Usability Evaluation of a Primary Healthcare Information System for Epidemiological Research

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SUMMARY
Background: The development of Information Systems for the support of healthcare research in clinical environments is a major endeavor. Based on this fact the Laboratory of Health Informatics, University of Athens, Greece developed a prototype application for the Health Surveillance and the Epidemiologic Study of the farming population, based on the routinely collected health data and agricultural health and safety paramount information. Scope: The current study aims to evaluate the theoretical perception of potential Information System users in terms of system usability as it is related to clinical practice and epidemiologic research on farmers’ health. In addition, the study is keen to evaluate the perception in terms of the system adoption by potential users, the system usefulness in a real clinical environment, its contribution to the typical activities of a Primary Healthcare Center and to the planning of health promotion strategies addressing farmers. Material and Methods: The evaluation was performed with the use of a questionnaire which included questions on the system usability, the computer experience and the potential contribution in epidemiologic research, health promotion policies and clinical practice. The sample consists of 58 Medical, Nursing and Dentistry students, which were identified as potential users. Results: Multiple regression analysis was used to test possible correlations, according to the fore mentioned research hypotheses. Based on the results, the determinant factors of the users’ perception regarding the support in clinical practice are the system use and the system information quality. The system applicability has also been found to be positively correlated with the system usage. Finally the screen display appears to be correlated statistically significant with both the perception that the system is a useful epidemiological research tool and the perception that it can contribute to the planning and implementation of health promotion strategies addressing farmers’ health.

1. INTRODUCTION
According to the literature, farmers are at risk of developing a series of adverse health effects, which are mainly caused by exposure to pesticides, allergenic agents, bad posture and weight lifting. The exposure to pesticides can cause malignant diseases [1], [2], whereas allergenic dusts are associated with the development of respiratory symptoms [3], [4]. In addition, inappropriate body posture, vibrations and heavy weight lifting may cause various musculoskeletal problems. Moreover, accidents consist of an important hazard for the safety of farmers [5, 6].

Data collected in Primary Healthcare Centers in rural areas is not easily utilizable for the efficient surveillance of the patients’ health. An effectively organized health record could efficiently be used for the improvement of the surveillance of farmers’ health. The implementation of Electronic Health Records for Primary Healthcare Centers is crucial [7]. Until now, there have been few attempts towards the use of new technologies to support the epidemiologic surveillance of the population at large [8], [9]. These efforts have been achieved either by incorporating surveillance systems into existing information systems, or by the extraction of health data from Electronic Health Records for further processing to make sound medical decisions [10], [11]. Rather very few health Information Systems focus on farmers’ health in specific. In order to support the epidemiologic surveillance of farmers the system should not only be based on the routinely collected health data, but also on data related to the exposure to harmful agents, to the extent of use of Personal Protective Equipment (PPE) and to the type of farming activities.

Primary Healthcare Information System project for the Health Surveillance and the Epidemiologic Study of farmers

Based on the above data, the Laboratory of Health Informatics has undertaken the initiative to develop a prototype Primary Healthcare Information System for the Health Surveillance and the Epidemiologic Study of farming population. The structure of the Information System is based on literature research regarding farmers’ health, habits and factors related to various hazardous exposures. The Information System is composed of two modules. A web application has been developed for the storage, editing and retrieval of health and occupational health and safety data. The module can be accessed from Primary Healthcare Settings, namely Primary Healthcare Centers, Remote Rural Health Centers and Primary Homecare Services. The data collected through the web application are stored into a Central Database Server which synchronizes the second module of the Information System, namely the Local Application for the “Health Surveillance and Epidemiologic Research of Farmers”. The second module can be installed in Hospitals, Health Surveillance Sectors (i.e. Ministry of Health) and University Institutes. The Local Application can be utilized for the production of general descriptive and inference statistical information as well as for the estimation of epidemiologic indicators and time series charts on farmers’ health. The Local Information System is comprised of six distinct sections namely “Descriptive Statistics”, “Graphs and
Charts”, “Inference Statistics”, “Prevalence Map”, “Time Series” and “Epidemiologic Indicators” [12]. The visualization of both spatial and temporal dimensions is therefore expected to enhance the ability to undertake environmental health research using time referenced geospatial data [13]. In addition, the information system uses the data stored into the main server from the Primary Healthcare Settings for the calculation of a series of feasible farmer-specific indicators, based on the results of the European project [14], [15], [16]. Table 1 shows the main categories of research hypotheses that can be tested with the use of the Information System. The Information System has been presented in detail by Diomidous et al [17].

Table 1: Research hypotheses supported by the Information System

<table>
<thead>
<tr>
<th>Epidemiologic Research on farmers</th>
<th>Surveillance of farmers health and agricultural work</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is a possible correlation between the demographics with the development of specific diseases</td>
<td>The surveillance of the health status of farming population may contribute to the strategic policy implementation on Primary Healthcare Level</td>
</tr>
<tr>
<td>There is a possible correlation between the demographics with the extent of use of Personal Protective Equipment</td>
<td>Personal characteristics and information on agricultural work may contribute to the investigation of farmers profile</td>
</tr>
<tr>
<td>There is a possible correlation between the level of use of PPE with the development of certain diseases</td>
<td>The extent of PPE use may contribute to the identification of insufficient protective measures so far adopted and in a second step towards the implementation of targeted interventions</td>
</tr>
<tr>
<td>There is a possible correlation between the type of farming production and the exposure to hazardous agents with the development of specific diseases</td>
<td>The identification of time related changes in the health status of population and other parameters may contribute to efficiently organized health promotion strategies addressing farmers</td>
</tr>
</tbody>
</table>

Evaluation of Information Systems

The evaluation of Information Systems in terms of system usability is crucial due to the fact that system usability may positively influence the system adoption. According to Nielsen [18] the usability components refer to the ease of use perception, the familiarization with the system, the system effectiveness as well as the subjective perception of users. System usefulness refers to the system value –allowing the user to manage the job tasks efficiently. A difficult to manage and use computer system is expected to have limited adoption by the potential users, thus leading to restricted use. The quality of information also seems to be a major factor, thus leading to restricted use. The quality of information should be taken into account to enhance system adoption, parameters such as the familiarization with the system, the system efficiency, the time required to familiarize with the system, and the system effectiveness can be considered as potential factors affecting system adoption. According to Nielsen [18] the system usability may positively influence the system effectiveness as well as the subjective perception of users. System usefulness refers to the system value –allowing the user to manage the job tasks efficiently. A difficult to manage and use computer system is expected to have limited adoption by the potential users, thus leading to restricted use. The quality of information also seems to be a major factor, thus leading to limited use. The quality of information should be taken into account to enhance system adoption, parameters such as the familiarization with the system, the system efficiency, the time required to familiarize with the system, and the system effectiveness can be considered as potential factors affecting system adoption.

2. SCOPE OF THE EVALUATION

The scope of the evaluation process is to evaluate the theoretical perception of potential users of the Information System in terms of usability as well as the perception in terms of: the system adoption by potential users; the system usefulness in a real clinical environment; contribution to the typical activities of a Primary Healthcare Center; potential contribution towards the planning of health promotion strategies addressing farmers; potential system support for the Epidemiologic Studies of farmers.

The study aims to test the existence of possible correlation between demographic characteristics of potential users and their perception in terms of usability and usefulness for the epidemiologic study of farmers. Another alternative hypothesis describes a possible correlation between the perceived usability and the perception of the contribution to the epidemiologic research and the clinical practice.

Overall, the study aims to investigate the following hypotheses: Is the Information System efficient in terms of usability?; Is the Information System sufficient to contribute to future epidemiological research and current clinical practice?; Is the experience in computer use a factor that has a major impact in the system usability?; Is there a correlation between the perceived usability and the perception of the contribution to the epidemiologic research and the clinical practice?

3. MATERIAL AND METHODS

The system usability evaluation has been performed with the use of a questionnaire based on two well known system usability tools as a reference base, namely the PSSUQ (Post Study System Usability Questionnaire) tool [19] and QUIS questionnaire (Quality of User Interaction Satisfaction) [20]. Nineteen questions from PSSUQ have been incorporated into the questionnaire, as well as a selected set of parameters based on the QUIS tool. In addition, some questions on demographic data as well as a set of coherent questions referring to the perception of the users in regards to the potential contribution of the system have been included. The latter aims at identifying the potential usefulness of the Information System in relation to the strategic objectives of the application (Table 7). Finally the questionnaire includes a section with questions on the existing experience in computer use and on the level of knowledge in statistics and epidemiology. Fifty eight Medical, Nursing and Dentistry students, were identified as potential users and attended a 20 minute presentation of the Information System. They were then requested to complete a scenario with typical operations and fill-in the questionnaire. The central indicators of the PSSUQ and QUIS questions, as well as the parameters regarding the System Contribution related to Research and Health Surveillance were calculated afterwards.

4. RESULTS

Sample Characteristics

The selected sample that evaluated the Information System has an mean age of 26.8 years (st. dev=4.69). 27.6% (N=16) of the sample were male and 72.4% (N=42), female (Table 2). Male participants have an average age of 28.93 years (st.
Experience of Computer Use

In order to calculate the experience of computer use, six 5-scale questions have been used, referring to the ability to use a word processor, use copy-paste options, create a simple spreadsheet document, browse the worldwide web, develop an application, and create a simple database. These variables have been used for the calculation of a central computer experience indicator, namely “PC_OVERALL”. Also, two additional questions have been used, which refer to the time duration and frequency of computer use. Regarding the number of years of computer use, 6.9% (N=4) has been using computers less than one year. 12.1% (N=7) and 19% (N=11) has been using computers 1-3 years and 3-5 years, respectively. Finally, the majority of the participants 62.1% (N=36) has been using computers for at least 5 years. As far as the frequency of computer use is concerned, 43.1% (N=25) of the sample uses computers all the time, 43.1% (N=25) uses computers frequently and 12.1% (N=7) uses computers occasionally. This finding is expected, due to the fact that the evaluators are university students, and the computer is an indispensable tool for their studies.

Regarding the PSSUQ questionnaire section, the Central Usability Indicator (PSSUQ_OVERALL) has been calculated to be 4.95 in the 7-grade scale. The Overall System Use (PSSUQ_SYSUSE) indicator was found to be equal to 4.71 and the Quality of Information (PSSUQ_INFOQUAL) indicator proved to be 5.03. Finally, the Quality of Interaction (PSSUQ_INTERQUAL) estimator has been calculated to be 5.28, in the 7-grade scale.

As far as the QUIS section is concerned, the Overall System Perception (QUIS_OVERALL) was found to be equal to 6.18, in the 9-grade scale this time. In addition, the Screen Output Indicator (QUIS_SCREEN) and the Quality of Information Indicator (QUIS_INFO) proved to be 6.79 and 6.76 respectively.

Perception for the System Contribution in research and clinical practice

The Information System has been evaluated in terms of research contribution, contribution in Primary Healthcare, contribution in promotion policies addressing farmers and to the system applicability in clinical environment. Regarding the participants’ perception of the system contribution in the epidemiological research the average score was found to be equal to 7.599 (st.dev=1.380), in the 9-grade scale. The indicator that has been used for the estimation of the system contribution in clinical practice was equal to 7.425 (st.dev=1.554).

The potential contribution of the application to health promotion policies was calculated to be 7.491 (st.dev=1.644). Finally in terms of System applicability, the mean value was found to be equal to 6.316 (st.dev=1.698) in the 9-grade scale (Table 6).
In order to test the hypothesis whether the usability variables affect the perception regarding the contribution of the application to the Health Surveillance and Epidemiologic research, multiple regression statistical analysis was used. The normality test for the central indicators, showed that all but the “CONTRIB_PRIMARY_HEALTHCARE” estimators are normally distributed (Table 8).

### Table 8: Test of Normality for the produced central indicators

<table>
<thead>
<tr>
<th>Central Indicator</th>
<th>Kolmogorov Smirnov Z</th>
<th>Asymp. Sig (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSSUQ OVERALL</td>
<td>0.162</td>
<td>0.692</td>
</tr>
<tr>
<td>PSSUQ SYSUSE</td>
<td>0.138</td>
<td>0.710</td>
</tr>
<tr>
<td>PSSUQ INFOQUAL</td>
<td>0.731</td>
<td>0.639</td>
</tr>
<tr>
<td>PSSUQ SYSTEMQUAL</td>
<td>0.682</td>
<td>0.664</td>
</tr>
<tr>
<td>QUIS OVERALL</td>
<td>0.638</td>
<td>0.725</td>
</tr>
<tr>
<td>QUIS POWER</td>
<td>0.438</td>
<td>0.698</td>
</tr>
<tr>
<td>QUIS INFO</td>
<td>0.327</td>
<td>0.733</td>
</tr>
<tr>
<td>QUIS LEARN</td>
<td>0.771</td>
<td>0.239</td>
</tr>
<tr>
<td>QUIS POWER</td>
<td>0.438</td>
<td>0.698</td>
</tr>
<tr>
<td>CONTRIB_APPLICABILITY</td>
<td>0.438</td>
<td>0.698</td>
</tr>
<tr>
<td>CONTRIB_PROMOTION_POLICIES</td>
<td>0.384</td>
<td>0.051</td>
</tr>
<tr>
<td>CONTRIB_APPLICABILITY</td>
<td>0.193</td>
<td>0.635</td>
</tr>
</tbody>
</table>

Usability testing of the system and perceptions on the contribution to epidemiological research and clinical practice. It has been presumed that certain correlation between the system usability and the contribution to epidemiological research and clinical practice, exist (Figure 1). After testing each “Contribution” variable with each “Usability” variable separately using single linear regression, the non-significant variables were excluded from the multiple regression model Backwards Elimination regression model has been used. According to the results, the variable QUIS_SCREEN (Screen output) synthetic variable is a determinant factor for the perception of potential contribution of the application to research (B=0.726, p=0.000). For each 1 point rise of the 9-grade scale QUIS_SCREEN (Screen output) variable, there appears to be a rise in the perception of potential contribution to the research and clinical practice (Figure 1).

### Table 9: Predictive usability factors for the potential system contribution to epidemiological research and clinical practice

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Beta</th>
<th>T</th>
<th>P (Sig)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTRIB_APPLICABILITY</td>
<td>0.422</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>

5. DISCUSSION

The usability of an information system is related to the usefulness of the system in a real environment, according to the literature [18]. This paper aims to identify the usability factors that may influ-
ence the contribution of the Information System in a Primary Healthcare environment. The information system that has been developed has some unique characteristics. The system is not only intended to be used for the support of everyday clinical practice, but it has been designed with the main purpose to support the health surveillance and the epidemiological research. The system addresses a specific quite large occupational group of the Greek population, namely farmers. In this sense, some of the usability components which have been evaluated may prove positive the foremost research hypotheses of the study.

It seems that a well prepared application of such an Information System is able to persuade a potential user for its contribution both to research and health promotion of the farming population. It has been noted also a statistically significant relationship between the perception that the information and the terminology used by the system, are positively correlated to the contribution of the system in a Primary Healthcare environment. The latter means that the four mentioned parameters prove to be important determinants to ameliorated healthcare services provided in a Primary Healthcare Centre. It also seems that, according to the results of the multivariate analysis, the perceptions on the system usage based on the “System Use” indicator, are positively correlated with the overall activities of a Primary Healthcare Setting. Finally the perception of the “System Use” seems to be a major determinant for the potential users, regarding the system applicability in a real environment. It should be noted that the underpinned correlation between the variables under study does not necessary imply a causal relationship between them, but may enable to estimate possible determinants of the application potential contribution in terms of supporting the epidemiologic research and the clinical practice.

REFERENCES