A Web-based Support System for the Breast Cancer Screening Program in the Province of Luxemburg, Belgium

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Abstract

The Belgian Breast Cancer Screening program has been launched in 2001 according to the recommendations and quality assurance guidelines of the European Union. Women in the age range 50-69 years are invited to pass a mammography which is read by two independent radiologists. In case of discrepancy, a third reading is requested. Each reading is documented in detail. In this context, a novel Web-based computer system was designed and developed to support the program. Difficulties related to graphical data entry on Web pages were smartly resolved. A complex algorithm for comparing mammography readings has been implemented in the system, enhancing the quality of the screening program. The application has been tested in the Province of Luxemburg, a widespread rural region particularly suited for Internet solutions in preventive medicine. The Web-based system provides all management facilities, ubiquitous online statistics, and builds up a reservoir for official statistics and scientific research. Administrative and medical personnel have expressed their total adherence to the system, while health authorities have used it to justify their involvement in the screening program.

Keywords:

Breast neoplasms / Prevention and control, Public Health, Internet, Telemedicine, Mass screening.

Introduction

Breast cancer is the most prevalent cancer affecting women in western countries. Assuming a life expectancy of 84 years, one woman among eleven will be affected by the disease and one out of 24 will die of it. The risk of developing breast cancer increases with age but 75% of the cases occur after the age of 50 years. The etiology of breast cancer is still unknown and measures to prevent the disease are difficult to establish. Today, prevention mostly consists in early detection of the disease by mass screening programs, thus enhancing the chances of remission [1]. In 1992, the European Union recommended that breast cancer screening programs by mammography (MM) be implemented in all its Member States. To be efficient, such screening programs require a quality assurance policy at all levels of the process [2], namely:

- massive participation of women in the age range 50-69 years (>70%)
- involvement of all the actors concerned (general practitioners, gynecologists, radiologists, oncologists, radiotherapists, healthcare authorities and policy makers, public health professionals and public relation specialists)
- quality of mammography
- double reading
- data management and follow-up of positive cases
- continuous quality assessment.

A Web-based computerized management system was designed, developed and tested to support the breast cancer screening program in Belgium while fulfilling the quality assurance requirements.

Methods

Screening program

The Belgian Breast Cancer Screening program [3] is based on 2-year cycles during which every woman between 50 and 69 years of age is invited to pass a mammography. In case of no response, a reminder is sent 6 months later. If the person still fails to respond, her case is postponed to the next cycle. Women are always free to consult their general practitioner or gynecologist to get an MM-prescription. Each MM is read and protocoled separately by two radiologists. Several radiologists have been officially appointed by the health authorities for the screening program. The two readings are entered in the database and detailed clinical findings carefully recorded. Readings are then compared and in case of discrepancy, a third reading of the MM is requested and carried out by an independent radiologist to reach a consensus. Each participant is informed by her attending physician about the test result and in case of abnormality the patient can be referred for an in-depth clinical investigation.

Software tools

The software developed for this project is a Web application where Web pages are created dynamically and can interact with a database. It uses the *ASP (Active Server Page)* technology from *Microsoft*. This solution has several advantages:

- The application can be accessed from anywhere with no installation needed.
- All data are centralized in one database.
- Every update is immediately available to the users.

For encoding the MM-readings, in particular graphical location of abnormalities on left and right breasts, some pages of the Web-site use DHTML (Dynamic HTML) which provides features for positioning elements dynamically on the page. Because the compatibility of DHTML between different kinds of browsers is low, only an Internet Explorer version has been developed. This is the most widely used browser and it offers a great compatibility with DHTML. This limitation can be justified by the fact that only a small number of users have access to the site.

Database

The application is built upon an *SQL Server 2000* database. This database mainly contains (see Figure 1):

- A table for the characterization of each patient (demographical, social and administrative data,…).
- A table for the follow-up of each MM performed.
- Tables for each of the three radiological readings of the MM. They contain the details of the clinical findings and the radiologist's diagnosis.

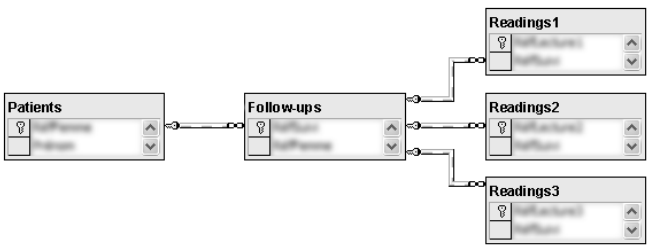

Figure 1 – Database diagram

Hardware

The site is hosted on a Web server running *Windows 2000 Server* with *Internet Information Server 5.0*. It is connected to Internet by means of a T1 connection.

Results

Pilot implementation

The Province of Luxemburg (Belgium) has served as a pilot for implementing and testing the Web-based support system. This Province is known worldwide for its famous Battle of the Ardennes in 1944 but also for its tremendous epidemiological interest [4]. Several studies have shown that it has one of the highest prevalence of cardiovascular diseases and associated risk factors not only in Belgium but also among surrounding European countries. It is mostly a rural and forested region sparsely populated (220.000 inhabitants) with remote villages and mid-sized cities. Long distances between healthcare facilities make Internet solutions particularly suitable and cost efficient.

Encoding of the readings

Data and graphical entry of the MM-readings from the Web-site was the most salient and time consuming part of the conception and development of the application.

The major difficulty resides in the encoding of the type and location of abnormalities on the breast drawing. Indeed, the radiologist can choose among a list of abnormalities and then he can point out their position on the drawing. Thus, a way had to be found to allow the user to put crosses on a drawing in the Web-page and to indicate to which abnormalities these crosses corresponded.

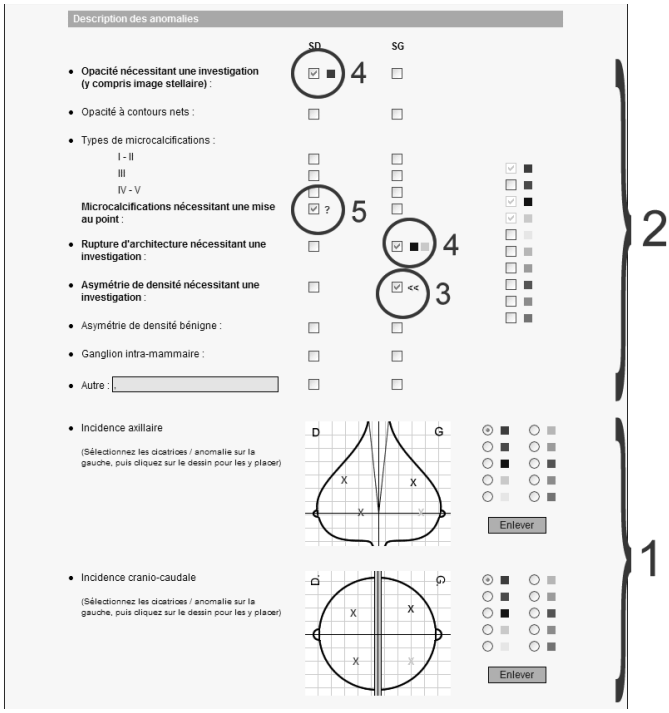

Figure 2 – Data entry of graphical abnormalities on the breast drawings (will be translated in English in the final version)

Figure 2 displays the chosen solution. In zone 1, there are two breast drawings (axillary and cranial-caudal) on which crosses can be placed. It is possible to place 10 crosses per drawing, each of a different color. The color is selected from the palette at the right of the drawing, and then the corresponding cross can be placed or moved on the drawing with mouse clicks. Once the crosses are placed, they must be associated with the corresponding abnormalities. In zone 2 of Figure 2 there is a list of eleven abnormalities (one of which can be defined freely), each one with two check boxes (one for each breast). Each time a check box is selected, a red mark appears at its right (see zone 3). This means that a color must be associated with it by clicking on the palette located at the right of the list. Colors already associated with an abnormality are disabled and can not be selected. Once the color is chosen, it replaces the red mark at the right of the abnormality (see zone 4). The user has to take care that the color of the abnormality corresponds to the color of the cross on the drawing specifying its location. Several colors can be associated with an abnormality to allow the placement of several crosses on the drawings for the same abnormality. If the user forgets to associate a color to an abnormality that he has selected, a question mark appears at its right and validation of the page will be refused (see zone 5).

Comparison algorithm

Once the two MM-readings have been entered into the system, they will be compared by a complex algorithm. First, the recommendations of the readers and their conclusions are compared. Of course, if they are not similar, the readings are declared not valid. If similar and negative, the readings are declared valid. If similar and positive, a deeper comparison is made concerning the abnormalities and their position to decide if the readings are valid.

If the comparison succeeds, a conclusion (third reading) is automatically generated with the data of the two readings (small differences are possible, in this case the "worst" finding is taken into account). If the comparison fails, a third reading will have to be realized by an independent radiologist. The final concensus reading is encoded into the system.

Functionalities of the application

The Web-site application offers a wide range of functionalities which facilitate the support of the screening program, namely:

- Comprehensive administrative management of the program (personal invitations, follow-ups, pending problems, financial management, etc.).
- Mass encoding of target women by means of an Excel file containing the data. The file is uploaded to the site and is automatically parsed to insert the new women into the database. A procedure checks for collisions.
- Automatic generation of letters, lists and other correspondence. These documents are generated in RTF (Rich Text Format).
- Online statistics give ubiquitously a real-time vision of the status of the screening program to the Public Health authorities (number of invited women, response rate, prevalence of positive cases, etc.).
- The richness of the database authorizes advanced statistical analyses such as the agreement between readers, the calculation of prevalence according to different parameters (age, location of abnormalities, etc.).
- Information can be systematically extracted from the database and sent to the Ministry of Public Health within the framework of the European Union Breast Cancer Screening program (global European statistics). Random samples can also be drawn from the database to analyze the reasons for non-participation or for other evaluation purposes.

Security aspects

As the application is concerned with sensitive medical data, special attention has been paid to provide a maximum of security:

- An SSL (Secure Socket Layer) certificate was installed on the server for 128 bit encrypting of the transmitted data.
- Access to the Web site is only allowed to the actors involved in the screening program and a username and password are required to enter the application.
- Within the application, there are various levels of authorization depending on the user profile. Clinical data are only accessible to physicians, while online statistics can be visualized any time by health policy makers.

Current status

The Web-based support system has been running successfully for more than one year. Meanwhile, several minor improvements have been made to the system upon the request of the users. The clerical staff and the radiologists have found the system user friendly, reliable, secure and fast despite the remote access to the Internet server. Provincial public health authorities have also expressed their satisfaction about the Web-based application and health policy makers used the system to document and justify their involvement in the national breast cancer screening program.

Currently, the database contains 14,692 women with a mean age of 59.5 ± 6.1 years (range: 50 – 70 years). The participation rate amounts 17.2%, about twice more than in the other provinces. After the first MM-reading, 20.4% of the women were found to be positive, but this figure dropped to 10.2% after the second MM-reading, thus confirming the usefulness of the second reading. The overall disagreement rate between the first and second readings currently amounts 19.7%. It follows that a third reading is required in about 20% of the cases. Statistical analyses have shown that Cohen's Kappa agreement coefficients between radiologists range between 0.37 and 0.70.

Discussion

In the fight against cancer, Belgium, like other industrialized countries, has launched a long-term mass screening program for the prevention and control of breast cancer. The design and implementation of the national program has been time consuming and difficult. As for the centralized computer support of the program to be provided by the Ministry of Public Health, promises have not been held. Therefore, provinces responsible for the actual execution of the screening program have developed their own computer application (ranging from simple Excel solutions to local area network Access-based systems). By contrast, the Province of Luxemburg, the most widespread Belgian province, has favored an Internet-based application with a central SQL Server database. Such solutions are increasingly used in clinical trials [5] and in remote patient care. Their implementation in Public Health and in preventive medicine is novel and by no means straightforward.

To develop the Web-based support system of the breast cancer screening program, the database had to be carefully designed and difficulties with graphical data entry on site pages smartly resolved. A complex computer algorithm was also written for comparing MM-readings, up to the most detailed information reported by the radiologists on each breast. This comparison algorithm is one of the salient element of the entire application because it enhances the quality of the screening program. Security aspects have also been dealt with.

The support system developed bears all the advantages of Internet-based facilities (e.g., low cost, remote data entry, flexibility, work comfort, ubiquitous access, user friendliness and advanced technology). With little additional work, the system could be easily extended to other provinces or nationwide. Managerial and medical personal have been quickly acquainted with the system and almost no training was required.

A major advantage of the application results from the fact that it keeps a comprehensive historical record of all women involved in the screening program and of their mammographies. This enables to perform an evaluation of the breast screening program and to readjust the program with respect to the target population and all the actors involved, whenever necessary. In other words, the Web-based support system that has been designed permits a rigorous and quality assured mass screening program policy. Finally, the richness of the database offers a vast reservoir for official statistics and scientific research.

Conclusion

In the absence of a nationwide central support computer system to be provided by the Ministry of Public Health, a Web-based pilot computer system has been developed to support the breast cancer screening program in the Province of Luxemburg, Belgium. The application has been running for one year with success to the satisfaction of managerial and medical personnel as well as of provincial public health authorities.

Acknowledgments

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