EXAMINATIONS

P.1	Have you ever been on a preventive examination?	yes no
P.2	Have you performed a preventive examination this year?	yes no

B. Objective Measurements

The objective information flow comprises objective data from 14 measurement modules obtained with objective measurements about 9 organ systems. The objective measurements are missing for nervous system S10, psycho-emotional status S11 and reproductive system S12. The modules and acquired parameters are represented in Table 9.

TABLE 9

MEASURED AND CALCULATED PARAMETERS

No.	Module	Number of measured parameters	Parameter description	Calculated parameters
M1	ECG device	8	At least 500Hz sampled potentials at RA; LA; C1-C6, 10 second segment	12 Lead ECG,
M2	Tonometry	3	P_{SYS}, P_{DIAST}, Pulse rate (PR)	Mean Arterial Pressure (P_{MAP})
M3	Pulse oximetry	2	SpO_2 level in % or HbO_2%, Pulse rate (PR)	Compared to normal
M4	Digital phonendoscopy	3	Sound in 3 frequency ranges on heart, lungs, arteries	
M5	Cholesterol strip test	1	Cholesterol level	
M6	Spirometry	1	Flow velocity in time	FVC, FEV_1, Tifno index
M7	Digital thermometry	1	Body temperature in ˚C	
M8	Urine strip test	11	Standard parameters of urine analysis	
M9	Dermoscopy	Individual number	Photos of suspicious formations in visible and infrared light	
M10	Anthropometric measurement module	6	Distance (in relative units) between predetermined anatomical points on the human body	Body height (H), waist circumference (WC), hip circumference (HC), waist-hip ratio (WC/HC), Scoliosis index, Kyphosis index
M11	Body weight meter	5	Weight (kg), muscle%, fat%, visceral fat%, Body mass index	Body mass index
M12	Glucose strip test	1	Glucose level in blood	
M13	Computer-based visual acuity meter	4	Visual acuity in each eye, colour vision in each eye	
M14	Audiometric test	14	Hearing threshold for each ear at 7 frequency values	

More detailed descriptions of some measurement modules are given in our previous publications [14-16].

The information received from the measurement modules varies both in number and range of parameter values [17-20]. For screening diagnosis, only parameter deviations from normal values are used, which indicate some changes in organism functioning.

The screening decision making for measurement module M1 "ECG" uses only two symptoms, whose codes and meaning are the following:

M1=0 - normal ECG,

M1=1 - ECG deviations from the norm.

The measurement module M2 "Tonometry" estimates 2 symptoms of the arterial blood pressure:

M2=0 - normal arterial blood pressure,

M2=1 - increased arterial blood pressure.

The measurement module M3 "Pulse oximetry" for screening decision making uses 2 symptoms:

M3=0 - SpO_2 % and Pulse rate (PR) are normal values,

M3=1 - hypoxemia.

The measurement module M6 "Spirometry" for screening decision making uses 4 symptoms:

M6=0 - the volume/flow measurements are within the range of the normal values,

M6.1=1 - reduced FVS,

M6.2=1- reduced FEV_1,

M6.3=1- reduced Tifno index.

The measurement module M13 "Computer-based Visual Acuity Meter" determines individual acuity for each eye and colour vision capability. Four symptoms for visual acuity and colour vision are used:

M13.1=0 – normal vision,

M13.1=1 – reduced vision acuity,

M13.2=0 – normal colour vision,

M13.2=1 – colour vision problems.

III. DISCUSSION

Our produced MTSC is designed for family doctors' practices, outpatient departments and preventive centres and for examinations of people outside medical service offices in order to facilitate the work of family doctors and general practitioners in preventive health screening of adult population. MTSC has several functions:

- to obtain subjective information about the person's chronic diseases, subjective sensations, ill-disposed heredity and different risk factors using an interactive questionnaire;
- to acquire objective data about the person's health using 14 measuring modules;
- to make preliminary screening decision about the individual's health carried out by MTSC;
- to provide wireless transmission of all information to the analysis centre in order to confirm a final conclusion of screening results;
- to set up a database of each individual.

A new model of MTSC essentially differs from the models existing in the market (Tapuz Medical Ltd., Israel, Modular Examinations Centre (MEC); TMA Medical, Austria,

Complex Mobile Care Unit (MCU); RDT Ltd., GB, Complex Tempus IC).

Novelties of our produced MTSC are the following:

Firstly, our model of MTSC comprises an interactive questionnaire with 126 questions, thereby relieving the doctor's work and economizing the doctor's time – it is not necessary to elicit anamnesis from the examined person.

Secondly, the employment of 14 measurement modules of our MTSC ensures quick, comprehensive information about parameters of 9 organ systems, glucose and cholesterol level in the blood and urine analysis (summary about 69 parameters), as well as findings of the analytic centre about the skin formations. All examinations are carried out approximately in an hour (maximum in two hours) without leaving an examination room.

Thirdly, all functions of the produced MTSC are implemented by the specially developed software that gathers information from the person's complaints and from objective measurements, bands together these information flows and draws a preliminary screening decision which is received by a person on the spot. The complete screening conclusion is received by a person after receiving an answer about findings of the analytic centre and doctor.

Two information flows provide a more credible screening conclusion than in the case with only one information flow. Unfortunately, two information flows complicate the decision-making procedure of the MTSC. The complaints or objective information from one organ system are frequently associated with the complaints or objective information from another organ system; therefore, the elaboration of the screening decision in this situation asks for specially developed original software. It must be noted that a screening decision made by MTSC is only a preliminary screening decision. The complete screening conclusion is made by a doctor after receiving the answer from the analytic centre about the skin formations and checking accuracy of collected information from the examined person.

IV. Conclusions

1. Our produced Mobile Telemedicine Screening Complex (MTSC) summarizes two different information flows – the subjective information flow from an interactive questionnaire and the objective information flow from the data of measurement modules.
2. Two information flows serve as a basement for a credible preliminary screening conclusion about the health of the examined person.
3. Preliminary screening decision made by MTSC has to be confirmed by the doctor.

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Zigurds Markovičs, Dace Matisone, Ieva Markoviča, Gunārs Balodis. Informatīvo plūsmu organizācija skrīninga sistēmā

Darbs izstrādāts E-medicīnas jomā un attiecas uz profilaktisko skrīningdiagnostiku (atsijājošo diagnostiku). Šim nolūkam ir izveidots mobils telemedicīnas skrīninga komplekss (MTSK), ko var izmantot profilaktiskās veselības pārbaudēs pieaugušiem cilvēkiem. Tas ir domāts ģimenes ārstiem, profilakses centros un veselības pārbaudēs ārpus medicīnas iestādēm.
MTSK darbību nodrošina portatīvais dators, kas ir apgādāts ar interaktīvās aptaujas anketu un 14 mērmoduļiem. Aptaujas anketa ar 126 jautājumiem par personas veselību nodrošina subjektīvās informācijas plūsmu, bet 14 mērmoduļi, ar kuru palīdzību tiek noteikti vai izrēķināti 69 parametri, veido objektīvās informācijas plūsmu. Šīs divas informācijas plūsmas nodrošina ticamāku lēmuma pieņemšanas datorrealizāciju par skrīninga rezultātiem nekā tas būtu, ja skrīninga lēmums būtu jāpieņem, tikai balstoties uz vienu no informācijas plūsmām. Rakstā aplūkoti pozitīvie ieguvumi un grūtības, ar ko jāsaskaras apkopojot šīs divas informatīvās plūsmas.

Зигурдс Маркович, Даце Матисоне, Иева Марковича, Гунарс Балодис. Организация двух информативных потоков в профилактической медицинской скрининг-системе.

Статья ориентирована на сферу е-медицины. Авторы предлагают разработанный Мобильный Телемедийинский Скрининг-Комплекс (МТСК), предназначенный для проведения профилактических осмотров взрослого населения. Скрининг-комплекс рекомендуется для семейных врачей, для врачей в поликлиниках, в профилактических центрах и для обследования людей вне медицинского учреждения.
МТСК имеет несколько функций: сбор субъективной и объективной информации о здоровье пациента, принятие заключения о состоянии здоровья пациента, - обеспечении беспроводной передачи всей информации на центр анализа для утверждения заключения и создания базы данных о каждом обследуемом.
Все функции осуществляются с помощью портативного компьютера со специальным программным обеспечением. В статье рассматриваются положительные и отрицательные стороны в процесе организации двух информационных потоков и принятии решений.