Review Article

Development of a Diabetes Registry to Improve Quality of Care in the National Healthcare Group in Singapore

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Abstract

In Singapore, chronic care is provided by both ambulatory primary care clinics and specialist clinics in hospitals. In 2005, the National Healthcare Group (NHG) embarked to build a diabetes registry to enhance the continuity of care for patients with diabetes and facilitate greater efficiency in outcome measurement. This *Chronic Disease Management System (CDMS)* links administrative and key clinical data of patients with diabetes mellitus across the healthcare cluster. At the point of patient care, clinicians view a summary of each patient's chronic disease records, consolidated chart with physical parameters, laboratory investigation results and the "patient reminders" listing the clinical decision support prompts when key laboratory and screening tests are due for each patient. The CDMS provides reports of clinical outcomes in a systematic and efficient manner for quality improvement and evidenced-based population management. These include process indicators consisting of the rates of glycated haemoglobin (HbA1c), low-density lipoprotein-cholesterol (LDL-c) and nephropathy tests; and intermediate outcome indicators of the proportion of patients with poor HbA1c (>9%) and optimal LDL-c (<2.6 mmol/L) control. From January 2007 to December 2008, the rates of the 3 process indicators were relatively unchanged and that of HbA1c and LDL-c tests were high. There was gradual improvement in the proportion of patients achieving target level of LDL-c in both primary care clinics and hospitals. Fewer patients at primary care clinics had poorly-controlled HbA1c. As a tool for chronic care delivery, the NHG diabetes registry has made clinical monitoring and outcome management for patients with diabetes mellitus more efficient.

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Introduction

In the last decade, the use of electronic medical records (EMR) has been widely recommended as a method for reducing errors, improving the quality of health care, and reducing costs in ambulatory care settings.[1-9] EMRs have been shown to improve the quality of care for patients with chronic illnesses, such as diabetes. By facilitating the management of complex clinical information, EMRs could improve the coordination of tasks among members of the health care team,[8] lead to lower rates of missing clinical information,[10] and support evidence-based clinical decision making.[11-14] Several recent systematic reviews of EMRs and clinical decision support systems have shown that systems developed in-house over many years lead healthcare institutions to improve adherence to clinical guidelines.[15-17]

Singapore is a country with a high prevalence of diabetes mellitus,[18] 8.2% amongst its population aged between 18 and 69 years,[19] and is joint second in the world for "pre-diabetes" after Nauru.[20] Diabetes mellitus is the 7th leading cause of death with 3.6% of all deaths being attributable to diabetes alone.[21]

In Singapore, the National Healthcare Group (NHG) is an integrated healthcare delivery system managing 3 acute care hospitals, several specialist centres and 9 primary care clinics serving 2.2 million residents who live in the central and western zones of Singapore. About 17% of all patients admitted to 3 acute hospitals in the National Healthcare

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Group (NHG) have coexisting diabetes.[22]

Since 2000, the NHG has initiated a wide range of chronic disease management (CDM) programmes for patients with diabetes mellitus, heart failure, stroke and asthma. Our patients move across the healthcare spectrum from primary to tertiary care and vice-versa. Chronic care used to be fragmented between and within healthcare institutions as patient's information either resided in individual silos system or was not captured electronically at all, often resulting in inconsistent care. In order to facilitate the continuity of care for patients with long-term chronic diseases and for greater efficiency in outcome management, an enterprise-wide information technology enabler was needed. Monitoring of treatment progress used to be handled manually and was tedious. A computerised disease management registry and business intelligence system was thus needed to drive evidence-based medicine for holistic cost-effective quality care.

The NHG Chronic Disease Management System (CDMS)

In 2006, the senior management of the NHG endorsed the building of an enterprise-wide chronic disease registry with the main intent to harmonise clinical health records and provide seamless quality care for patients with chronic conditions across the healthcare cluster's 3 hospitals and 9 primary care clinics. Named the *Chronic Disease Management System (CDMS)*, it sought to link administrative and key clinical data of patients seen within the healthcare cluster, riding on the existing framework of multiple clinical applications which had been harmonised. The first phase was to build the diabetes mellitus module and this was completed in 18 months. Subsequent modules of the CDMS would include hypertension, dyslipidaemia, stroke, cardiovascular diseases and chronic renal disease.

As a computerised registry and business intelligence system, it serves the following functions:

i) Population management. The identification of patients with diabetes mellitus for disease management, and stratification for different intensity of interventions. It facilitates longitudinal and vertical tracking of patients through different levels of care from inpatient and specialist outpatient clinic (SOC) at hospitals to primary care clinics.

ii) Clinical decision support. "Patient reminders" at consultation points to highlight laboratory results when they are out of normal range or when core investigations and screenings are due for each patient as defined by the Ministry of Health Clinical Practice Guidelines (MOH CPG) on Diabetes Mellitus.[23]

iii) Outcomes management. Clinical audits on processes, appropriateness of care and compliance with evidence-based interventions and treatments. Reports can be generated for disease programme directors, senior management, doctors and nurse clinicians on the outcomes for quality management.

Identification of Patients with Diabetes Mellitus into the CDMS

Table 1 shows the hierarchy of algorithms, using the International Classification of Diseases Ninth Revision (ICD-9CM) diagnostic codes, pharmacy medication records and laboratory data, as defined by the endocrinologists in the NHG Diabetes Disease Management Workgroup to identify patients with diabetes mellitus into the CDMS.

Each day, the CDMS identifies all the patients who have attended the hospitals or clinics in the NHG. For patients who have yet to be identified with diabetes mellitus, the CDMS runs through the hierarchy of algorithms sequentially from Step 1 (diagnosis code) to Step 2 (pharmacy medication records) to Step 3 (laboratory test records) until a criterion for diabetes mellitus is met. The patient will be identified as having the disease and be added to the CDMS. For

Table 1. Step-wise Algorithm to Identify Patients with Diabetes Mellitus into the CDMS

Algorithm	Source of information
Step 1	Diagnosis codes • Using ICD-9CM codes • Includes both primary and secondary diagnosis • Available for patients who are discharged from hospital or visited a primary care clinic • Not available for hospital Specialist Outpatient Clinics • Patients with Type 1 diabetes mellitus are identified by the codes 250.x1 or 250.x3 • Patients with Type 2 diabetes mellitus are identified by the codes 250.x0, 250.x2, 357.2 or 362.xx
Step 2	Pharmacy medication records • Patients who are dispensed with any of the following classes of medication are included: a. Sulphonylureas b. Biguanides c. Alpha-Glucosidase Inhibitors d. Thiazolidinediones e. Insulin preparations f. Meglitinides g. PPAR-gamma agonists[#]
Step 3	Laboratory test records • Any one of the following confirms the diagnosis of diabetes mellitus a. Oral Glucose Tolerance Test (OGTT) - 2 hour reading $\geq$11.1 mmol/L b. Random Plasma Glucose $\geq$11.1 mmol/L on 2 occasions within 2 years c. Fasting Plasma Glucose $\geq$7.0 mmol/L on 2 occasions within 2 years d. Random Plasma Glucose $\geq$11.1 mmol/L on 1 occasion AND Fasting Plasma Glucose $\geq$7.0 mmol/L on 1 occasion within 2 years

* International Classification of Diseases Ninth Revision

[#] PPAR: peroxisome proliferator-activated receptor

example, if a patient has a diagnosis code of 250.00, he will be identified as having diabetes mellitus based on Step 1 and CDMS will not run Steps 2 and 3. The patient will not be identified with diabetes mellitus if he does not fulfill any of the criteria for diabetes mellitus after Steps 1 to 3.

Data Elements for the Diabetes Registry

The CDMS captures the date and values of key laboratory tests and screening results and is able to identify patients who are either overdue for a routine test (such as glycosylated hemoglobin every 6 months or lipids panel every year) or have a laboratory result outside the normal range highlighting the need to repeat the test or to consider therapeutic intervention. The key data elements in the CDMS are categorised into subgroups, as shown in Table 2.

Clinician Decision Support

At the point of patient care, physicians and nurse clinicians are able to view a summary of the patient's chronic care records. There is a chart with physical parameters such as height, weight and body mass index (BMI) and records of systolic and diastolic blood pressure.

When key laboratory and screening tests for comprehensive diabetes care as defined by the MOH CPG on Diabetes Mellitus[23] are due for each patient, these "patient reminders" will appear in a red box. These contain both process and outcome message alerts to facilitate clinical decision making. Table 3 shows examples of these alerts.

Table 2. Key Data Elements Captured in the CDMS for people with Diabetes Mellitus

Group	Key data elements
Demographic characteristics	1. Patient identifier or registration number 2. Patient name 3. Date of birth 4. Gender 5. Ethnic group 6. Nationality
Diabetes mellitus core information	1. Type of diabetes mellitus (e.g. Type 1 or Type 2) 2. Date of diagnosis
Co-existing chronic conditions	1. Presence of hypertension or dyslipidaemia 2. Presence of macro- and micro-vascular complications such as retinopathy, nephropathy, ischaemic heart disease, cerebrovascular disease, neuropathy, vasculopathy, lower limb amputation
Clinical outcomes	1. Weight, height and BMI calculations 2. BP readings 3. Laboratory results, e.g. HbA1c, lipid profile, serum creatinine, urine ACR 4. Diabetic Retinal Photography service or eye review 5. Foot screening

BMI: body mass index; BP: blood pressure; ACR: albumin:creatinine ratio

Clinical Outcome Management

Since the launch of the diabetes module in August 2007, the NHG is now able to study clinical outcomes of patients with diabetes mellitus in a more systematic and efficient manner for quality improvement and evidenced-based population management. Inter-hospital and inter-primary clinic variations can be studied in greater detail. The key indicators monitored included 3 process and 2 intermediate outcome indicators.

i) Process indicators

These were adapted from the MOH Diabetes Mellitus CPG 2006,[23] and enhanced by including the following 3 components in the CDMS:

i. HbA1c test (once in 6 months)
ii. Lipid profile / LDL-c test (once in 15 months)
iii. Nephropathy assessment (once in 15 months)

A process indicator was considered "achieved" for each patient if there was a record of the laboratory test result during the stipulated interval for each test. The percentage of uptake for the process indicator is calculated as the number of patients who had record of the test done divided by the total number of patients in each specialty or primary care clinic. Having urine albumin:creatinine ratio (ACR) and a serum creatinine done would satisfy the criteria for nephropathy assessment.

ii) Intermediate outcome indicators

The 2 intermediate outcome measures were HbA1c and LDL-c levels, where the most recent result was taken for each report period. Each quarter, we measured the proportion of patients with poor glycaemic control having a HbA1c 9% and over and the proportion of patients with good LDL-control below 2.6 mmol/L. Blood pressure was not included in the analysis as the process of data entry of blood pressure readings started in late 2008.

Table 4 shows the performance of the 5 quality indicators over the 8 quarters from January 2007 to December 2008 for the 3 hospitals and 9 primary care clinics in the NHG.

Rates of HbA1c and LDL-c tests were consistently above 85% for the hospitals and 95% for the primary care clinics. For nephropathy assessment, the rates were about 64% to 67% for the hospitals and 84% to 87% for the primary care clinics. Rates of the 3 process indicators were relatively unchanged over the 2 years.

From January 2007 to December 2008, the proportion of primary care clinic patients with poor HbA1c (9% and above) has gradually reduced from about 12% to 9% and there was a corresponding increase in the proportion with

Table 3. Patient Reminders for Process and Outcome Indicators in the CDMS

Indicator	Condition	Message Alert
HbA1c [Process]	HbA1c test is not detected for 4 months or more.	HbA1c not done / Last HbA1c done more than 4 months ago. Please order.
HbA1c [Outcome]	Two HbA1c results within the last 6 months were 8.0% to 8.9%.	Latest two HbA1c readings within the last 6 months >= 8%. Titrate anti-diabetic agent / Refer Nurse.
	Two HbA1c results within the last 6 months were 9.0% and above.	Latest two HbA1c readings within the last 6 months >= 9%. Titrate anti-diabetic agent / Refer Nurse / Consult Senior Doctor.
Lipid panel (LDL-c) [Process]	LDL-c test is not detected for 12 months or more.	LDL-c not done / Last LDL-c done more than 12 months ago. Please order.
Lipid panel (LDL-c) [Outcome]	Latest LDL-c reading was 2.6 to 3.3 mmol/L.	Latest LDL-c reading within the last 15months is >= 2.6 mmol/L and < 3.4 mmol/L. Titrate statin or other lipid-lowering drug / Refer Nurse.
	Latest LDL-c reading was 3.4 to 4.0 mmol/L.	Latest LDL-c reading within the last 15months is >= 3.4 mmol/L and < 4.1 mmol/L. Titrate statin or other lipid-lowering drug. Refer Nurse / Consult Senior Doctor.
	Latest LDL-c reading was 4.1 mmol/L and above.	Latest LDL-c reading within the last 15 months is >= 4.1 mmol/L. Titrate statin or other lipid-lowering drug / Refer Nurse / Consult Senior Doctor.
Blood pressure (BP) [Process]	BP reading is not detected for 4 months or more.	BP readings not done / Last BP reading done more than 4 months ago. Please measure and enter BP.
Blood pressure (BP) [Outcome]	Latest BP reading was above 130/80 mmHg to less than 160/100 mmHg during the last 6 months.	Latest BP reading >130/80 mmHg to <160/100mmHg the last 6 months. Please consider use or titrate anti-hypertensive drug. Refer Nurse.
	Latest BP reading was 160/100 mmHg and above during the last 6 months.	Latest BP reading ≥160/100 mmHg the last 6 months. Please consider use or titrate anti-hypertensive medication. Refer Nurse/Consult Senior Doctor.
Nephropathy screening [Process]	System does not detect the following groups of tests within the last 12 months: • Urine ACR / PCR or 24hr microalbumin or UTP • Serum Creatinine or CCT	Nephropathy screening not done / done more than 1 year ago. Please order at least one of the following, where relevant: • Urine ACR / PCR or 24hr microalbumin or UTP AND • Serum Creatinine or CCT
Diabetic retinopathy screening (DRP) [Process]	No record of DRP / Eye Review is detected.	DRP / Eye Screening not done. Please order DRP.
	Last DRP or eye screening was done more than 1 year ago.	DRP / Eye Screening last done on <date of last DRP / Eye Screening>. Please order DRP.
Diabetic foot screening (DFS) [Process]	No record of DFS or visit to Podiatrist is detected.	Foot screening not done. Please order DFS.
	Last DFS or visit to Podiatrist was done more than 1 year ago.	Foot screening / Podiatrist visit last done on <date of last DFS / Foot Screening>. Please order DFS.
Diabetic foot screening (DFS) [Outcome]	If system detects code for "At Risk" or "High Risk" after DFS / Podiatrist visit and does not have any DFS / Podiatry Attendance after "High Risk' has been identified.	Found to have "High-risk" foot (King Classification's) on <date>. Please review feet and assess the need for referral to podiatrist or orthopaedic surgeon or vascular surgeon.

ACR: albumin/creatinine ratio; PCR: protein/creatinine ratio; UTP: urine total protein

good LDL-c control from 35.5% to 52.0%. At the hospitals, a similar trend was seen for good LDL-c control, increasing from 53.5% to 64.4%. However, the proportion of patients with poor HbA1c (9% and above) remained at about 16% to 17%. The patients seen at the hospitals by specialists tended to have more complicated medical problems and poorer HbA1c control than the ones at primary care clinics. The patients with improved HbA1c control would eventually be discharged to primary care clinics. In turn, these specialist clinics would be filled with new patients with poorer glycaemic control.

Discussion

The CDMS has become an operational chronic disease registry for patients with diabetes mellitus in the NHG. It has enhanced patient care to become more holistic and patient-centred by integrating multiple sources of patient care data from both administrative and clinical applications to a central point access which updates process and clinical outcomes of each patient and their progression over time.

The attending physician or nurse clinician would be able to access each patient's pertinent clinical information in a more timely and systematic fashion. The message alerts which had been incorporated into the CDMS serve to provide comprehensive and complete care for patients. The CDMS highlights patients with suboptimal risk factor control and prompts the attending physician to make adjustment to patients' therapeutics.

Our patients benefit through an overall improvement in the coordination of care. For patients who visit multiple clinics or hospitals, tests need not be repeated unnecessarily, saving them money and inconvenience.

Table 4. Performance of Clinical Process and Outcomes Indicators of Patients with Diabetes Mellitus in NHG Primary Care Clinics and Hospitals in 2007 and 2008

Year	**2007**				**2008**			
Quarter	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
HbA1c test every 6 months (%)								
Primary Care	97.96	97.69	97.84	97.72	97.38	97.27	95.23	95.27
Hospitals	88.45	87.74	88.32	88.15	87.74	88.24	86.78	86.16
Lipid profile / LDL-c test every 15 months (%)								
Primary Care	95.39	95.54	95.83	96.19	96.35	96.75	95.98	95.38
Hospitals	87.56	87.77	88.57	88.52	88.40	88.82	88.32	87.70
Nephropathy assessment every 15 months (%)								
Primary Care	85.54	85.37	85.70	85.98	86.12	87.04	85.55	84.32
Hospitals	66.37	65.99	66.65	66.26	65.63	66.40	65.15	64.64
Proportion of patients with HbA1c 9% or more (%)								
Primary Care	11.26	12.82	10.57	9.61	9.60	8.82	8.66	9.18
Hospitals	17.83	17.02	16.14	16.12	17.20	16.23	16.02	16.86
Proportion of patients with LDL-c below 2.6 mmol/L (%)								
Primary Care	35.56	39.58	43.10	46.40	49.12	50.78	51.55	52.15
Hospitals	53.52	55.48	57.29	60.00	60.96	62.77	63.89	64.41

Primary care: 9 primary care clinics in the NHG
Hospitals: 3 acute hospitals in NHG

Manual audit of clinical care can now be replaced by the reports generated by the CDMS. The performance of quality indicators can be studied more readily by clinicians and stakeholders for quick process reviews and quality improvement projects.

As described by Bodenheimer[24] and Nagykaldi,[25] the computer revolution has shown great potential to improve patient care by bridging the communication between physicians and patients and foster information sharing among health care providers, and providing rapid access to reliable medical information for both physicians and patients.[24-25] Chronic illness registry capable of identifying patients for whom treatment intensification would be warranted or offering real-time clinical guidelines support could support improved health care quality.[26] The prompt, recall, and reminder functions could help healthcare providers rethink and change their practices, resulting in improved patient care and the fostering of a team-based patient- and outcome-centered approach.[24-25]

There are several limitations with the CDMS.

(i) The correct identification of patients into the diabetes registry depended entirely on the quality of primary data residing in the many clinical application systems. Clinical information in paper-based case records or in verbatim or non-coded formats could not be drawn into the CDMS. Incomplete data or erroneous coding inevitably resulted in misclassification bias and incorrect stratification of disease severity and inappropriate display of patient reminders. It is a constant challenge to maintain accurate and high quality information within the chronic disease registry. This is dependent on all partners who are directly or indirectly involved in patient care to provide accurate and comprehensive documentation.

(ii) The disease registry was developed in phases. For a start, only patients with diagnosis of diabetes mellitus, impaired fasting tolerance, impaired fasting glycaemia and gestational diabetes were included. Patients with other chronic conditions could not be viewed. There was no detailed classification of complications from diabetes such as type of stroke or ischaemic heart disease in the first phase. Cardiovascular modules of hypertension, dyslipidaemia and stroke will be developed after the diabetes module. Where electronic patient data was unavailable or reports uncoded, data could not be drawn into the registry. Upgrading of existing clinical documentation modules would be new sources of information to draw into the disease registry.

(iii) The CDMS was designed to extract data from systems within the NHG-cluster of hospitals and primary care clinics. Clinical information of the patients who also visited the hospitals or primary care clinics or the private practitioners and specialists outside the cluster will not be available in the CDMS. Clinicians managing these patients would have to rely on other means of communication or records.

(iv) Being the first chronic disease registry in Singapore, time was needed for healthcare professionals to familiarise and use the registry during patient care. Feedback and preferences from end-users were gathered and some modifications were made, including the direct launch into the clinical charting screen instead of the clinical history page.

More research is needed to study the impact of EMR effects on diabetes care quality. Most of the clinical reports from the CDMS are cross-sectional in nature, providing valuable population-based information to care of people with diabetes. These can be monitored over time as part of organisation's quality improvement efforts. The improvement in health outcomes cannot be attributed to the CDMS alone. Physician and patient factors also contribute to these outcomes. As an IT application, the CDMS has empowered physicians to manage patients with greater efficiency. The "patient reminders" is customised for each patient and this has assisted physicians to provide timely and comprehensive care according to standard guidelines. Eventually, these will translate into better heath outcomes and doctors will become more confident that the IT system can help them to provide better care for their patients.

Conclusion

As a tool for chronic care delivery, the development of the NHG diabetes disease registry has enabled more efficient clinical monitoring and outcome management for our patients with diabetes mellitus across the entire healthcare cluster of hospitals and primary care clinics.

Simply having a chronic disease registry does not guarantee higher quality care. There must be a culture of improvement and quality from within the organization to continually strive to improve diabetes care while tapping on advancing health information technology as an enabler or tool to achieve its means.

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