Original Article

Establishment of a Three-Tier Dynamic Cancer Registration Analysis System with an Example for Breast Cancer

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Abstract

Objective: In recent years, with the advancement of medical technologies, many cancers are no longer frightening and incurable. With the development of medical treatments, many therapies can be applied to prolong the life of cancer sufferers. Due to the increasing complexity of cancerous diseases, a patient can no longer be treated as a single, special case in cancer registration management. This study aims to establish an integrated platform to facilitate data collection, and further provide immediate information for cancer evaluation and treatment.

Materials and Methods: A dynamic website was linked to an information bank. The cancer management system was developed as a web service on Microsoft Visual Studio ASP.NET and the back-end database was built upon Microsoft SQL Server 2005.

Results: The three-tier dynamic website includes "operational interaction", "user and data selection" and "convenient management". The web content can change according to the user's needs or selections, and provide different information for different users at different times. Case managers can use the integrated function to transfer the patient's basic data into the cancer management system. Therefore, this integrated platform allows easy acquisition of all kinds of real-time information and instant reports. In this paper, we give a fabled example of breast cancer registration.

Conclusion: Tracking patients and information collection can be more effective via the integrated platform. The registered cancer cases can also be statistically analyzed and the data applied to the investigation of variables in clinical treatments so that doctors will be able to provide patients with the best medical advice. (*Tzu Chi Med J* 2007;19(4):233–240)

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1.   Introduction

In recent years, with the advancement of medical technologies, people tend to have more understanding about cancer, and many cancers are no longer frightening and incurable. According to the statistics released by the Department of Health, Executive Yuan, cancer still topped the 10 major causes of death in 2005, with a proportion of 26.8% (1). In Taiwan, approximately 50,000 people suffer from cancer annually and 30,000 die from cancer. In other words, the death ratio for cancer is about 60%. With the development of medical treatments, many therapies can be applied to prolong the life of cancer sufferers. Due to the extension of life, follow-up and management for possible recurrence and metastases as well as epidemiology have become more important. According to previous reports, recurrence of cancer usually occurs within 2 years (2,3). Follow-up developments should be traced on a regular basis. Further, with the fast-growing number of cancer sufferers, a patient can no longer be treated as a single, special case in cancer registration management. Instead, a systematic division of cancerous areas is needed so that follow-up management can be provided according to the characteristics of each respective area. Due to the increasing number of cancer patients and the complexity of cancerous diseases, this study aimed to establish a system that can effectively trace a patient's condition, reduce history data retrieval and paperwork through digitalization, and further promote and maintain the wellbeing of cancer patients.

In practice, cancer registration and clinical follow-up are difficult to coordinate. Thus, the idea of integrating the systems in these two areas has been developed to make cancer registration information available for clinical use. Doctors also expect to have an integrated system that provides comprehensive information about cancer cases. A doctor's treatment and evaluation of cancer cases is not usually instantaneous (4). Thus, the integrated platform is expected to facilitate data collection, and further provide immediate information for cancer evaluation and treatment.

2.   Materials and methods

2.1.   *System structure and operation procedures*

A cancer management system was developed as a web service on Microsoft Visual Studio ASP.NET and the back-end database built on Microsoft SQL Server 2005.

Currently, Java and Microsoft Visual Studio .Net are the mainstream development platforms for dynamic websites. In this study, Microsoft Visual Studio .Net was adopted as the development tool, mainly because the existing system used in the hospital was compiled with Visual Basic. It was easier to transfer the existing system on to the Microsoft Visual Studio .Net platform and the vitality of the existing system could be maintained. Further, the interface of the Microsoft Visual Studio .Net is simpler and the system error repair speed is fast. The only weakness is that Java is compatible with any web browser while Microsoft Visual Studio .Net is only compatible with Microsoft Internet Explorer, due to copyright and compatibility. However, all the computers in our hospital use Microsoft Internet Explorer, so the incompatibility of the program with web browsers will not be a problem in the future.

3.   Results

The traditional design of websites with fixed content does not meet the modern demands for instant information, service diversity and maintenance. Thus, integrating databases and providing information based on user demands has become the main type of website design. As the web content is stored in the database, website administrators can manage and maintain the huge amount of information in a convenient and efficient way. For users, dynamic websites have "operational interaction" so that the web content may be changed according to the user's needs or selections. From the perspective of information, dynamic websites also have "user and information selection": different types of web content can be provided for different users and at different times. For web administrators, dynamic websites have "convenient management" as web content can be changed simply by updating the information in the database, without re-editing or modifying web pages (5).

The advantage of digitalizing paperwork is that it is not necessary to re-enter basic data, and the data can be reused again and again. Based on this concept, in the development process, we expect to connect our system to the existing medical information system so that a patient's basic data and various examination results can be retrieved and imported into our cancer management system. Cross-platform communication is difficult but the integrated cancer information system can filter cancer cases from the hospital-based database and actively import a patient's basic data into the cancer management system. Case managers will spend less time on query and input operations, so they will have more time for professional work.

3.1.   *Introduction of system functions*

In this paper, we give a fabled example of breast cancer registration. The brief history was: a 42-year-old

female teacher felt a left breast mass that had been present for 3–4 months. Physical examination in the outpatient department revealed a mass >5 cm in size in the upper-outer area. There was no family history and the patient had been quite well previously. Tumor markers, such as CA-153, were elevated. Biopsy confirmed malignant cancer and the patient underwent modified radical mastectomy. The pathology report showed infiltrating ductal carcinoma, tumor grade 2, score 6, tumor size $7.5 \times 6.2 \times 2.5$ cm, axillary lymph node (13/19), lymphatic permeation positive, vascular permeation negative and neural invasion negative, and immunohistochemistry showed ER(+), PR(–) and HER-2/neu(2+). Abdominal echo, chest X-ray and bone scan demonstrated no specific findings. Tumor stage was pT3N3aM0. Due to the advanced stage of the cancer, adjuvant chemotherapy and radiotherapy were given. Chemotherapy regimens were: six cycles

of Endoxan® 500 mg/m^2, epirubicin 75 mg/m^2 and Taxotere® 75 mg/m^2. Radiotherapy was also given: 5040 cGy after six cycles of chemotherapy. During treatment, surgery and chemotherapy, health education was provided. Further, toxicity was evaluated and recorded using the common toxicity criteria of the National Cancer Institute.

3.1.1.   Data import mode

The "basic data of suspected cancer patients" and "integration of clinical and hospitalization data into the basic file" can assist case managers to transfer the basic data of suspected or confirmed cancer cases from the hospital information system (HIS) into the proposed cancer management system (Fig. 1), so they are not required to input the basic data of cancer patients again. The function of filtering cancer cases by date or by cancer type allows case managers to
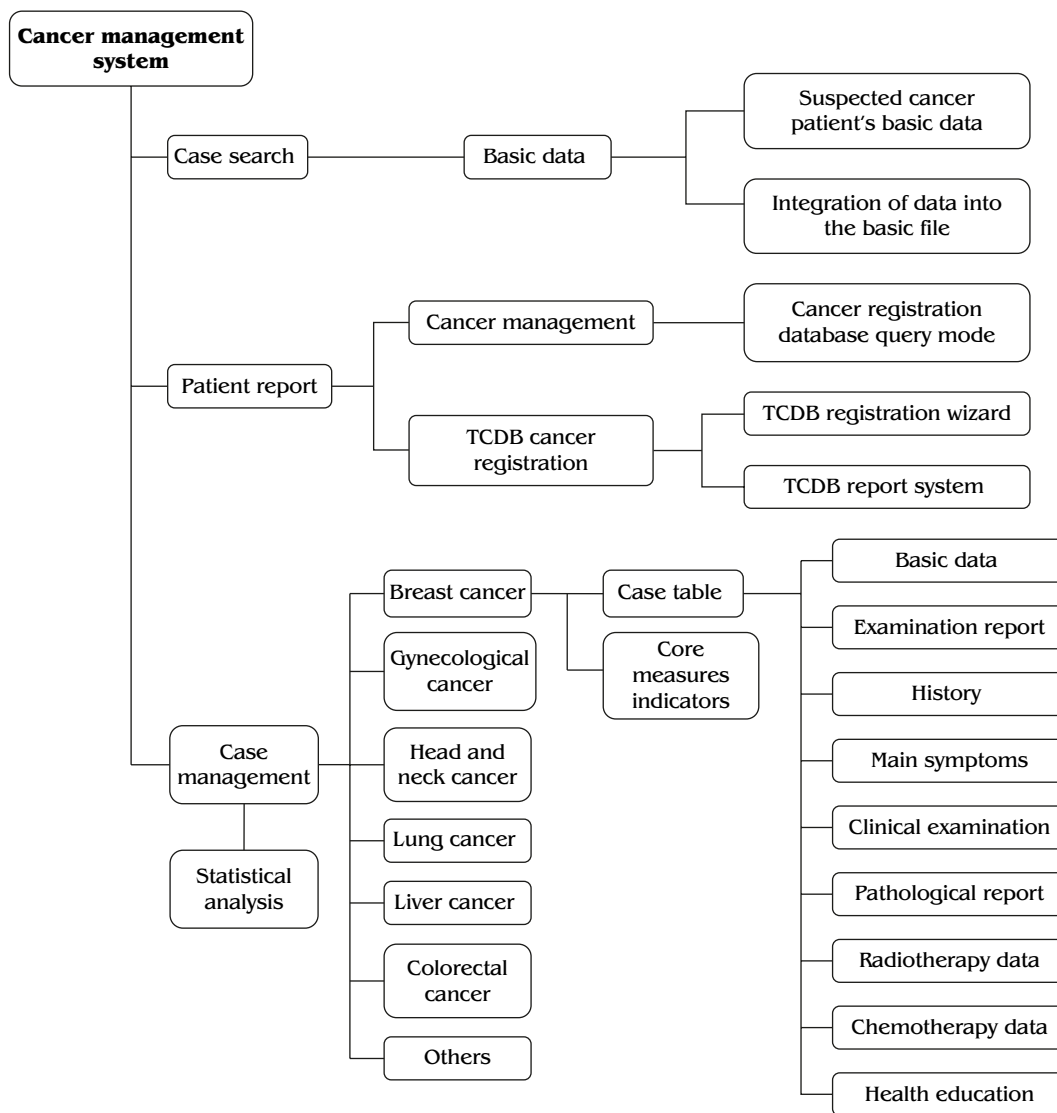

Fig. 1 — Tree chart of the cancer registration analysis system. TCDB=Taiwan Cancer Center Database.

Fig. 2 — The program can assist case managers to transfer the basic data from the hospital information system into the proposed cancer management system.

Fig. 3 — An example of the cancer data screening. The criteria include gender, age and tumor type.

search for cases according to their requirements. The system also provides the function of importing selected cases into Microsoft Excel format so that case managers can download the list on to their personal computer for further processing (Fig. 2).

3.1.2. Cancer registration database query mode
This function helps case managers retrieve a patient's data and history. The search methods include search by complete registration number, search by the first letter and search by certain registration numbers. For instance, the case managers can input "P100" in the registration number column and a list of patients whose first 4 registration numbers meet the criterion will be provided. Further, multiple criteria can be used in the search for registered cancer cases. So far, the criteria include gender, age, cancerous part, tumor type, duration, treatment type and follow-up. More criteria can be added if necessary (Fig. 3).

3.1.3. Bureau of Health Promotion report mode
TCDB stands for Taiwan Cancer Center Database. It is a database promoted by the Bureau of Health Promotion, Department of Health. If any detected cancer case is one of the six major cancers, a 65-column report should be filed with the Bureau of Health Promotion. To collaborate with this project, we designed a TCDB registration wizard and a TCDB report system for cancer registration staff.

There are a total of 65 columns in the TCDB report. To help cancer registration staff reduce errors and consultation time, we designed an online cancer registration wizard. If any column is unclear or the staff require any assistance, they can just click on the button of the column and an explanation will be provided to aid the registration process. In addition, we also included some simple rules in the wizard to help cancer registration staff exclude some contradictive situations, so instant alerts help to reduce errors and enhance the accuracy of cancer registration (Fig. 4). Moreover, the registration files can be converted into the text format required by the Bureau of Health Promotion. The system is able to export compatible text files by date and various cancer patient statuses (such as registration, modification and already registered).

Fig. 4 — An online cancer registration wizard can help to reduce errors and enhance the accuracy of cancer registration.

3.1.4.   Case management mode

In case management, different cancer types have different symptoms and require different treatments. Thus, we have classified cancer into seven types, including breast cancer, gynecological cancer, head and neck cancer, liver cancer, colorectal cancer, and other cancers. In this report, we use breast cancer as an example to introduce the content and functions of the system.

For breast cancer, the case file can be divided into nine sections, including (1) basic data, (2) examination report, (3) history, (4) main symptoms, (5) clinical examination, (6) pathological report, (7) radiotherapy data, (8) chemotherapy data, and (9) health education.

In case management mode, case managers can use the function mentioned earlier to transfer the patient's basic data into the cancer management system. Therefore, they just need to click on the patient and the system will show the basic data of the patient automatically and provide links to the testing system for more information (Fig. 5). Further, whether the patient is receiving radiotherapy, chemotherapy or health education will also be noted in case management mode (Fig. 6).

3.1.5.   Real-time statistical analysis mode

As this system integrates several platforms into one, it is easy to acquire all kinds of real-time information and instant reports. If all the necessary parameters are imported, such as gender, cancerous part, stage or therapy, various figures can be generated. A better understanding about the correlation of various variables can help case managers or doctors make more in-depth investigations (Fig. 7).

4.   Discussion

Most of the previous cancer management systems have been built on Microsoft Access. Microsoft Access is a database system designed for desktop applications. It features a powerful table and report production function as well as a user-friendly interface, although storage is an evident problem. Microsoft Access 2000 can support data storage only up to 1 gigabyte and Access 2003 can support only 3 gigabytes. For single users, Microsoft Access is powerful and has sufficient storage capabilities. However, its performance may be subject to low expansibility and extensibility for multiple users or for large storage applications.

The database of the proposed system was built on Microsoft SQL Server 2005. With the three-tier architecture, the database server may not be excessively busy and a cost-saving benefit can also be obtained [5]. The three-tier architecture makes the server a central data manager. When clients use web browsers, they can access various types of data through the web server, which works as a temporary storage terminal. Thus, the data in the database can be accessed by multiple users, like a website. For databases built on Microsoft Access, the software has to be installed on each client's computer. Three-tier architecture can spare such hassles as the database software need only be installed on the server, so a considerable amount of hardware cost can be saved.

Web application is a trend of modern software development. If data can be delivered across systems via web browsers, it is no longer necessary to install two systems and switch between the two systems for queries. As described earlier, in the proposed system, we can embed the testing system into our system window for consultation. For users, it will be convenient to communicate between the two systems and they do not need to open all the systems to make queries. We expect to establish an integrated platform on the network that allows users to consult necessary data from other systems so that a lot of consultation time and hardware space can be saved.

A (下方資料的日期請遵循西元格式，例如：20070101)

| 過去病史 | 主要癌症現狀 | 外科資料 | 病理報告結果 | 放療資料 | 化療資料 | 檢驗報告 | 衛教 |

腫瘤型態 infiltrating duct carcinoma ▼   腫瘤分化 II ▼ 6 ▼

最大TumorSize 7.5   CM DCIS + ▼

Surgical margin   deep fascia - ▼   nipple + ▼   skin - ▼   淋巴感染 13 / 19   哨兵淋巴 [ ] / [ ]

Vascular permeation + ▼   Lymphatic permeation + ▼   Neural invasion - ▼   新發生年齡 42

ICH study   ER + ▼   PR - ▼   HER-2 ++ ▼ /4

診斷報告：

文字報告：

B (下方資料的日期請遵循西元格式，例如：20070101)

| 過去病史 | 主要癌症現狀 | 外科資料 | 病理報告結果 | 放療資料 | 化療資料 | 檢驗報告 | 衛教 |

月經史 初經 15 歲 停經 [ ] 歲 停經原因 [▼]

婚姻狀態 已婚 ▼   子女 [▼] 人   懷孕次數 [▼]   生產次數 [▼]

以前是否罹癌 否 ▼

家族是否罹癌 是 ▼   癌症別 肝癌   罹患家屬 父親

抽煙 否 ▼   喝酒 否 ▼

檳榔 否 ▼   糖尿病 否 ▼   高血壓 否 ▼   心臟病 否 ▼

洗腎 否 ▼   肝炎帶原 是 ▼   氣喘 否 ▼   個人是否吃素 否 ▼

是否有團隊討論 是 ▼   日期 [ ]

是否參與實驗計畫 是 ▼   日期 [ ]

是否符合治療指引 是 ▼   日期 [ ]

確定建檔

C (下方資料的日期請遵循西元格式，例如：20070101)

| 過去病史 | 主要癌症現狀 | 外科資料 | 病理報告結果 | 放療資料 | 化療資料 | 檢驗報告 | 衛教 |

癌症部位 Left ▼ Upper-Outer quadra ▼   確診日期 xxx

腫瘤型態 infiltrating duct carcinoma ▼   分化 Mod ▼

臨床分期 [▼]   T [▼]   N [▼]   M [▼]

病理分期 III C ▼   T 3 ▼   N 3a ▼   M 0 ▼

治療 ☑ OP ☑ R/T ☑ C/T ☑ 荷爾蒙治療 □ 支持 □ 中醫 □ 化療口服藥 □ 其他 [ ]

復發 無 ▼   轉移 無 ▼

出院日期 xxxx   出院品質 輕鬆活動 ▼

預定回診日期 xxxx   最後回診日期 xxxx

死亡日期 [ ]   死亡原因 [ ]   存活天數 [▼]

確定建檔

Fig. 5 — Examples of (A) past history, (B) cancer presentation, and (C) pathological report and treatment screens.

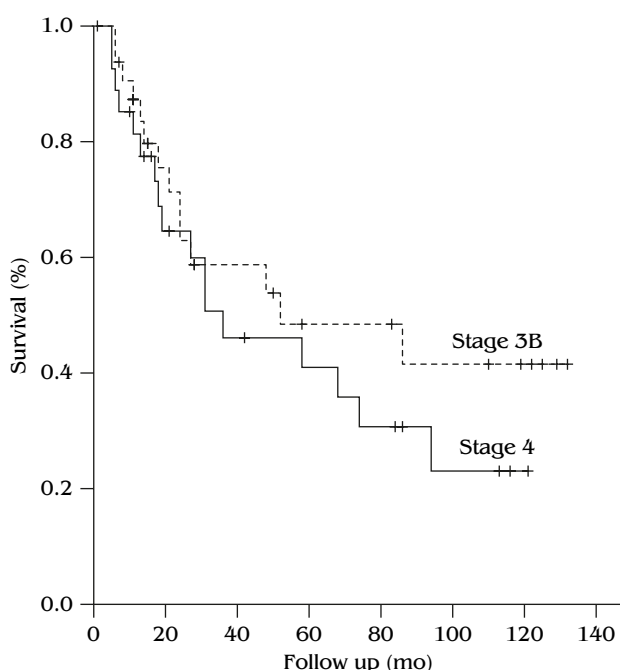**Fig. 6 — An example of the chemotherapy health education screen.**

Fig. 7 — An example of data on overall survival from breast cancer at different stages.

On the home page of the system, users are required to enter their account and password for authentication. Our system not only classifies access rights by account and password but it also expects to comply with the Web 2.0 standard. In other words, it has the spirit of "operational interaction", as mentioned earlier. Through configuration of different access rights, the system provides customized access rights for different users (such as query only or add/edit

allowed). Further, more functions can be developed for users to select necessary functions and adjust the template. This system will be able to satisfy everyone's needs.

To help cancer registration staff reduce errors and consultation time, we designed an online cancer registration wizard. We included some simple rules in the wizard to help cancer registration staff exclude some contradictive situations, so instant alerts help to reduce errors and enhance the accuracy of cancer registration.

In modern cancer case management, a patient is no longer treated as a single, unique case. Instead, systematic planning is required for case managers to trace and manage cases by different characteristics. Due to the increasing number of cancer patients and the complexity of cancerous diseases, the establishment of an integrated system will be able to trace a patient's condition effectively and comply with guidelines if necessary. Through the integration of multiple platforms, cancer registration staff can collect, organize and manage related data in a more efficient way. In addition, this system also provides a comprehensive analysis of registered cases, which can be applied to the investigation of clinical variables so as to increase the adaptability of treatments. In the future, we hope the information bank will have back coupling and functions that are updated along with the newest criterion or suggestion.

To date, the tumor center system has been constructed. It is expected that the system will not only provide a more convenient work environment for case mangers but will also reduce query and paperwork hassles. Further, it is also expected that the cancer registration system for the tumor center can

be a communication platform for doctors from different areas. With the cancer data and instant information provided by the system, doctors can offer the best medical advice to their patients.

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