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ORIGINAL PAPER

An Architecture Model for Multiple Disease Management Information Systems

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Abstract Disease management is a program which attempts to overcome the fragmentation of healthcare system and improve the quality of care. Many studies have proven the effectiveness of disease management. However, the case managers were spending the majority of time in documentation, coordinating the members of the care team. They need a tool to support them with daily practice and optimizing the inefficient workflow. Several discussions have indicated that information technology plays an important role in the era of disease management. Whereas applications have been developed, it is inefficient to develop information system for each disease management program individually. The aim of this research is to support the work of disease management, reform the inefficient workflow, and propose an architecture model that enhance on the reusability and time saving of information system development. The proposed architecture model had been successfully implemented into two disease management information system, and the result was evaluated through reusability analysis, time consumed analysis, pre- and post-implement workflow analysis, and user questionnaire survey. The reusability of the proposed model was high, less than half of the time was consumed, and the workflow had been improved. The overall user aspect is positive. The supportiveness during daily workflow is high. The system empowers the case managers with better information and leads to better decision making.

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Introduction

Disease management is a program that attempts to overcome the fragmentation and improve cost effectiveness of the health-care delivery system [1]. Patients benefit from the coordination of multidisciplinary care team, which provides wider range of skills and the inner sight of knowledge [2, 3]. The case managers act as the coordinators between multiple care providers, monitoring patient problems, and timely responding to patient care throughout the entire procedure [4]. Many studies have proven that disease management care has effectively improved patient outcomes, education and self-management [5–7]. It leads to less readmission rates, less length of stay, better quality of life, and eventually provides an overall control over the average hospitalization cost [7–9]. However, instead of spending more time with patients, it had been reported that case managers has been spending the majority of time in documentation, coordinating the members of the care team [10, 11], and are looking forwards to information technology to reduce unnecessary and redundant activities [12, 13].

Several discussions indicate that information technology played an important role in the era of disease management [14–19], and other research have examined the effects that computerized application have had upon reforming workflow processes [20, 21]. The work of disease management can be well facilitated with the help of information technology [22]. However, the practice of disease management is diverse according to various illnesses, disorders, and institutes [23, 24]. It is inefficient to develop information system for each disease management program individually. Considerations for reusability of the information system components are important.

The aim of this research is to support the work of daily disease management, reform the inefficient workflow, and propose an architecture model that enhance on the reusability and time saving of information system development. Instead of developing information system for each disease management service individually, this work considered the diversity of each setting, and extracted functional components from daily workflow. The proposed model was then implemented into the development of Disease Management Information System (DMIS) for two disease management programs, the human immunodeficiency virus (HIV) and diabetes mellitus (DM) disease management care, respectively.

Background

The effectiveness of disease management towards chronic disease has been proven by previous studies [5–9], and it is emphasized by the National Health Insurance (NHI) of Taiwan. The NHI had broadened the payments of for several disease management programs during 2001 and 2003 modulation, such as pulmonary tuberculosis, asthma, etc. National Taiwan University Hospital (NTUH), a 2,300-bed educational medical center in Taiwan, had decided to develop DMIS to support disease management service. NTUH consists of 10 disease management settings, including HIV, DM, heart failure (HF), chronic kidney disease (CKD), hepatitis, tumor, asthma, Parkinson disease, tuberculosis (TB), and central auditory processing disorder (CAPD). The job of disease management requires large amount of disease-specific documentations, screening of abnormal events, and integrating information from various sources. Care plans were then developed based on the accumulated information. Whereas a majority of time had been spent in documentation and transcription, it is inefficient to accumulate the information manually, and the potential risks of human error were high [10, 11, 25]. Several discussions indicated that information technologies have the potential of improving coordination across the care teams and supporting disease management care [14–19], but it has been consider as inefficient to develop DMIS for each disease management setting individually, which will rise the costs and difficulties for future expansion and maintaining.

Despite the workflow of disease management may differ based on various illnesses, disorders, and institutes, the general workflow of disease management care can be decomposed into five sections [26], including assessment evaluation, care plan development, care delivery, evaluation and follow-up, and outcome review. Through the analysis of general workflow and requirements, common components can be extracted and defined. Instead of developing DMIS for each service individually, this work considered the diversity of each disease management program and proposed an architecture that fit into different disease management workflows. This work emphasizes on the reusability of the DMIS components, saving of development time, and decreases the effort of future maintaining.

NTUH had rebuilt the healthcare information system (HIS) since 2003 into a web-based, single sign-on, 4-tier, service-oriented architecture (SOA). The database was accessed through HL7 standardized middleware web service layer [27], and exchanged messages in an XML based documentation. The architecture facilitated the expansion of subsystems and enabled the data sharing and exchanging between diverse systems. The developed disease management system was also added under the framework.

Method

This study supports the daily practice of disease management and reform inefficient workflow through implementing the proposed architecture model into the development of DMIS. This research consists of three phases, namely the requirement analysis and system design phase, the system development and implementation phase, and the outcome validation phase.

The workflow and the requirements were firstly analyzed to design the architecture model in the requirement analysis and system design phase. A meeting was convened with the case managers from seven disease management programs in NTUH, including HIV, HF, CKD, tumor, asthma, DM, and TB. The workflow and requirements were collected and analyzed to define the common components. Use case was adopted as a description of steps or actions between the user and the software system. Each requirement was matched to a corresponding component. The identical components were identified and considered of sharing and reusing. The common components for an information system, such as user interface, access control, and data repository, were included to make the model complete. The integration of external data resource was included due to the inevitable requirement of patient data integration from other information system repositories and devices.

During the system development and implementation phase, the proposed model was then implemented into the development of HIV and DM DMIS. The components were organized based on model-view-controller (MVC) to facilitate independent development, increase flexibility and reusability [28, 29]. The model was initially implemented into HIV disease management program, and the same model and components were reused and implemented in DM service afterwards. The systems are web-based application based on ASP.NET MVC framework, using Windows Server 2008 R2 and SQL Server 2008. DMIS was implemented under the framework of the existed HIS, and exchanged data through the standardized HL7 web service.

Finally, the system was validated through various analyses, including reusability analysis, time consumption analysis, pre- and post-implement workflow analysis, and a user questionnaire survey. Reusability analysis was to show how the components were reused, and time consumption analysis was to show how the proposed model contributes to time saving. Pre- and post-implement workflow analysis was done to demonstrate the changes of the workflow. A supporting rate was calculated by the percentage of work replaced by the DMIS. The user questionnaire survey was done to understand the aspects of the case managers who use the system. The questionnaire evaluated the supportiveness, the satisfaction, the acceptance of the system, and the aspects of case managers. It was scored with Likert scales, ranging from one to five for strongly disagree to strongly agree. There are three HIV case managers and five DM educators employed in the institute, each of them uses the system in daily practice. The survey was distributed in 2012 January, after 6 months system using.

Result

Requirement analysis and system design

The requirements collected from the seven disease management programs were shown in Table 1. It can be observed that the requirements were mostly similar. Only a few

Table 1 Information requirements of disease management programs

	HIV	HF	CKD	Tumor	Asthma	DM	TB
A. Patient data requirement							
Patient basic general info	○	○	○	○	○	○	○
Medical records	○	○	○	○	○	○	○
Medications	○	○	○	○	○	○	○
Lab results	○	○	○	○	○	○	○
B. Abnormal event notification							
Abnormal lab results	○	○	○	○	X	○	○
Unexpected visits	○	○	○	○	○	○	○
C. Assessment record							
Specified forms	○	○	○	○	○	○	○
D. Report generation							
Lab results	○	X	○	X	X	○	○
Billing information	X	X	X	X	○	○	○
Specific indicator statistics	○	○	○	○	○	○	○
E. Others							
Incoming patient list	○	○	○	○	○	○	○
Phone tracking support	○	○	○	○	○	○	○

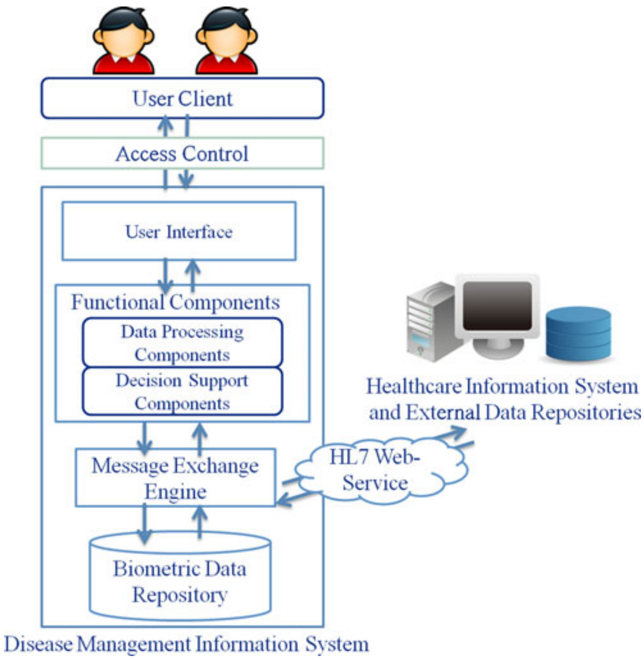

Fig. 1 Architecture of disease management information system

functions, such as the demand for printing laboratory results and generating billing information were different, which is marked a cross. This work focused on the care delivery after diagnose, where patient were referred to the disease management programs. The only component outside the definition was the screening of potential patients, which was considered as a vital part of preventive care and early intervention, and therefore was included.

Based on the requirement analysis, the workflow process were extracted and matched to a corresponding component. The architecture for the system is summarized and presented on Fig. 1, and are introduced in the following:

1. User Interface and Access Control: While the layouts of the user interface were generally related to different assessment forms and user preferences, the user interface was isolated in the concept of MVC. The isolation ensured the capability of frequent modification. The system validated user identification with ID and password. The system designed a role and authority validation to identify the authority of individual staff, which differs from staff to staff.
2. Functional Components: Including the data processing and decision support components. It presents patient-related information, such as general information, medications, treatments and laboratory results. The data processing components include patient data records, assessment records, routine lists generation, and phone contact records. Each of the components supported the corresponding practice. The decision support components include advanced disease-specific event screening, event notification, and data searching. The disease-specific event screening enabled multiple indicators monitoring. It automatically

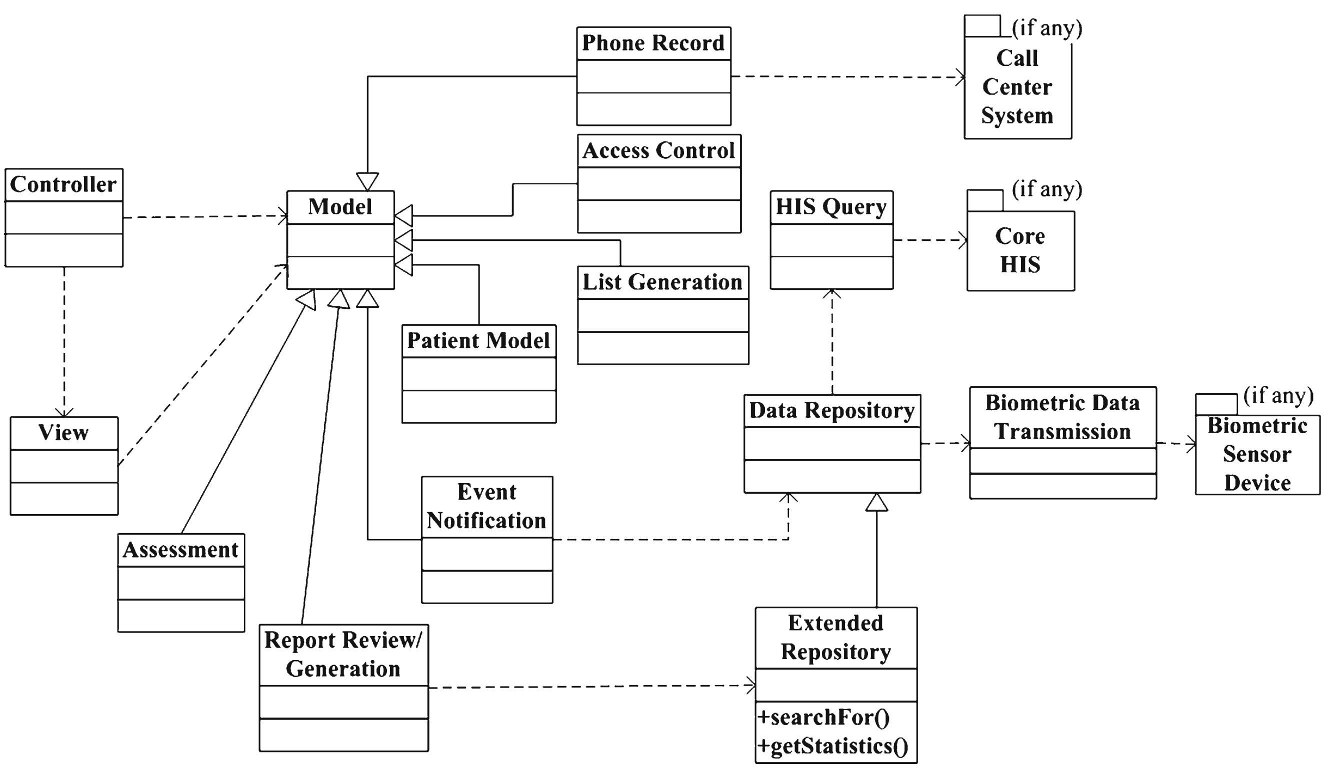

Fig. 2 UML class diagram for disease management information system

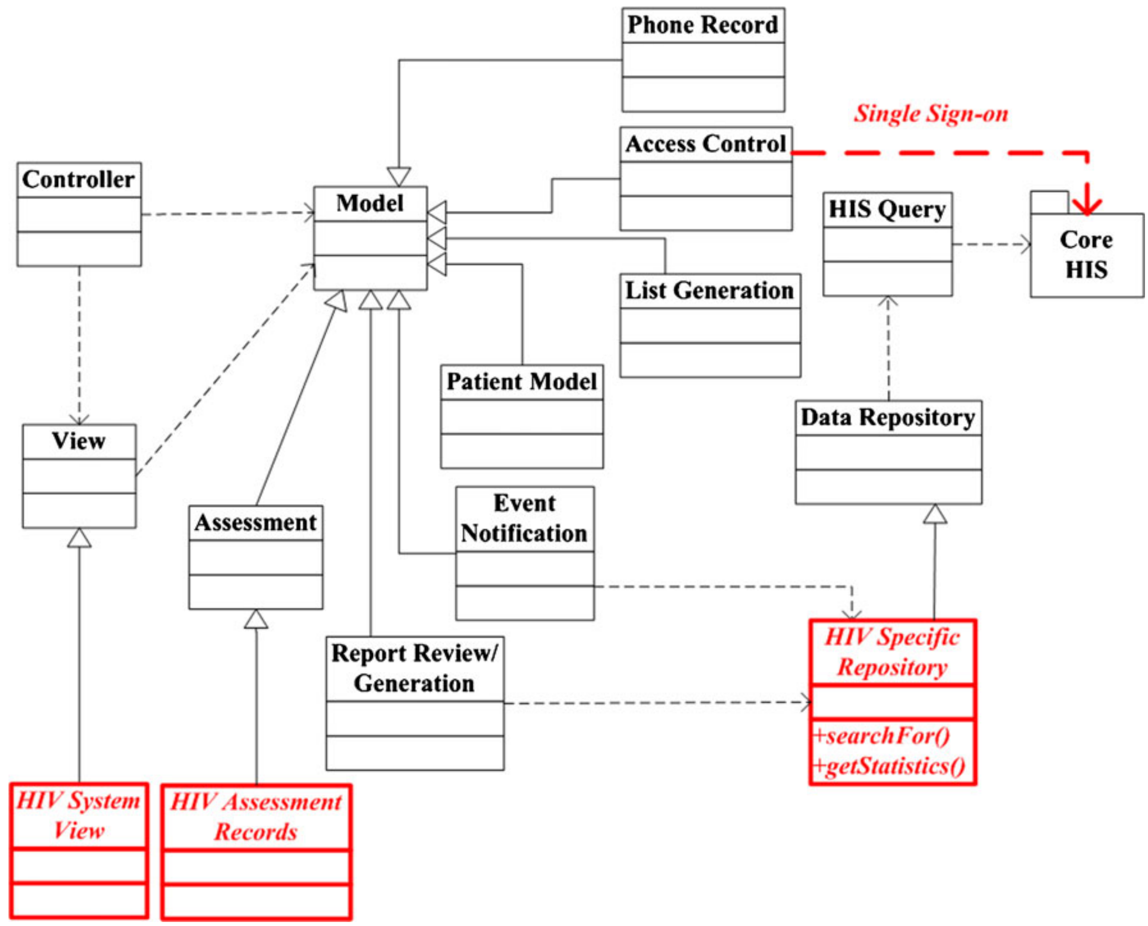

Fig. 3 Class diagram for HIV disease management information system

screened abnormal or special events, supporting various kinds of disease monitor activities. The event notification notified case managers of scheduled events, including phone calls and detected abnormal events by the implemented rule. The searching performed query based on demands. Also, the routine statistical report was accumulated by this component.

3. HL7 Web-Service and Message Exchange Engine: The component stood for a data exchange coordinator in-between disease management system and external data repositories, such as HIS or the other subsystems in the institute. It was included due to the inevitable requirement of data integration from other subsystems or data resources, and it represented the receiving and exporting of data.
4. Disease Repository and External Data Resources: The system retained its own repository, maintaining integrated data from internal and external data resources.

System design and implementation

The designed components of the proposed architecture model were decomposed in MVC, and are illustrated in unified modeling language (UML) class diagrams, shown in Fig. 2. The design is first implemented into the HIV DMIS, and the components were shared or reused to develop the system of DM DMIS. The implemented designs of the two systems are shown as Figs. 3 and 4. The architectures of both systems were identical, and the components were shared or reused. The components that were adjusted from the original model are represented in red italics. The access control, in this case, was directly linked to the session service of HIS.

Both the systems were developed and currently in used in the disease management settings. The HIV DMIS supported the management of approximate 2,200 patients, including more than 700 new enrollments. The service was previously supported by an isolated commercialized system, and the patient data requires repetitively manual input. After the development, the data from the previous system is loaded to the current system. The DM DMIS currently supported approximate 1,300 patient care, with more than 300 new enrollments after the system implementation. The service was previously based on paper, and it had become an extra work to input the original patient data into the system.

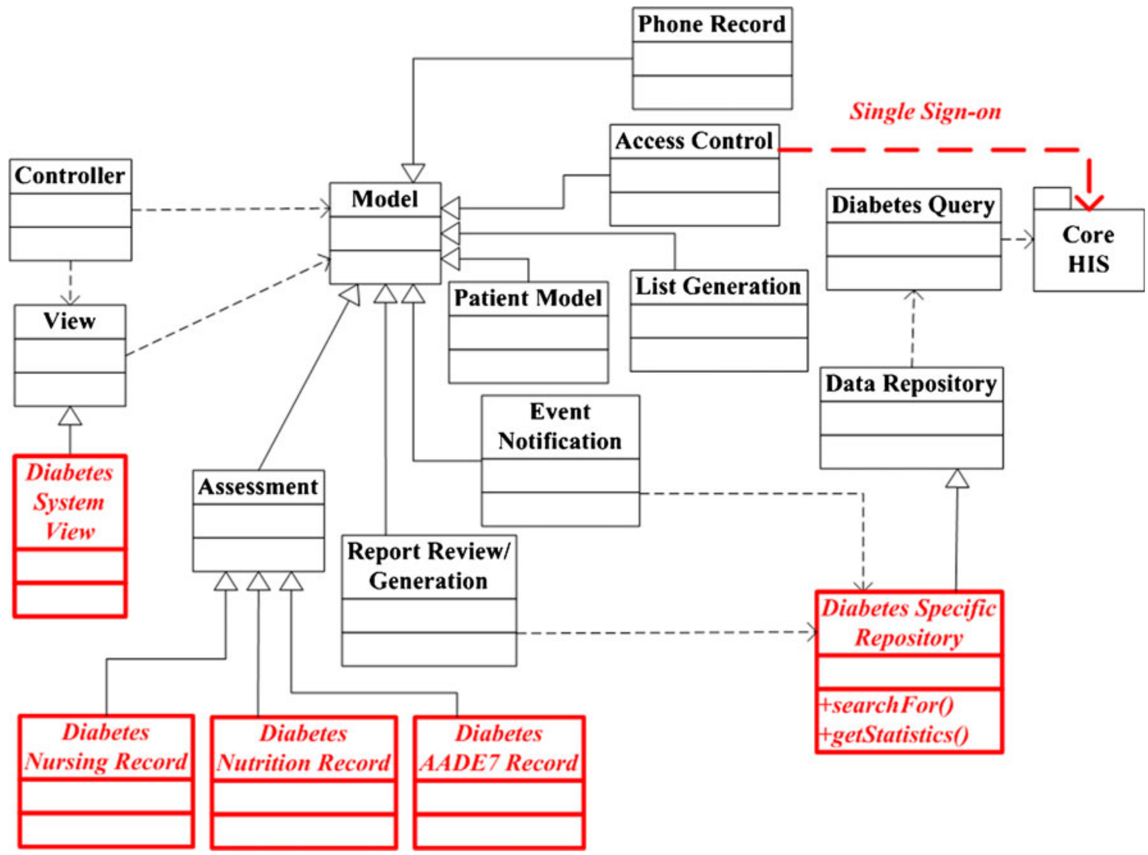

Fig. 4 Class diagram for DM disease management information system. AADE7: American Association of Diabetes Educators

Outcome validation

Table 2 lists the components in each system and analysis the reusability. There were 8 in 10 (80 %) components with the same program logics, and 6 in 10 (60 %) components were identical program components. Table 3 shows the development time required for both of the system. With the same man-power, the development time of the HIV DMIS consumed approximately 10 months, from 2010 July to 2011 May. And the DM DMIS took approximately 4 month, from

Table 2 Components reusability analysis

Model	HIV	DM	Comparison
Access control	HIS sign-on	HIS sign-on	Identical
Common list generation	Patient lists, outpatient visits, abnormal events	Patient lists, outpatient visits, abnormal events	Identical
Patient data manipulation	Personal information, clinic data, medication, lab results	Personal information, clinic data, medication, lab results	Identical
Assessment manipulation	HIV/AIDS assessment	AADE7, nursing and nutrition assessment, complication screening	Different
Phone record manipulation	Phone record	Phone record	Identical
Decision support	Potential case, abnormal lab results, visit absence or unexpected visit	Abnormal lab results, staging reminder	Different
Event notification	Notify CM of stored event	Notify CM of stored event	Identical
Data search/statistics	Search/perform statistics using HIV indicators	Search/perform statistics using diabetes indicators	Same logic different parameter
Report generation	Report of HIV indicators	Report of diabetes indicators	Same logic different parameter
External data integration	Exchange data with HIS	Exchange data with HIS	Identical

Table 3 Development time consumed of the systems

	Development time	Total time (Man-months)
HIV information system	2010/07–2011/05	10 months (30 man-months)
DM information system	2011/03–2011/07	4 months (12 man-months)

2011 March to 2011 July. Table 4 summarizes the work item of pre- and post-implement workflow analysis. The supporting rates have been moderately high, except for the assessment evaluation.

The demographic information of the staff is summarized as Table 5. All staffs consider themselves familiar with information technology, and the number of computers available during practice was sufficient. The supportiveness, satisfaction, and the overall acceptance of the system were summarized as Table 6. The overall aspect towards the system was positive, and the supportiveness and the satisfaction have been moderately high.

Discussion

Disease management has the nature to increase the continuum of care and to response to rapidly increasing of medical costs. Considering the data exchange and future modification of clinical practice and regulations, NTUH had decided to utilize the rebuilt HIS infrastructure and developed the DMIS by self.

This research proposed an architecture model, which considered the diversity of each disease management program and extracted the common components from the workflow. The model had been proven effective through the

Table 4 Pre- and post-implement workflow analysis

Pre-implement workflow	Post-implement workflow	Matching component	Supporting rate (%)
Assessment evaluation			
• Screening of disease-specific criteria	• System browsing	• List generation	33.3
• Patient interviews and assessments	• Patient interviews and assessments	• Patient model	
• Patient evaluation and enrollment	• Patient evaluation and enrollment	• Assessment	
Care plan development			
• Collection of patient past medical records	• System browsing	• Access control	75
• Collection of current assessment data and lab results	• Patient education	• HIS query	
• Information sharing between multidisciplinary staffs		• Patient model	
• Patient education		• Assessment	
Care delivery			
• Collection of patient past medical records	• System browsing	• Access control	71.4
• Collection of current therapy data and lab results	• Patient care	• HIS query	
• Patient care	• Phone call making	• Phone record	
• Routine phone call list generation and phone call making	• Identify patients require follow-up	• Event notification	
• Screening for not-returning patients			
• Identify patients require follow-up and reminder			
• Monthly statistics and patient outcome indicates generation			
Evaluation and follow-up			
• Data accumulation and quality of care evaluation	• System browsing	• List generation	75
• Patient outcome indicator generation and monitor	• Patient care adjustment	• Patient model	
• Annual statistics and patient outcome indicates generation		• Report review generation	
• Patient care adjustment			
Review and outcome measurement			
• Accumulate various kinds of data	• System browsing	• Report review generation	75
• Overall statistics and patient outcome indicates generation	• Data upload		
• Regulation report generation			
• Data upload			

Workflow Supporting Rate: the percentage of work automated by the system

Table 5 Demographic information of case managers

Variable	Numbers of case managers		
	Overall (%)	HIV	DM
Gender	N=8	N=3	N=5
Male	0 (0)	0	0
Female	8 (100)	3	5
Ages, mean±SD			
Years	43.71±4.1	39	45.2
Education			
BS	3 (37.5)	0	3
MS	5 (62.5)	3	2
Work year, mean±SD			
Years	16.57±5.63	8	18.6

implementation into two DMIS, for the HIV and DM care respectively. It had enhanced on the reusability of system components and largely decreased the development time. The reusability analysis shows that 60 % of the components were identical and 80 % with the same program logics. Only three compositions that require customization, namely the assessments for different diseases, the medical data required, and the data stored.

With the same man-power, the development of the HIV DMIS consumed approximately 10 months. Meanwhile, DM DMIS took advantages of the reusability of the model, consumed approximately 4 month, which is less than half of the time that HIV DMIS spent. While the HIV care has been previously supported by a commercialized system, it is easier to load the history data to the current system, thus consists of more patients and more comprehensive information. For DM care, the patient lists require manual registration and the DM assessment data requires data input, which were not previously stored in HIS.

Some of the workflow had been reformed and considered beneficial. For HIV care, the retention in care had been a critical indicator. In the past, the screenings for patients who do not return were done by case managers after the clinic. With the system, patients not returning on schedule were detected and listed automatically during clinic time. Schedule lists and notifications facilitate case managers to make phone calls or text message to remind patients for clinic visit in time, or provide further support if necessary. For DM care, after the DM patients were done with the educational course, the patients were to visit the physician's office and the educators were to deliver the assessment records to the clinic. The records were originally base on paper, and require to be sent to the clinic. Physicians were to wait for the record in order to receive complete information of the patients. With the system, the assessments and summaries were stored, and physicians were able to view the summary through a click on the system, which also decrease the waiting time for patients and lessen the burden of record delivery.

The overall user aspect towards the system was positive. The systems have been considered as easy to use, stable, and fast in responses. The supportiveness and the satisfaction of the system were high. The supportiveness of management, searching, accessing of patient data, and analysis reports have been rank as the highest. The function of patient lists and the searching for patients have gained the highest satisfaction. Further expectation for data sharing among other information systems in the institute has been pointed out, such as outpatient or inpatient settings. Also, the data are expected to export into all kinds format, such as Excel.

Changes in both settings lessen the burden of documentation and provide opportunities for the cases managers to spend more time to patient care. It could be observed from the pre- and post-implement workflow analysis and the ranking of system functions that data accumulation occupied a huge portion in the original workflow, and that the case managers were most satisfied with the automation of patient data accumulation and the analysis reports. DMIS did not provide direct support for patient care. Instead, it accumulates the information automatically, detect and reveal patient status, which empowers the case managers with better information and leads to timely intervention. The automation of data accumulation from different data resources decrease potential transcription errors, lessen the burden of paper record maintaining, and allow the increasing of service amount of case managers. Less workflow supporting rate was shown in the assessment evaluation section, which may due to the works were mostly involved in patient interaction, initial assessments, and data collection. DMIS also acted as a platform to ensure the consistency among case managers during patient assessment, and potentially improved the quality of care.

Table 6 User aspect evaluation

Evaluation item	N=8, Mean±SD		
	Overall	HIV	DM
Supportiveness of individual function	4.78±0.4	4.94±0.2	4.69±0.6
Satisfaction of individual function	3.5±0.9	3.8±1.1	3.3±1
Overall acceptance of the system	3.78±0.73	4.13±1	3.58±0.6

Disease management consists of multidisciplinary cooperation, and patient data sharing had been considered as essential. This research focused on the work of case managers, with the workflow of other staffs unchanged, which may become a limitation of this work. Also, no additional portable devices were added to the disease management program, and still require the case managers to return to a PC to finish the documentation.

Conclusion

While the healthcare information technology being identified as a way of improving the provision of healthcare, DMIS has the potential of optimizing current workflow, and results in better patient care. DMIS empowers the case managers with better information and leads to better decision making. This study adds up to the development of a sophisticated DMIS to support disease management service and reforming inefficient workflow, and is also promising to extend the model to other service programs.

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Conflict of interest No competing financial interests exist.

References

1. Kersbergen, A. L., Case management: A rich history of coordinating care to control costs. *Nurs. Outlook* 44(4):169–172, 1996.
2. Ellrodt, G., Cook, D., Lee, J., Cho, M., Hunt, D., and Weingarten, S., Evidence-based disease management. *Jama* 278(20):1687, 1997.
3. Wagner, E., The role of patient care teams in chronic disease management. *Br. Med. J.* 320(7234):569, 2000.
4. Meyer, M., Kobb, R., and Ryan, P., Virtually healthy: Chronic disease management in the home. *Dis. Manag.* 5(2):87–94, 2002.
5. Lin, R.-L., Lin, F.-J., Wu, C.-L., Peng, M.-J., Chen, P.-J., and Kuo, H.-T., Effect of a hospital-based case management approach on treatment outcome of patients with tuberculosis. *J. Formos. Med. Assoc.* 105(8):636–644, 2006. doi:10.1016/s0929-6646(09)60162-5.
6. Ofman, J. J., Badamgarav, E., Henning, J. M., Knight, K., Gano, J. A. D., Levan, R. K., Gur-Arie, S., Richards, M. S., Hasselblad, V., and Weingarten, S. R., Does disease management improve clinical and economic outcomes in patients with chronic diseases? A systematic review. *Am. J. Med.* 117(3):182–192, 2004. doi:10.1016/j.amjmed.2004.03.018.
7. Chan, D. C., Heidenreich, P. A., Weinstein, M. C., and Fonarow, G. C., Heart failure disease management programs: A cost-effectiveness analysis. *Am. Hear. J.* 155(2):332–338, 2008. doi:10.1016/j.ahj.2007.10.001.
8. Markle, A., The economic impact of case management. *Case Manag.* 15(4):54–58, 2004. doi:10.1016/j.casemgr.2004.06.003.
9. Shumway, M., Boccellari, A., O'Brien, K., and Okin, R. L., Cost-effectiveness of clinical case management for ED frequent users: Results of a randomized trial[small star, filled]. *Am. J. Emerg. Med.* 26(2):155–164, 2008. doi:10.1016/j.ajem.2007.04.021.
10. Ball, M. J., Weaver, C., and Abbott, P. A., Enabling technologies promise to revitalize the role of nursing in an era of patient safety. *Int. J. Med. Inform.* 69(1):29–38, 2003.
11. Newbold, S. K., Kuperman, G. J., Bakken, S., Brennan, P. F., Mendonca, E. A., Park, H., and Radenovic, A., Information technology as an infrastructure for patient safety: Nursing research needs. *Int. J. Med. Inform.* 73(7–8):657–662, 2004.
12. Merkouris, A., Computer–based documentation and bedside terminals. *J. Nurs. Manag.* 3(2):81–85, 1995.
13. Mei, Y. Y., Marquard, J., Jacelon, C., and DeFeo, A. L. Designing and evaluating an electronic patient falls reporting system: Perspectives for the implementation of health information technology in long-term residential care facilities. Int. J. Med. Inform., 2011. doi:10.1016/j.ijmedinf.2011.03.008.
14. Carneal, G., and Gervais, M. E., Linking the power of information technology and case management interventions: An assessment of recent medical-management trends. *Case Manag.* 17(3):38–44, 2006. doi:10.1016/j.casemgr.2006.03.010.
15. Coleman, J. R., The paradigm switch for case managers: Some thoughts on the information technology challenges ahead. *Case Manag.* 10(6):56–58, 1999. doi:10.1016/s1061-9259(99)80156-8.
16. Stutz, L., Case management as a foundation for an accountable care organization. *Prof. Case Manag.* 16(3):152–155, 2011. doi:10.1097/NCM.0b013e318212fa6d.
17. Adams, J. M., Applying e-health to case management. *Prof. Case Manag.* 5(4):168–171, 2000.
18. Matthews, P., Case management information systems: How to put the pieces together now and beyond year 2000. *Prof. Case Manag.* 7(6):255–260, 2002.
19. Wyne, K., Information technology for the treatment of diabetes: Improving outcomes and controlling costs. *J. Manag. Care Pharm.* 14(2):12–17, 2008.
20. Banet, G. A., Jeffe, D. B., Williams, J. A., and Asaro, P. V., Effects of implementing computerized practitioner order entry and nursing documentation on nursing workflow in an emergency department. *J. Healthc. Inf. Manag.* 20(2):45, 2006.
21. Wong, H. J., Caesar, M., Bandali, S., Agnew, J., and Abrams, H., Electronic inpatient whiteboards: Improving multidisciplinary communication and coordination of care. *Int. J. Med. Inform.* 78 (4):239–247, 2009.
22. McKay, J. R., Continuing care research: What we have learned and where we are going. *J. Subst. Abus. Treat.* 36(2):131–145, 2009.
23. Coleman, J. R., MCO trends: Integration trends are resphaping MCOs—And may change CM as well. *Case Manag.* 6(1):34–37, 1995. doi:10.1016/s1061-9259(05)80142-0.
24. Severson, M., Case management diagnosis: Rapid change. *Case Manag.* 9(1):31–33, 1998. doi:10.1016/s1061-9259(98)80159-8.
25. Kohn, L. T., Corrigan, J., and Donaldson, M. S. To err is human: Building a safer health system. National Academies Press 6, 1999. Committee on Quality of Health Care in America, Institute Of Medicine, National Academy Press, Washington, D.C.
26. Liu, S. Y., Hsiao, J. L., Shen, J. L., and Li, H. Q., A research for information integration in case management system of diabetes mellitus. *J. Nurs.* 4(2):169–179, 2006.
27. Yang, T., Cheng, P., Yang, C., Lai, F., Chen, C., Lee, H., Hsu, K., Chen, C., Tan, C., and Sun, Y. A scalable multi-tier architecture for the National Taiwan University hospital information system based on HL7 standard. In: 19th IEEE Symposium on Computer-Based Medical Systems (CBMS'06), 2006. pp 99–104
28. Krasner, G. E., and Pope, S. T., A cookbook for using the model-view controller user interface paradigm in Smalltalk-80. *J Object Oriented Program* 1(3):26–49, 1988.
29. Reenskaug, T. (1978–79) MVC XEROX PARC 1978–79. Accessed 05-25 2011.