Cervical Cancer Screening Web Application

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Abstract: This paper presents the main CANSCREEN (CEEX project – ctr. no. 125/2006) project team researches concerning an appropriate screening strategy for Romania in order to reduce cervical cancer incidence and mortality rates and to improve the quality of life for the patients. Many studies confirmed the efficiency of cervical cancer screening, and our work supports these studies by providing an organized framework, in line with European directives, for collection and validation of resulted screening data.
For the management of the information and medical data referring the cervical cancer screening, the CANSCREEN relational database has been designed and implemented under a web application form, easy to use and manage.

Keywords: relational database, medical data management, cervical cancer screening, web technologies

1. Introduction

Annually, in Romania, there are average 3001 new cases of cervical cancer. In 2000 were 1784 deaths by cervical cancer. The new cases of cervical cancer founded every year in our country increased from 2169 to 3001 (38, 35%) and the number of deaths from 1396 to 1795 (28, 58%). In 2000 Romania registered the highest incidence and mortality for cervical cancer in Europe after the estimated date of International Association of Cancer Registries. This situation is constantly in the last years.

All these mentioned above considerations demonstrate the necessity of a coherent and strategy of cancer early detection. This strategy represents the main objective of the CANSCREEN project, financed by Romanian Government, through Romanian National Research & Development Programme - CEEX 2006 (ctr. no. 125/2006).
The CANSCREEN project’s main objectives are presented in the following:

- development of a complex fail safe system which ensures the diagnosis and treatment quality according to EU Standards;
- design of a database which includes data related to tested women and also registers for high risk women;
- design of algorithms for individualized diagnosis and a protocol for subsequent therapeutics indications;
- improvement of the smears interpretation procedures;
- analysis and selection of smears containing cytological abnormalities;
- providing system’s quality by random selection of a percent of samples from the interpreted smears, and further transfer to an expert cytologist;
- smears distance transmission and assurance of their quality control;
- design of the cost-effectiveness study which allows the selection of the screening strategy with the lowest ratio of cost-effectiveness, using the Markov model.
2. CANSCREEN architecture

Through CANSCREEN project we have designed and implemented a complex software solution based on web technologies in order to collect, analyse, and validate the cervical cancer screening data and to monitor the screening program actions. The project methodology supports is the Oncology Institute of Cluj Napoca screening program for cervical cancer study, started in 2002.

The software solution’s hardware and software architecture were defined in order to accomplish the project objectives. Technical solutions and possible architecture analysis indicated that the best solutions that satisfy the requirements of such a system is an n-tier web architecture (figure 1), with the following development levels: presentation level, management logic level, data access logical level and database level. The presentation level will be implemented for the family doctors offices, the bleeding centers, cervical investigations, and cytological laboratories, for HPV testing, and others. The management logical level is implemented on the web server, while the data access logical level and database level are implemented on the application and database server and file server.

![Diagram](image)

**Figure 1. - CANSCREEN “n-tier” hardware architecture**

After conducting hardware architecture, it became possible to define the main modules that will compose the software application, which consisted in the interface design module (MPI), the medical data generation and exploitation module (MGEBD), the quantification and representation module (MRCD), the medical image acquisition module (MAI) (Pap smears), the image the filtering module (MFI), the system quality module (MAC), the economical analysis module (MAE).

Data which contain information related to the identification of tested women and the registers about women at high risk, are stored in a medical database – the system’s medical data generation and exploitation module (MGEBD) – which offers the possibility of retrieving data according to certain criteria, after a previous stage in which the data was encoded – quantification and representation module (MRCD). The relational model of the database ensured the data and relationships integrity and also the connection with various programming languages which generate interfaces. Beside the patient’s identification data, the informational system comprises an image acquisition module (MAI). The acquired images are pap smears which will be stored in the image databases. Using the filtering module (MFI) it is intended to optimize the interpreting procedures for the cytological smears, by elaborating recognition algorithms for extracting the quantifiable features. The system quality is implemented by the quality module (MAC) which randomly selects a percentage of the analyzed images, which are afterwards re-read and transferred to a cytology expert. The economical analysis module (MAE) decides the screening strategy in accordance with the cost-efficiency ratio, by using Markov models applied to existing data in the database. In order to accomplish the user access, there is the interface design module (MPI) at the level of the medical centers involved in the screening program for the cervical cancer.

Figure 2 presents the system’s software architecture and the connections between the system’s software modules.
3. CANSCREEN relational database

Adequate recorded data evaluation, in cervical cancer or other form of this kind of malady is a key factor in taking decisions regarding personal medical care and health politics. Accurate interpretation of medical parameters involves knowing statistic associated indicators meaning and clinical aspects faced with pathology. Medical parameters are represented by quantity, quality or survival type data. What meters are parameters type and their scale because these characteristics will determine tables’ type, graphics or resumed tables which represent data with best precision and manage to send observations to those who are interested. Choosing the most appropriate method of analyzing one issue depends on the way comparison is meant to be done and by selected data. Data are set to influence by their type, size of compared samples, by their property of being normal, by equality of variations, most frequent frequency. Choosing the most appropriate static method adapted to current situation can be done only after collecting all data. A system made for "all people purpose" has to be created for continuous monitoring of screening program. An appropriate legal frame is necessary for recording individual data and the link between "all people purpose" database, screening database, cancer and mortality registers. This system is an essential instrument for screening program management, participation indicator calculation, comprehension, quality and impact, feedback for medical staff, decision and authority factors in public health department. An experimental design has been chosen because is appropriate for evaluating the new strategies for organized programs. The right way to operate is by using epidemiologic regulations, their purpose are defining the basic structural architecture of screening programs and recommending a common methodology for organizing, evaluation and reporting. These regulations are relevant mainly for planning new screening programs in Europe. The result of screening program depends mainly on the quality of pathologist labor. Using samples prevailed from women that participate at screening program the pathologist offers particular information regarding each examined woman's condition. The therapeutic decision depends on the quality of pathologic exam, of its precision and forecast/prediction indicators. In order to achieve screening purposes, a firm set of information regarding each patient is required. Using an identical methodology and terminology for formulating the diagnosis is also required.

CANSCREEN medical data are presented in an encoded format, according to the screening programs guidelines, existing at European level. At the base level of a patient’s registering in the cervical cancer screening program are the personal data that characterizes the patient, the data specific to a certain screening phase, and the evaluation and treatment data necessary for patient’s surveillance during the whole screening period. The database design for CANSCREEN project consisted in defining its structure. The database being relational, in the first place, it was necessary to design it before elaborating it, after a database design methodology which consists in:

- developing the logic model;
- developing the physical model.

Beside the medical data identification for system’s necessary, the existing relationships were emphasized, and the restrictions imposed. The design was conducted is two phases:

- the development stage of the conceptual model, described by the entity-relationship model obtained;
• the development stage of the logic model, described by the relational schemes (figure 3).

Figure 3. - CANSCREEN relational database logic model

The logic model obtained could be imported easily in the database management system (Microsoft SQL Server 2005), which represents the necessary support for implementing the CANSCREEN database.

Some existing data were imported in CANSCREEN database. We have started from IOCN existing application description (developed in File Maker), from "Siruta" database belonging to "National Statistics Institute" (developed in Visual Fox), and we’ve developed a modular application which has done following: import data from Excel (*.xls) into CANSCREEN database (SQL structure). We have managed to import data from Excel into SQL Server by using server type links and SQL language distributed queries.

4. CANSCREEN web application

A software application was made for cervical cancer screening based on Web technology and developed under ASP, VB. NET, using for the system data management Microsoft SQL Server 2005. The .NET Framework (Microsoft Visual Studio) together with Microsoft SQL Server and Ajax controls offers tools in order to approach the screening strategy by developing the n-tier architecture, support of a web application with the above mentioned modules.

In generating CANSCREEN web application, the start was the user interfaces and the database designed. They have implemented the application modules that take data from the interfaces, convert data in order to save them in database and historic visualization or power supply of the operative elements of the screen. The implementation of the application modules is made in VB.NET, so the resulting file types are * .aspx, * .vb, grouped in the application _asp_Canscreen project. The modules that make the web application CANSCREEN are the management module login, related to the main page of the application, the management module of population lot, the management module of dictionaries of doctors and medical centers, module management of programs screening, management module results of the screening process, and module of post processing and interpreting statistics.

The functional verification (the security through the application of restricted access to users based on their own defined role, the management visualize them in other synthetic interfaces, respectively extract data from database for through lists and individual lot population, the management of dictionaries of specialized medical centers, and medical staff involved in screening, the visualization of individual history of the subjects of screening program, the image of cytological processing in order to improve quality, and the increase of usability) of the CANSCREEN web application were made on a database loaded with simulated data. The population lot included a restricted number of subjects, and it's based on data that have been specially edited. At this level of the population lot, there have been compiled all the necessary formal rules of the imported data, as well as mechanisms of the web application in a functional whole.

Next figures present some CANSCREEN web application user interfaces.
### Formular Pentru Screeningul Cancerei de Col Uterin

**Data:** 06/07/2008

<table>
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<tr>
<th>Seria formularului</th>
<th>COD NUMERIC PERSONAL</th>
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**Antecedente personale** (bileți în casute corespunzătoare)

- Chirurgie abdominală (C in cazul appendicitis, C în ultimuliz 6 luni, C mai mult de 6 luni)
- Radioterapie (C in cazul terapeutici, C în ultimuliz 6 luni, C mai mult de 6 luni)
- Hormonoterapie (C contraceptiva hormonală)
- Treapte chirurgicale col uter (C hysterectomia totală)
- Leziuni de reproducere (C contraceptiva subtotale)
- Alte

**Status hormonal**

- Ciclica
- Serură Menopauză
- Laizi (12 săpt.
- Aplacate

Data ultimei menstruații: 22/04/2008

**Conținut recoltat**

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<th>Selectăți centru de recoltare</th>
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**Laborator**

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<th>Selectăți medicul citologic</th>
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Data interpretării: 06/05/2008

- Tip fosform: C tricomi, C candida, C cocobacili, C acíciozmi, C vitamine herpes simplex, C Gardnerella, C alte

- Selecție: C negativ pentru leziuni intraepiteliale sau malignitate
- Tricomi
- Candida
- Cocobacili
- Acíciozmi
- Vitamine herpes simplex
- Gardnerella
- Alte

- Celule endometriale pt. femei > 40 ani
- Anomaliile ale celulelor epiteliale
- ASC-US
- ASC-H
- LSIL
- LSIL cu atipii HPV
- HSIL
- HSIL cu suspecțiune de invazie
- Carcinoom cu celule scuamaze
- Anomaliile ale celulelor glandulare
- Atipii celular endocervicale NOS
- Atipii cellular endometriale NOS
- Atipii celular glandulare NOS
- Atipii cellular endocervicale FN
- Atipii celular glandulare FN
- AIS
- Adenocarcinom
- Endocervical
- Endometrial
- Extranerul
- NOS

**Observații**

**Indicații**

- Repetare imediată
- Repetare după tratament antiinflamator
- Repetare la 6 luni
- Repetare de rutină (în 6 luni de screening obisnuit)
- Testare HPV
- Biopsie / colposcopie
- Chirurgie biopatică

**Registrare formular** | **Validează formular**
5. Conclusions and future work

CANSCREEN web application permits the screening target population monitoring and calculates some statistic indicators, such as: the characteristics of the screening program (definition of the target population, invitational mode, protocol for cytological repeat) and the annual tabulations utilising individual screening data (invitations, invitational coverage, and status of target population in the cervical cancer screening programme, pap smear tests and population coverage with smear tests in the cervical cancer screening programme, results of all smears taken in the cervical cancer screening program, number of women recommended for repeat cytology in the cervical cancer screening programme, number of women referred to colposcopy in the cervical cancer screening programme, etc.). Based on these indicators the web application contributes to the screening program quality.

As future work, CANSCREEN web application through its database could facilitate the screening data and indicators export to other applications, such as national/regional cancer registry.

Bibliography
