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IMPROVING BREAST CANCER AWARENESS THROUGH AN EXPERT SYSTEM

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Abstract

The mission of this research paper is to demonstrate the development of a breast cancer awareness and diagnosis expert system utilizing human experts' knowledge that focuses on users' lifestyle, personal and family history, and various symptoms of breast cancer to raise awareness about this disease and help early detection. Breast cancer is considered a second kind of cancer impacting women's lives globally, and it affects about twenty percent of women in Oman, mainly due to a lack of awareness and early detection programs in some places and to cultural barriers. This study developed a simple breast cancer awareness and diagnosis expert system prototype to raise awareness among the female population in particular and to help diagnose breast cancer at early stages for better success rates in treatment. The system has been developed by using a web content rule-based expert system shell. Subsequent to the development of the system, it was evaluated by various users to check its benefits and advantages through a set of evaluation criteria. The potential users noted the advantages and limitations of the system.

Keywords: Breast Cancer, Expert System, Knowledge, Awareness, Diagnosis, Detection.

1.0 Introduction

Cancer is one of the leading causes of deaths worldwide, and it has become a significant public health dilemma all over the world. The burden and expense of cancer treatment have severely increased in the past 3-4 decades (Nooyi and Al-Lawati, 2011). The term *cancer* is a Latin word meaning *crab*, and it was used long ago to identify malignancy. It refers to a group of more than one hundred various and distinct types of illnesses. Bancroft (n.d.) defines cancer progress

and process as the development and production of cells in an unusual and exceptional manner in which the cells tend to reproduce and increase rapidly without any control. Breast cancer is one of the main types of cancers affecting women worldwide as it is second kind of cancer impacting women's lives globally. It affects almost one out of eight women (Hook, 2013).

The Sultanate of Oman is one of the member countries of the Gulf Cooperation Council (GCC) with a developing healthcare system. Like other countries worldwide, Omani women also experience breast cancer diseases and associated deaths (Al-Lawati, Santhosh Kumar, Mohammed, and Jaffar, 1999). About twenty percent of women in Oman have suffered from breast cancer during their lives (Kumar, Burney, Al-Ajmi, and Al-Moundhri, 2011). The reasons behind this are mainly a lack of awareness and early detection programs in some places and cultural barriers (Nooyi and Al-Lawati, 2011; Kumar et al., 2011).

Considering that preventive and early detection measures are lacking and underutilized by the public, this study aims to develop a simple breast cancer awareness and diagnosis expert system to raise awareness among the female population, in particular, and to help diagnose breast cancer. Because breast cancer cases are on the rise, the proposed system should be an ideal tool as it can be easily accessed by all concerned users from anywhere and at any time.

Users, especially from the female population, need to conduct routine breast self-examinations to detect breast tumours and diagnose cancer at an early stage since they will have better chances of treatment and full recovery if the cancer is treated early.

The terminology "stage of cancer" or "staging" often indicates the size of a cancer/tumour and how far it has spread. According to Cancer Research UK (2013), breast cancer is divided into four stages as follows:

Stage 1 is split into two groups:

- Stage 1A: Cancer within the breast is less than 2 centimetres (cm), and there are no cancer cells within the lymph nodes.
- Stage 1B: Limited cancer cells are found in the lymph nodes (under the arm), but no cancer is found in the breast; OR limited cancer cells are found in the lymph nodes, and there is less than 0.2 cm cancer in the breast.

Stage 2 is divided into the following:

- Stage 2A: Cancer within the breast and lymph nodes is less than 2 cm in size; OR cancer is between 2 and 5 cm in the breast, and there are no cancer cells within the lymph nodes; OR 1-3 lymph nodes have cancer cells, but no cancer is found in the breast.
- Stage 2B: Cancer within the breast is between 2 and 5 cm in size, and there are cancer cells in the lymph nodes; OR cancer is more than 5 cm in the breast, and there are no cancer cells in the lymph nodes.

Stage 3 is split into three groups:

- Stage 3A: Cancer is found in 4-9 lymph nodes with no cancer in the breast; OR cancer is between 2 and 5 cm in the breast, with 4-9 lymph nodes affected; OR cancer is larger than 5 cm in the breast with cancer cells in the lymph nodes.
- Stage 3B: Cancer is attached to the skin or chest, but no cells are found in the lymph nodes; OR cancer is attached to the skin or chest, and fewer than 9 lymph nodes are affected.
- Stage 3C: Cancer in the breast can be any size, and 10 or more lymph nodes under the arm are affected.

Stage 4: Cancer can be any size, and it has spread to other parts and organs of the body.

2.0 Background Literature

An expert system, recognized as an extension of Artificial Intelligence (AI), is developed through a process to establish smart codes and intelligent programs and applications to perform solutions and tasks related to complicated issues and projects, provide business and technical conclusions, as applicable, and perform various functions, as deemed required, through the utilization of these codes, where usually requirements of human resources and expertise are needed (Duan, Edwards and Xu, 2005). Additionally, an expert system is a program on a

computer acquired by artificial intelligence, which is considered a division of computer science research. The main goal of artificial intelligence is to display intelligent behaviour as a computer program. The intelligence involves many knowledge skills such as problem solving skills and learning and understanding. The artificial intelligence program does the same tasks as expert work. It is considered an alternative way to gain knowledge rather than from human experts directly. It has been founded to solve problems about specific areas within the domain of the problems.

According to Feigenbaum, Friedland, Johnson, Nii, Schorr, Shrobe and Engelmore (1993), the expert system includes all knowledge and information obtained from human experts. People can turn to the expert system instead of having to collect such knowledge and information from books and articles or from non-knowledgeable people. Our goal is to establish a breast cancer expert system by developing a computer application that focuses on lifestyle, awareness, personal and family history, and various symptoms of breast cancer. We desire to raise awareness about this disease and make recommendations about lifestyle and diagnoses in one platform expert system.

The Knowledge Engineer (KE) and the human domain expert(s) are the main parties and components of expert system domain and knowledge acquisition. According to Waterman (1985), the expert is a knowledgeable, well-informed, and well-spoken person with a thorough knowledge in a specific field and has the ability to provide good solutions to problems within the domain. Next, Stein (1992) defines the methods for selecting the knowledgeable people needed to be experts in a specific domain. First of all, the expert must know all the system objectives and goals. Secondly, choosing the best expert depends on the expert's work, experience, and reputation (Liebowitz, 1998). Thirdly, the expert should be available while the system is developed and when the project is in the validation phase. In addition, the best way to select knowledgeable people for the expert system is to use the network analysis method (Stein, 1992).

The benefits and advantages of using an expert system are as follows: “cost reduction, increased output, improved quality, consistency of employee output, reduced overtime, captured scares expertise, flexibility in providing service, easier operation of equipment, increased reliability,

faster response, ability to work with incomplete and uncertain information, improved training and increased ability to solve problems" (Stylianou, Madey and Smith, 1992, p. 32).The speedy usage of Internet technology can enhance the utilization of an expert system, which is mainly to copy expertise and transfer such knowledge into non-experts' hands (Duncan, Edwards and Xu, 2005).

Because people around the world do not always manage their time properly, they neglect to take care of themselves. Thus, people reach to the Internet from anywhere and at any time because of its information and global networks. Therefore, the female population particularly can utilize the proposed system to obtain data on this killer disease and enhance their awareness and risk assessment because this expert system uses human experts' knowledge and transfers it into codes for a computerized system. An expert system provides information and solutions for the users through built-in and stored knowledge (Becerra–Fernandez, Gonzalez and Sabherwal, 2004).

The key benefits of an expert system for the detection of breast cancer in comparison with a breast cancer's doctor, as noted by Al Zahrani, Soomro, and Memon (2010), are that the expert system can include more knowledge than the doctor has. This knowledge is stored in the system's database. In addition, the expert system can include specialist information that the doctor does not have. And last but not least, the expert system may acquire knowledge from different areas of expertise and from various doctors around the world. Although there are benefits from the expert system, there are some challenges, as mentioned by Al Zahrani et al. (2010). Firstly, the system has no common sense as compared to doctors. Secondly, the expert system has no creativity while responding. In contrast, the doctor can easily adapt to changes that occur, while the expert system needs to be periodically updated. In addition, some of the target people and users of the expert system trust only what a doctor would say. Furthermore, the expert system cannot manage exceptions and/or complicated causes due to its limitations (Duncan, Edwards and Xu, 2005).

This study's proposed system is different from the other systems, such as those noted by Al Zahrani et al. (2010), as it advises users about the importance of maintaining a healthy lifestyle and being aware of breast self-examination methods, and it provides necessary recommendations and advice based on the users' interface and input regarding personal and

family history and detected symptoms so that users can diagnose the disease. The main mission of this proposed system is not only diagnosis but also prevention of the disease through improvements in the users' lifestyle and early detection of the disease through breast self-examination.

3.0 System Objective

The mission of the breast expert system is to develop a knowledge- based system utilizing humans' knowledge and to provide this knowledge to users through a friendly expert system. The breast cancer expert system will be able to provide simple answers to questions and solutions to problems raised by the users (Tripathi, 2011).

The objective of this prototype of a breast cancer expert system is to help raise awareness of cancer, help the female population be evaluated and diagnosed, and help users understand the likelihood of having this disease depending on their age, family history (Lee, Czene, Rebora, and Reilly, 2014), and other factors. As cancer is a major public health problem worldwide, it is essential that public awareness be improved in order to help people take appropriate preventive measures by changing their lifestyles, carrying out tests and procedures based on their risk factor(s), and detecting the disease early for better chances of successful prevention and/or treatment of the disease.

The expert system will provide useful advice based on the responses from the users, providing suggestions for self-screening methods and statistics and data relating to the disease, etc. Additionally, the expert system will advise users about the type of treatment needed. It will hopefully raise more awareness about risk factors so that users know more about the disease and its types and about preventive measures, etc., through a very friendly and simplified expert system.

4.0 Knowledge Elicitation Process

The main method for acquiring and processing knowledge from human sources is the interview technique (Becerra–Fernandez, et. al 2004). The authors utilized this method for the

development of an expert system as the experts provided/will provide us with sufficient knowledge and materials about breast cancer.

Our main sources of knowledge are two domain experts, who are medical doctors and senior consultants in Oncology. One of these experts was Dr. Bassim Al-Bahrani, Director of the National Oncology Centre at the Royal Hospital and the Senior Consultant of Oncology.

Interviews with them provided us with opportunities to gain tremendous knowledge and qualitative information on the awareness, early detection, and risk factors, etc., of breast cancer. However, the success of the interviews was usually dependant on various factors as indicated by Sagheb-Tehrani (2009): limitation of time with the expert, experience and knowledge of both parties, interrelationship between the knowledge engineer and the expert, and the readiness and willingness of the expert to advise adequately, share experience, and provide information.

We conducted a kick-off interview by utilizing a basic one-on-one interview process to capture all the knowledge and data on the subject matter in addition to learning the expert's opinions and ideas on this disease. Throughout the development of the system, we presented the experts with the prototype system so they could provide further consultation and help evaluate and refine the system.

The experts responded with more knowledge contributing to a definition of the disease and provided more information about the causes, types, prevention, and early detection of the disease as well as types of treatment, etc. They also offered leaflets and resources to help us as knowledge engineers in our project.

Although the interviews were time-consuming and there were difficulties associated with them, the knowledge and experience of the experts were great as they were ready to provide us with useful information to help us successfully accomplish our project and our mission, which is of great importance.

5.0 System Analysis

The system analysis is divided into: input, output, and the information in the middle. It is well established that an awareness of breast cancer, self-examination, and periodic screening have greatly enhanced early detection of the disease, which in turn has improved survival rates.

5.1 Inputs

The system asks the user(s) questions related to their personal data (gender, age, weight, pregnancy history, breast-feeding, etc.), lifestyle (exercise, smoking, alcohol use, eating habits, and exposure to pollution, etc.), and awareness of the disease, family history, and breast cancer symptoms. Risk factors for breast cancer include age, family history, no pregnancies, having the first pregnancy after age 30, not breast-feeding, being overweight, lack of exercise, drinking heavily, etc. (Hook, 2013). The items related to breast cancer symptoms were the following:

- A lump in the breast tissue detected through self-examination and screening
- Swelling under the arm
- A change in the skin of the breast
- Breast skin irritation
- Skin puckering (dent) in the breast
- Nipple discharge
- Inverted nipple
- None of the above

5.2 Outputs

There is only a small percentage of cancer cases resulting from genetic defects, while there is a huge percentage of cancer diseases associated with environmental and lifestyle factors. This study aims to raise awareness through self-examination and help alter the lifestyles of individuals by suggesting they avoid smoking, have good nutrition, avoid overuse of alcohol, avoid obesity, get exercise, and avoid overexposure to the sun, etc. The output of the system includes items related to body mass index, body status, breast cancer risk diagnosis, awareness, lifestyle requirements, and recommendations.

5.3 Middle

The information in the middle is the link between the input and output (Becerra–Fernandez et al. 2004) as the expert system will be able to utilize in a very simplified and friendly manner the expert's knowledge and information with the data inserted by the users in formulating proper outputs.

This study aims to raise breast cancer awareness and highlight risk assessment. Depending on the answers and input from the users, the system will raise awareness of the risks for the users and will provide needful advice about the risks the user and/or her relatives might have. The system will provide essential information about cancer, lifestyle, self-examination, early detection, and the ways users can check for the disease. Decision tables were built to simplify the middle logic.

6.0 Developed System Design

A breast cancer expert system is a system that is developed using a web content rule-based expert system called "eXpertise2Go". Expert Systems are considered better than computer-based advising method systems, as stated by the eXpertise2Go website, in terms of goal orientation, efficiency, adaptiveness, ability in dealing with uncertainty, and ability in providing explanation for their requested information and suggestions.

Below are some sample illustrations of what the proposed system looks like. Figure 1 shows the main interface of the system. The users of the system first click the start button to run the system.

Figure 1: The Main Interface of the Breast Cancer Expert System

Secondly, the users answer questions about some personal data (i.e., gender), as indicated in Figure 2.

Figure 2: A Snapshot Sample of Personal Data

Figure 3 shows a question about any breast cancer symptoms. This information allows the system to perform further analyses and give recommendations.

Figure 3: A Snapshot of Breast Cancer Symptoms Query

Finally, a conclusion is reached, as shown in Figure 4. The conclusion derives from the user's inputs on the questions.

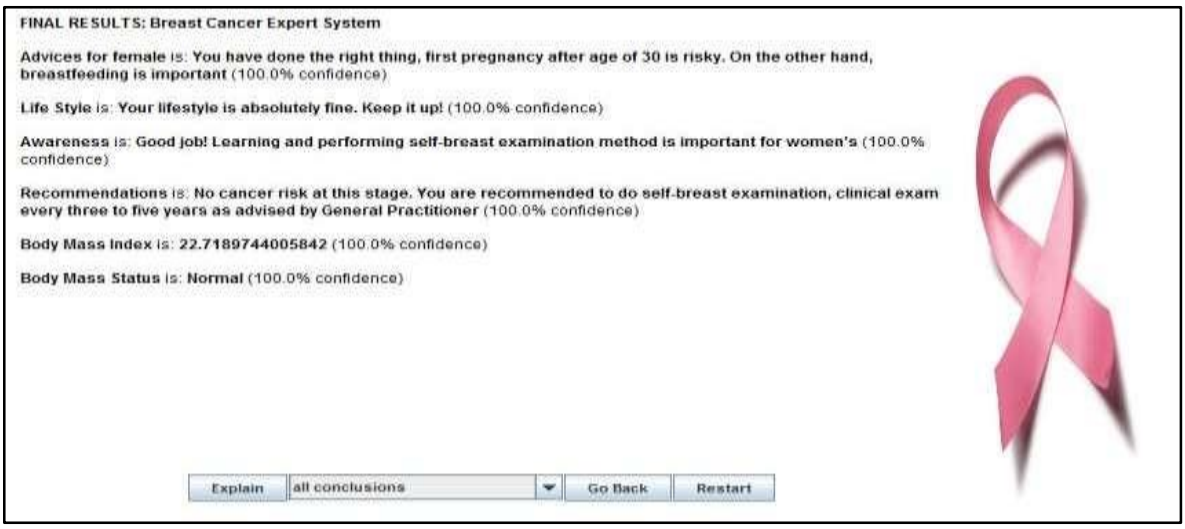

Figure 4: A Snapshot Sample of a Typical Conclusion

The user has to click on the underlined text in order to receive advice about the risk of having the first pregnancy after age 30. Brief information is provided, as illustrated in Figure 5.

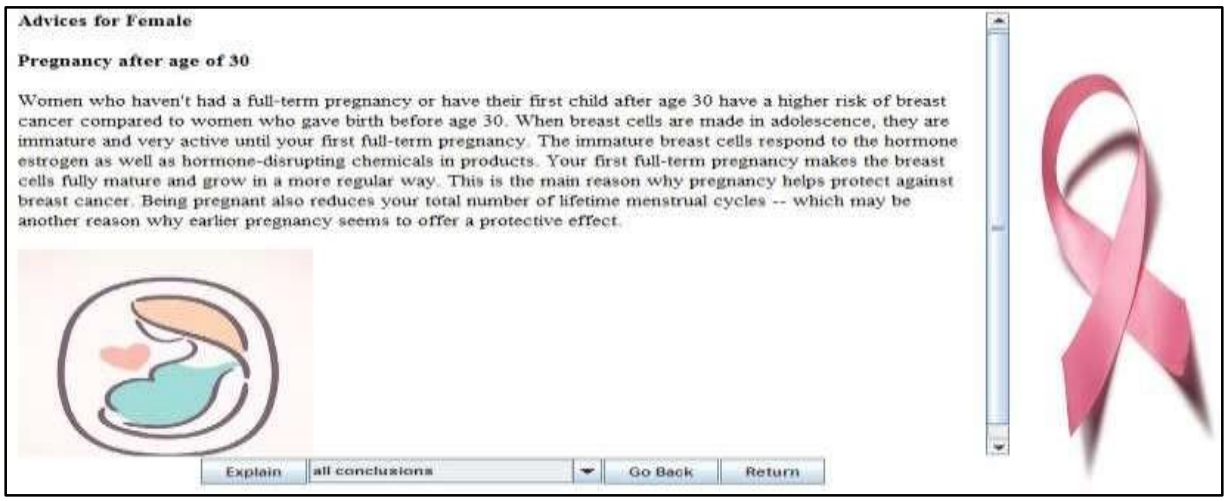

Figure 5: A Snapshot Sample of Brief Information for a User

7.0 Evaluation of the System

To gather more information and better enhance our proposed breast cancer expert system, a questionnaire was issued to obtain thorough feedback from domain experts and users of the system. Ten participants were given access to the breast cancer expert system, and a questionnaire was distributed for their evaluation of the system. The participants were asked to use the system first and then respond to the questionnaire.

7.1 Users' and Experts' Evaluation

The questionnaire included a total of ten questions divided into four parts as follows: (1) Participants' personal information, (2) participants' evaluation of the criteria related to the inputs quality, outputs quality and overall system quality adopted from popular studies, (3) participants' point of view on the expert system benefits and limitations, and (4) participants' preference of a human expert or a developed expert system, with justification of their selection. A summary of the 10 participants' responses is given as follows:

7.2 Participants' Personal Information

This part included personal information about the participants. About 90% of the participants were users and 10% of the participants were domain expert. About 80% of the participants were female, while 20% were male. Participants' employment and academic qualifications varied as most of the participants were students enrolled in a bachelor's degree program.

7.3 Participants' Evaluation of the System

Table 1 illustrates the views and responses by participants on input, output, and system evaluation criteria, based on a 5 Point-Likert scale: 1 to 5 (1 being strongly disagree and 5 being strongly agree). As indicated below, all or almost all participants confirmed the quality of the system's inputs and outputs and the quality of the system itself.

Evaluation Criteria	1 (Strongly Disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly Agree)
INPUTS Relevancy				30%	70%
INPUTS Accuracy				20%	80%
INPUTS Completeness				10%	90%
INPUTS Understandability				20%	80%
Output Relevancy				50%	50%
Output Accuracy				70%	30%
Output Completeness			10%	30%	60%
Output Consistency				50%	50%
Output Understandability				60%	40%
Output Trust			30%	40%	30%
System Reliability				50%	50%
System User Friendly-Interface				40%	60%
System Response time			10%	30%	60%
User Satisfaction				50%	50%
System Usefulness				50%	50%
Usage			10%	40%	50%
System Trust			10%	40%	50%

Table 1: Participants' Evaluation of the Criteria Set

7.4 Participants' Opinions on the Expert System Benefits and Limitations

Participants were asked about the benefits and limitations of the developed expert system. Listed below is the summary of the participants' responses:

Advantages

- The proposed system can be used anytime and from anywhere.

- The system is useful and costs nothing.
- It is easy to use.
- The developed expert system is available 24/7.
- It's important especially for females to know more about breast cancer and be aware of it.
- It is a very fast system and private.
- It can be used by everyone.
- The system could reduce the number of people affected by the disease by making them aware of it.
- The system requires last effort.

Disadvantages

- The system is restricted by limited input.
- A developed expert system cannot replace a human expert.
- The conclusions may not be correct or accurate.
- There are limited details.
- The system could stop working or may crash at any time.
- The network could be disconnected.
- There is the possibility of making mistakes.

7.5 Participants' Preference of a Human Expert or a Developed Expert System

This part included a question regarding participants' preferences, whether they prefer a developed expert system over a human expert or a human expert rather than a developed expert system, with justification of their choice.

Figure 6: Preference of Expert System vs. Human Expert

As shown in Figure 6, 60% of the participants claimed that they prefer the developed expert system over a human expert because human experts are not available anytime and anywhere. Also, some people felt hesitant to share their personal information with someone else. In addition, the system satisfies all their needs and saves their respective time, money, and efforts.

On the other hand, 20% of participants said that having a human expert is better than a developed expert system because they feel that a human expert can be much more accurate, reliable, and trustworthy, and one can communicate and interact with a person but not with a system. Also, these participants justified their preference by indicating that a human may be more intelligent than a developed expert system.

However, 20% of participants preferred both the developed expert system and the human expert. They indicated that both of them are important and can be used to provide information and recommend solutions. The one cannot replace the other as they depend on user choices and circumstances.

8.0 Conclusion

The system has many benefits as it can be accessed by anyone at any time and from anywhere. The system provides valuable information free of cost in a private manner without the difficulty of users having to schedule appointments with human experts. The system is also accurate and precise and works in a speedy manner. Moreover, the system provides data on the importance of a healthy lifestyle. Most importantly, the system raises awareness about breast self-examination and provides recommendations about diagnosis.

This research has some practical value. The authors conducted a background literature review of expert systems and now have a better understanding of the development of an expert system. Additionally, the researchers reviewed issues relating to breast cancer and its impact in the Sultanate of Oman, especially on the female population. Furthermore, this knowledge was acquired from domain experts, and it is captured in a computer expert system to help people with issues related to lifestyle and the awareness and diagnosis of breast cancer.

Subsequent to the development of the system, the feedback from the participants and domain experts acquired through the questionnaire was surprisingly rewarding because of the perceived benefits of the developed expert system.

Thus, we can assume that expert systems are excellent tools for users due to their friendly, simple approach and ease of accessibility by anyone at anytime from anywhere. The proposed developed system covers users' lifestyle issues, self-examination awareness, and thorough diagnosis based on input from users. It is a complete breast cancer system, particularly for the female population. The system is a basic system that could be further developed and enhanced by various experts to become more thorough. It could incorporate videos/photographs to demonstrate improvements in lifestyle, breast self-examination methods, and symptoms of breast cancer to educate users about diagnosis and treatment procedures.

As can be seen from the inputs and rules, the subject matter is vast with plenty of combinations and permutations. We hope through the proposed system and the feedback we received from the questionnaire that the system can add valuable improvement to the general population's lifestyle and raise awareness of this "silent" disease for prevention and early detection. In conclusion, this study illustrates the value of using expert system technology to improve awareness and early diagnosis of a killer disease. Such application is of even greater value in the increasing awareness of a conservative society.

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