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SYMPOSIUM

Using Web Technology to Support Population-Based Diabetes Care

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Abstract

Background:

Managed clinical networks have been used to coordinate chronic disease management across geographical regions in the United Kingdom. Our objective was to review how clinical networks and multidisciplinary team-working can be supported by Web-based information technology while clinical requirements continually change.

Methods:

A Web-based population information system was developed and implemented in November 2000. The system incorporates local guidelines and shared clinical information based upon a national dataset for multispecialty use. Automated data linkages were developed to link to the master index database, biochemistry, eye screening, and general practice systems and hospital diabetes clinics. Web-based data collection forms were developed where computer systems did not exist. The experience over the first 10 years (to October 2010) was reviewed.

Results:

The number of people with diabetes in Tayside increased from 9694 (2.5% prevalence) in 2001 to 18,355 (4.6%) in 2010. The user base remained stable (~400 users), showing a high level of clinical utility was maintained. Automated processes support a single point of data entry with 10,350 clinical messages containing 40,463 data items sent to external systems during year 10. The system supported quality improvement of diabetes care; for example, foot risk recording increased from 36% in 2007 to 73.3% in 2010.

continued →

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Abbreviations: (CHI) community health index, (DARTS) Diabetes Audit and Research in Tayside Study, (GENIE) GENeric Importer/Exporter, (GPASS) General Practice Administration System for Scotland, (MCN) managed clinical network, (NHS) National Health Service, (QOF) Quality and Outcomes Framework, (SCI-DC) Scottish Care Information—Diabetes Collaboration, (SEF) Scottish Enhanced Functionality

Keywords: electronic records, information technology, integrated care, managed clinic networks, shared care

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Abstract cont.

Conclusions:

Shared-care datasets can improve communication between health care service providers. Web-based technology can support clinical networks in providing comprehensive, seamless care across a geographical region for people with diabetes. While health care requirements evolve, technology can adapt, remain usable, and contribute significantly to quality improvement and working practice.

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Introduction

A 2008 Diabetes U.K. report estimated that diabetes accounted for approximately 10% of all National Health Service (NHS) expenditure.[1] In Scotland, those costs are generated by a prevalent national diabetes population that has increased from 103,835 (2%) in 2002 to 228,004 (4.4%) in 2009.[2] The managed clinical network (MCN) care model has been adopted as the vehicle to coordinate chronic disease management.[3] Clinical networks are defined as "linked groups of health professionals and organisations from primary, secondary and tertiary care, working in a coordinated manner, unconstrained by existing professional and health board boundaries to ensure equitable provision of high quality and clinically effective services."[4] The focus is therefore on organized collaboration and multidisciplinary team-working. In Scotland, MCNs for stroke, cardiovascular disease,[5] cancer services,[6] and diabetes[7] have developed. In England, cancer networks have reported significant benefits as a result of being able to focus on the needs of their patients, and in critical care, networks have been used to increase efficiency and responsiveness.[3]

A key factor in the success of MCNs is the implementation of equitable "joined-up" care with the use of integrated clinical information systems that span primary to tertiary care. We previously described how electronic record linkage of multiple data sources can identify all patients with diabetes mellitus in Tayside.[8] Our aim was to develop and evaluate the use of a Web-based information system that supported direct patient care, population-based monitoring, audit, and clinical governance for the multidisciplinary team members of our MCN. We have shown that information technology can play an important facilitative role in quality improvement[9] and now report the functionality and usage in Tayside for the first 10 years since November 2000.

The Diabetes Audit and Research in Tayside Study (DARTS) system, which became the Scottish Care Information—Diabetes Collaboration (SCI-DC) network system,[10] is the shared electronic record for diabetes in the NHS Scotland. We describe our experience that shows that MCNs and multidisciplinary team-working can be supported by Web-based information technology while supporting constantly changing clinical requirements.

Methods

Tayside covers an area of 3000 square miles, where health care is administered by 330 general practitioners in 69 practices and 3 community health partnerships. Integrated care is delivered in collaboration between every practice and three hospitals, in Dundee, Perth, and Angus.

Diabetes governance and services have undergone a significant period of evolution since the mid 1990s. In 1995, the Tayside Diabetes Advisory Group was formed to oversee diabetes service development before establishing the MCN for diabetes care in 2000. This multi-disciplinary team includes representation from patients, primary care, general practitioners, public health, podiatry, nursing, dietetics, specialist nursing, specialist services, and diabetologists. The diabetes MCN board interacts with the key NHS and university organizations in order to take forward a collaborative health strategy for the management of all people with diabetes in the region. Its remit is to advise local health bodies on the planning and delivery of diabetes health care in Tayside.

An agreed organizational structure promotes involvement of patients and professionals in the service delivery and development processes. The group is chaired by a general practitioner and a diabetologist, while a network

manager and data facilitator support the network. Multidisciplinary subgroups are responsible for network development. The group structure is shown in **Figure 1**.

Diabetes MCN network board
Implementation group
Patient council
Topic-specific subgroups Foot, retinopathy, education, information, inpatient, type 1, pregnancy
Wider clinical community Medical, nursing, podiatry, dietetics, pharmacy
People with diabetes and cancers

Figure 1. Structure of the MCN for diabetes in Tayside.

Managed Clinical Network Website

In October 1999, the Tayside Regional Diabetes Network Website was launched[11] (**Figure 2**). This Website contains information contributed by patients, health professionals, and researchers and includes details of network team members, regional diabetes clinics, retinopathy screening, children's diabetes services, latest news in collaboration with local Diabetes U.K. branches, regional research projects, and links to other relevant Web sites. Patient information leaflets are available and can be printed and tailored to the individual. Electronic guidelines for the management of diabetes-related issues are available to all in the form of the Tayside Diabetes Handbook[12] that provides regional protocols in accordance with national Scottish Intercollegiate Guidelines Network guidelines.[13,14]

The Website features the network annual report,[15] first published in 2001, that gives a lay description on all aspects of diabetes care and quality of outcomes in

Figure 2. The Tayside Diabetes MCN information Website (*http://www.diabetes-healthnet.ac.uk*).

Tayside. **Tables 1** and **2** show a comparison of key diabetes indicators published each year since the initial annual report in 2001.

Managed Clinical Network Support System

In November 2000, DARTS 2000, an integrated clinical management system, was made available to all health care professionals in Tayside who care for people with diabetes. In April 2002, this was rebranded as the SCI-DC to support a national rollout while maintaining the functionality of the original system. The system provides detailed, patient- and practice-specific information and is only available over a secure NHS connection to authenticated users. The key components of the system are data collection and linkage, data presentation, and data security and confidentiality.

Data Collection

The SCI-DC makes full use of automated deterministic electronic record linkage using the community health index (CHI),[16] but it also employs a variety of techniques to augment the overall process. These methods aim to collect the maximum data for the least cost in terms of time and resource. Information is collected either at the clinical review in general practice or at hospital clinics using a systematic agreed approach for the treatment of diabetes and screening for its complications.

Between 1996 and 2002, a manual data collection and validation process was performed to acquire data from general practice records. Information was collected from practice case notes and computer systems according to an agreed national clinical dataset,[17] including relevant biochemical and outcomes information. Manual validation was phased out after the development of an automated data collection mechanism: GENeric Importer/Exporter (GENIE).[18] The GENIE automated the collection of clinical information from different computer systems by exploiting the fact that most can export data as text. Each day, a snapshot of any data contained within the Scottish national dataset for diabetes,[19] or any associated clinical comments, are exported to a file that the GENIE compares to the previous export. Records that are new, modified, or deleted are marked for transmission. At a predefined time, these records are encrypted, compressed, and transmitted daily via the NHS N3 network. The GENIE has been used to transmit data from all diabetes clinics, regional biochemistry (three laboratories), retinal screening services,[20] a pediatric clinic, and a regional laser clinic. The GENIE's main use, however, has been to transmit data from the General Practice Administration System

Table 1.
Comparison of Annual Reports 2001 to 2004[a]

Comparator	Report 2001	Report 2002	Report 2003	Report 2004
Diabetes prevalence[b]	9694 patients (2.5%)	11,216 patients (2.9%)	11,932 patients (3.1%)	13,582 patients (3.5%)
Diabetes incidence[c]	888 patients (0.24%)	1148 patients (0.31%)	1127 patients (0.3%)	1274 patients (0.34%)
Hemoglobin A1c testing	8212 patients (91%)	9456 patients (93.1%)	11,408 patients (91.2%)	12,703 patients (93.5%)
Mean hemoglobin A1c	8.07% (range = 4.0–17.4)	7.7% (range = 3.9–16.9)	7.6% (range = 3.7–16.5%)	7.6% (range = 4.1–17.3%)
Cholesterol testing	6387 patients (71%)	7074 patients (78.5%)	9970 patients (79.7%)	12,034 patients (88.6%)
Mean cholesterol	5.03 mmol/liter (range = 1.7–23.1)	4.9 mmol/liter (range = 1.7–15.3)	4.8 mmol/liter (range = 1.1–15.9)	4.6 mmol/liter (range = 1.6–11.9)
Blood pressure testing	6712 patients (74%)	8675 patients (85.4%)	10,272 patients (82.1%)	11,582 patients (85.3%)
Mean blood pressure	140/79 mmHg	140/77 mmHg	140/77 mmHg	140/76 mmHg
Eye screening	5655 patients (63%)	6937 patients (68.3%)	7915 patients (63.3%)	10,013 patients (73.7%)
Body mass index screening	6306 patients (70%)	8375 patients (82.4%)	10,030 patients (80.2%)	10,944 patients (80.6%)
Mean body mass index	29.4 kg/m^2 (14.8–66.9)	30 kg/m^2 (14.7–65.0)	29.8 kg/m^2 (13.0–69.0)	30.1 kg/m^2 (14.2–68.2)

[a] Unless otherwise stated, all figures relate to the total population of patients with type 1 or type 2 diabetes during the report period. Please note that the data in this table has been calculated using a 12-month timeframe.
[b] Prevalence populations are limited to patients with type 1 or type 2 diabetes who were alive and registered with a Tayside general practitioner on a single, specified day, in this report, May 31, 2006. Denominators are via the General Register Office mid-year population estimates for Tayside for each year, in this report, June 30, 2005.
[c] Incidence populations are limited to patients diagnosed with type 1 or type 2 diabetes during a single, specified year.

for Scotland (GPASS).[21] Between 2001 and 2006, the GENIE for the GPASS was used to transmit the data from 65 general practice surgeries in Tayside.

In 2004, the national successor to the GENIE was specified in collaboration with the NHS Scotland Scottish Enhanced Functionality (SEF)[22] "Requirements for Accreditation" program. This new generic interface was designed to ensure that all primary care suppliers could supply data to the SCI-DC in a standardized format. Following a strategic decision by the NHS Tayside to move *en masse* from the GPASS to the In-Practice Systems Vision system,[23] the SCI-DC SEF interfacing functionality continued to transfer the necessary diabetes information. This migration was completed between September 2006 and August 2007.

Further acquisition of information has been achieved directly using the Web interface provided. Web forms have allowed the entry of data for patient administration, clinical review, foot screening, podiatry, dietetics, and diabetes specialist nursing.

Data Linkage

Data collected each night is consolidated into the "shared" diabetes record using the CHI. The CHI is a 10-digit unique identifier that can be used throughout all NHS computer systems in Scotland. The CHI master patient index system is used to collect further information on date of birth, death, migration, and general practice registration. This ensures that the SCI-DC system maintains an accurate record of those patients actively registered and receiving care. In addition, it means that the SCI-DC can group patients for reporting purposes and ensure that health care professionals can view only the records of those patients directly under their care.

Data Presentation

Following acquisition and linkage of clinical information from electronic and manual sources, it is made available in a concise, usable format to health care professionals via their NHS Web browser. Metadata on the identity of

Table 2.
Comparison of Annual Reports 2005 to 2009[a]

Comparator	3/1/2005–5/31/2006 (15 months)	10/1/2005–12/31/2006 (15 months)	10/1/2006–12/31/2007 (15 months)	1/1/2008–3/31/2009 (15 months)	1/1/2009–3/31/2010 (15 months)
Diabetes prevalence	14,900 patients (3.8%)	15,207 patients (3.9%)	16,150 patients (4.1%)	17,404 patients (4.4%)	18,355 patients (4.6%)
Diabetes incidence	1357 patients (0.36%)	1346 patients (0.36%)	1289 patients (0.34%)	1504 patients (0.39%)	1626 patients (0.43%)
Hemoglobin A1c testing	14,143 patients (94.9%)	14,629 patients (96.2%)	15,382 patients (95.2%)	16,690 patients (95.9%)	17,601 patients (95.9%)
Mean hemoglobin A1c	7.6% (range = 4.1–20.9%)	7.5% (range = 4.1–20.0%)	7.4% (range = 3.7–18.3%)	7.4% (range = 3.7–19.4%)	7.5% (range = 3.9–19.3%)
Cholesterol testing	13,326 patients (89.4%)	14,276 patients (93.9%)	15,128 patients (93.7%)	16,283 patients (93.6%)	17,156 patients (93.5%)
Mean cholesterol	4.4 mmol/liter (range = 1.5–14.4)	4.4 mmol/liter (range = 1.4–15.1)	4.4 mmol/liter (range = 1.1–13.6)	4.3 mmol/liter (range = 1.4–17.6)	4.3 mmol/liter (range = 1.6–16.9)
Blood pressure testing	13,380 patients (89.8%)	13,792 patients (90.7%)	14,680 patients (90.9%)	16,729 patients (96.1%)	17,556 patients (95.6%)
Mean blood pressure	138/75 mmHg	137/75 mmHg	137/75 mmHg	136/75 mmHg	135/75 mmHg
Eye screening	12,880 patients (86.4%)	11,879 patients (78.1%)	13,175 patients (81.6%)	14,880 patients (85.5%)	15,874 patients (86.5%)
Body mass index screening	13,039 patients (87.5%)	13,385 patients (88.0%)	14,133 patients (87.5%)	16,122 patients (92.6%)	16,413 patients (89.4%)
Mean body mass index	30.3 kg/m^2 (range = 15.1–69.0)	30.5 kg/m^2 (range = 15.1–68.3)	30.7 kg/m^2 (range = 13.4–66.7)	30.9 kg/m^2 (range = 13.4–78.9)	30.8 kg/m^2 (range = 12.2–70.9)

[a] Prevalence populations are limited to patients with type 1 or type 2 diabetes who were alive and registered with a Tayside general practitioner last day of the report period. Denominators are via the General Register Office mid-year population estimates for Tayside for each year. Incidence populations are limited to patients diagnosed with type 1 or type 2 diabetes during a 12-month period (as specified in each report). In 2005, eye screenings in this report included funduscopy and other nonspecialized visual assessments performed in diabetes clinics and general practices. Subsequent reports are limited digital image photography or attendance at an ophthalmology clinic in accordance with a change in national guidelines.

the clinician entering data allow users to see who has provided the information being viewed. There are 10 main clinical functional areas within the system:

1. **Individual patient summaries**: Patient-specific screens allow review of event-based patient data that have been collected from multiple sources. This provides a concise overview of the clinical information held on individual patients (**Figure 3**).

2. **Practice overview patient lists**: Provides practice diabetes population lists (e.g., type 1, type 2, impaired glucose tolerance), biochemistry, and clinical outcomes. **Figure 4** shows an example list of foot screening values for general practice.

3. **Clinical audit**: Allows the user to compare various aspects of their practice against regional averages in terms of demography, blood pressure control, glycemic control, and eye screening rates (**Figure 5**). Support for the Quality and Outcomes Framework (QOF)[24] is also available, presenting data based on the full shared electronic record rather than solely the general practice record. Customized *ad hoc* audit functionality is available on selected process outcomes.

4. **Retinopathy screening**: SCI-DC functionality supports local retinopathy screening services. These have evolved significantly since DARTS 2000 was implemented, when Tayside was the only board providing consistent digital retinal screening for all patients. Current functionality ensures that only eligible patients are called for retinopathy screening using the National Retinopathy Screening call–recall system, for which the SCI-DC automatically provides patient demography as soon as diabetes diagnosis is received.

Figure 3. Example patient summary. Icons allow access to clinic correspondence, prescribing, data histories, and Web forms (anonymized data shown).

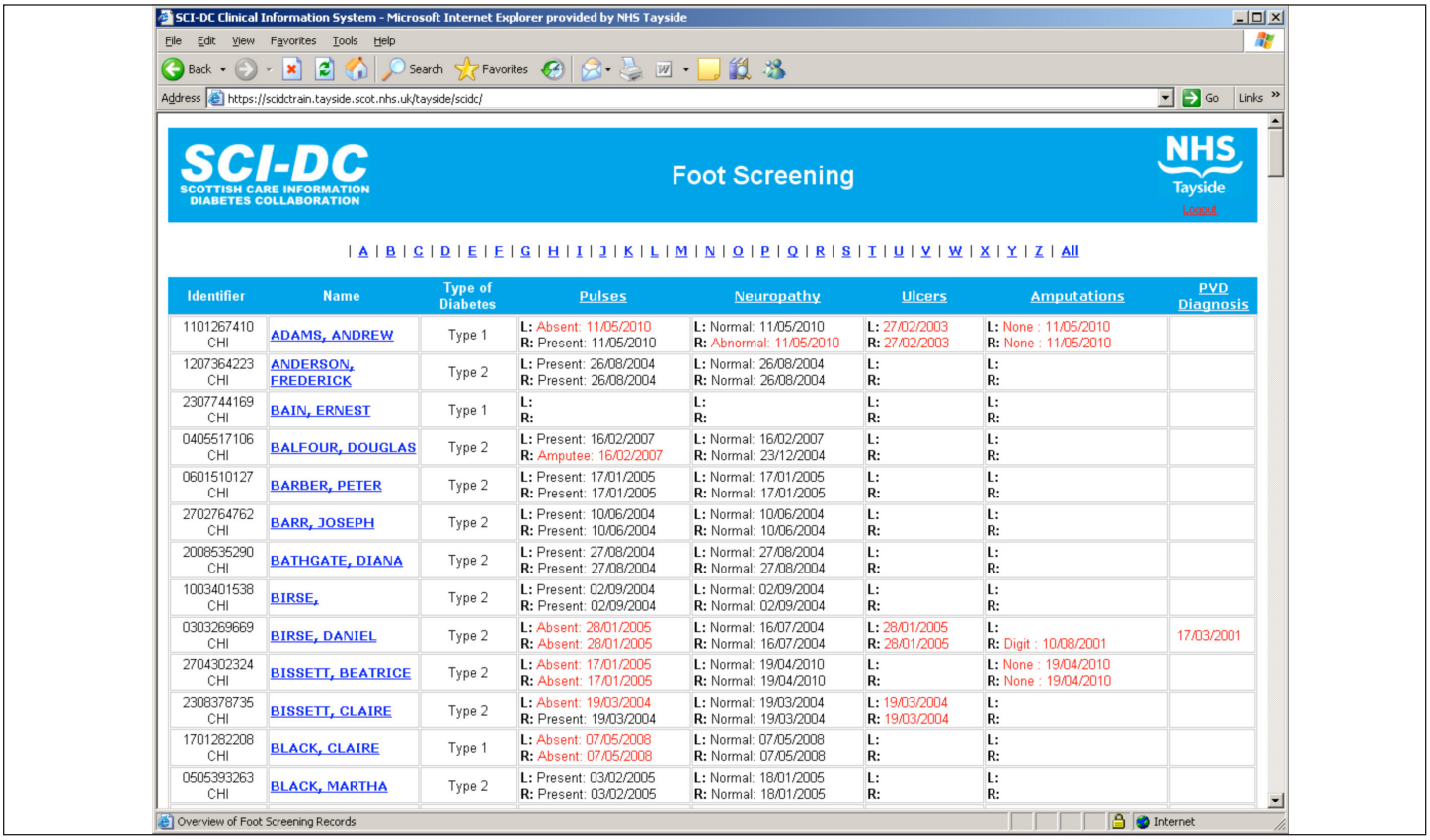

Figure 4. Example of practice list showing date and status of last foot screening with risk factors shown in red (anonymized data shown).

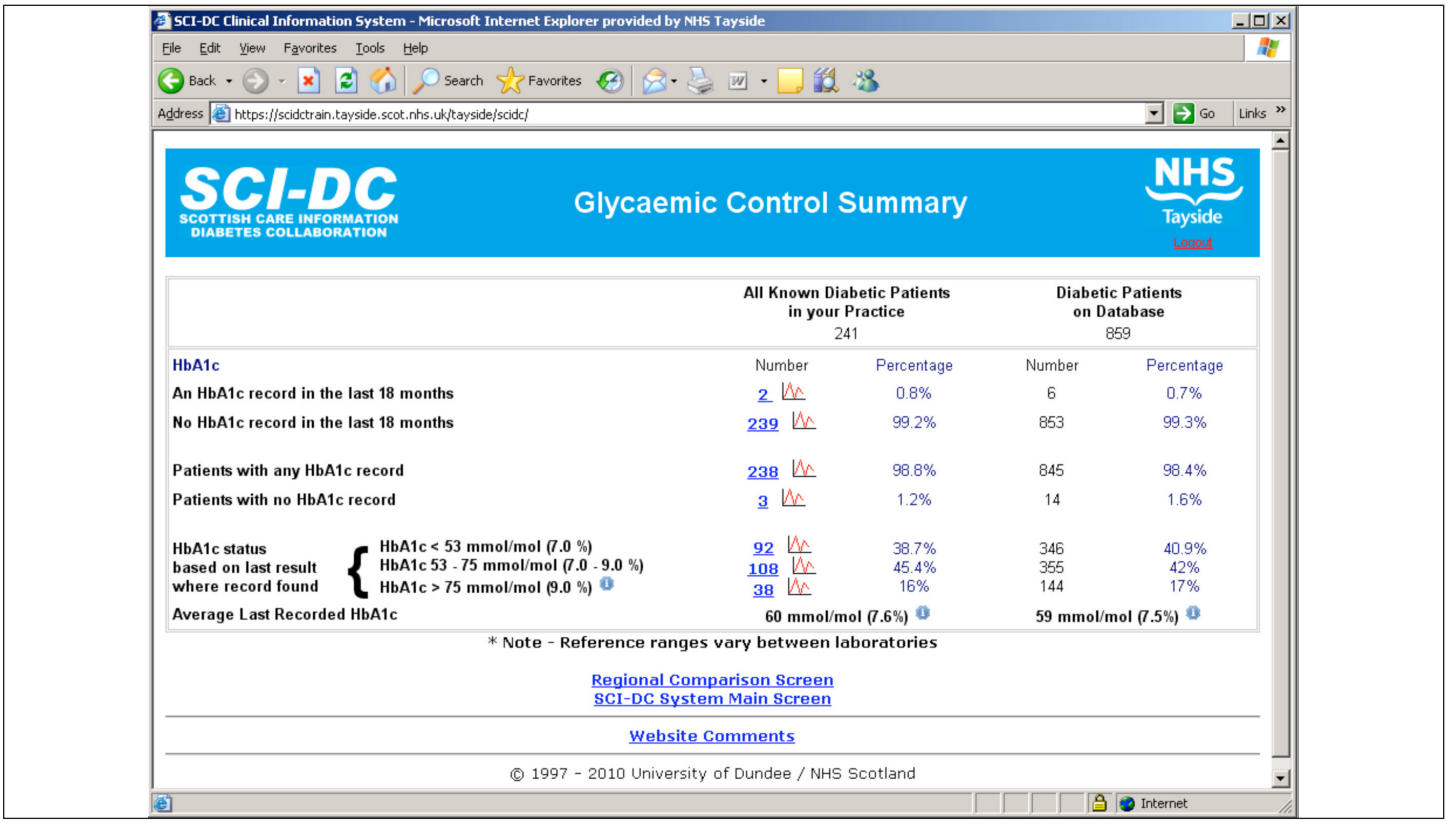

Figure 5. Example practice summary report for hemoglobin A1c. The practice is benchmarked against the whole region.

5. **Clinical guidelines**: Within each clinical area, the SCI-DC provides links to local guidelines to ensure that relevant processes are adhered to. In Tayside, these links refer to the local diabetes handbook.[12]

6. **Patient histories**: From the patient summary, users can drill down to longitudinal data for process and long-term clinical outcomes, ensuring that trends and interventions can be monitored.

7. **Patient comments**: The use of free-text correspondence has evolved from simply allowing access to clinic letters to providing a method of communication between health care professionals, most significantly in the case of Tayside's diabetes specialist nurses who use the SCI-DC as their sole clinical record.

8. **Prescribing**: Since the development and implementation of electronic links from general practice, the full prescribing record has been captured for dissemination throughout the clinical community. This has proved invaluable for those in secondary and tertiary care who would not otherwise have routine access to this information.

9. **Web data entry**: Automated data feeds are supplemented by the use of Web data entry forms for patient administration, clinical review, foot screening, dietetics, and diabetes specialist nursing. While the use of these forms has evolved over time, they remain a fundamental part of the current system.

10. **Patient searches**: Processes used to access an individual's information have evolved since the system was first implemented. While initially users would access records via patient lists, it is now clear that more targeted searching is preferred, either using the CHI number or a combination of surname and date of birth.

Confidentiality and security

All SCI-DC communication channels are encrypted and compliant with Scottish Government guidance on information security.[24] The SCI-DC servers and their operating systems are secured and hosted at a national data center, with only designated support staff having access. Access to confidential areas within the system is tightly restricted, with legitimate users nominated by their practices or clinics and verified by the MCN data facilitation team. User credentials are then issued to allow access to data pertaining to their own patients. A full audit trail of user activity is embedded within the system.

Results

Since manual data collection and validation began in 1996, Tayside has been in the position to provide aggregate statistics on the incidence and prevalence of diabetes and its associated risk factors. In 1999, there were 9005 people with known diabetes registered with a general practitioner in the health board area.[11] As shown in **Table 1**, the first Tayside MCN Annual Report published in 2001 reported a prevalence of 9694 (2.5%). The latest report published in 2010 (**Table 2**) shows that prevalence now stands at 18,355 (4.6%), an 89% increase.

Using the SCI-DC system audit trail, it is possible to identify the volume and main areas of usage within the system. Each system interaction, defined as a health care professional using the Web system to either retrieve or submit clinical information or to navigate through the system, is logged. **Table 3** shows how this has increased from 114,603 in year 1 to 870,361 in year 10—an increase of 659%.

Throughout the 10 years since implementation, **Figure 6** and **Table 3** show that this increase has been steady, despite the fact that total user numbers have leveled off since around year 4 (**Figure 7**, **Table 4**). This indicates that, although the user base remains consistent, those who

Table 3.
Total Annual and Daily System Utility by All Users[a]

	Year 1 2000–2001	Year 2 2001–2002	Year 3 2002–2003	Year 4 2003–2004	Year 5 2004–2005	Year 6 2005–2006	Year 7 2006–2007	Year 8 2007–2008	Year 9 2008–2009	Year 10 2009–2010
Total system utility	114,603 (313.98/ day)	221,664 (607.3/day)	339,400 (929.86/ day)	356,805 (977.55/ day)	434,230 (1189.67/ day)	524,033 (1435.71/ day)	576,010 (1578.11/ day)	552,817 (1514.67/ day)	746,006 (2043.85/ day)	870,361 (2384.55/ day)

[a] Each year runs between November 1 and October 31, inclusive, commencing in 2000.

use the system increasingly rely on it as a fundamental part of their daily working practice, a fact further demonstrated in **Figure 8** and **Table 4** where it is shown that users now log in more frequently. This increase in system use can be correlated with clinical priorities that have impacted health care professionals during this time, but it also demonstrates that the system remains highly usable.

In 2002, Tayside's diabetes specialist nurses moved from a paper-based record to using the SCI-DC as their sole data recording system. Since then, the diabetes specialist nurses have demonstrated increasing usage as their team has grown. Primary care usage increased significantly from 2004 after the implementation of the QOF,[25] which the SCI-DC supports as part of its clinical audit functionality. In addition to providing data on all diabetes-related indicators using the shared record, the SCI-DC now supports single data entry in support of the QOF. The SCI-DC back-population allows the electronic transfer of data from third-party systems onto the general practice electronic record, which is highly valued by practices. During the start of its rollout in year 10, 10,350 clinical messages containing 40,463 data items were "back populated" from the SCI-DC to general practice systems in Tayside.

In 2006, a national diabetic retinopathy screening program was implemented in the NHS Scotland. In Tayside, this meant that a migration was necessary to move from its existing legacy system to the new call–recall system. **Figure 9** and **Table 5** show that, during this time, system usage in this functional area peaked significantly as data integrity checks were performed.

Further to these initiatives, in May 2006, the Tayside Insulin Management Programme and, in 2007, the Tayside Diabetes Education Programme were launched. Since then, other developments ensure that formal foot risk assessments are carried out using the SCI-DC foot risk calculator. This is demonstrated by a significant increase in foot risk recording reported in the Tayside Annual Report (**Table 2**):

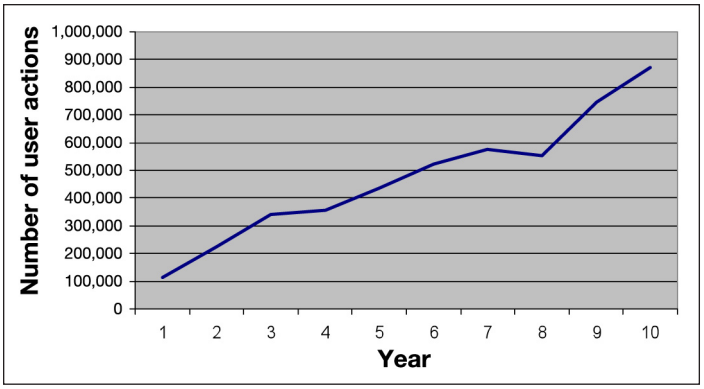

Figure 6. Annual system utilization.

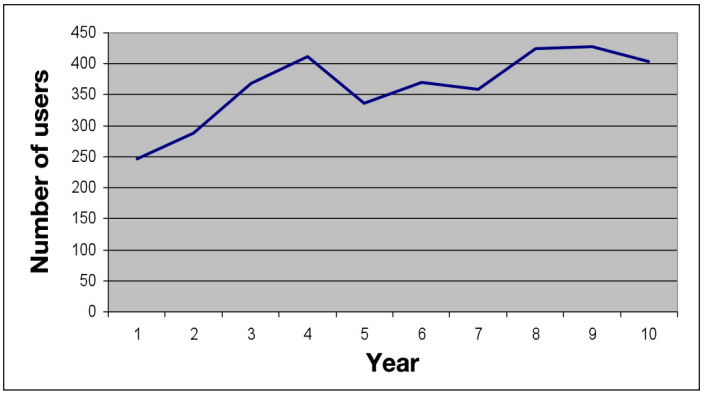

Figure 7. Annual active users.

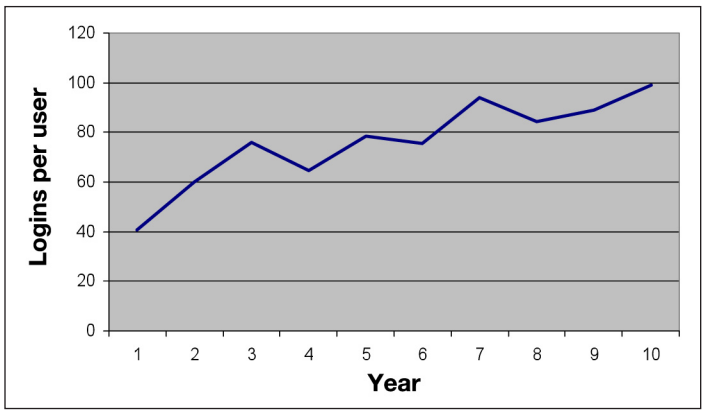

Figure 8. Number of logins by user.

Table 4.
Total Number of Active User Accounts and Successful Logins per Year

	Year 1 2000–2001	Year 2 2001–2002	Year 3 2002–2003	Year 4 2003–2004	Year 5 2004–2005	Year 6 2005–2006	Year 7 2006–2007	Year 8 2007–2008	Year 9 2008–2009	Year 10 2009–2010
Active user accounts	246	288	369	412	336	370	359	424	428	403
Successful logins	10,003 (40.66/ user)	17,329 (60.17/ user)	27,948 (75.74/ user)	26,556 (64.46/ user)	26,422 (78.64/ user)	27,880 (75.35/ user)	33,729 (93.95/ user)	35,761 (84.34/ user)	38,129 (89.09/ user)	39,936 (99.09/ user)

36% between October 1, 2006, and December 31, 2007, and 73.3% between January 1, 2009 and March 31, 2010.

Discussion

As people with diabetes consult a range of health care professionals within the NHS, their information should move with them in tandem. The creation of MCNs has been a pivotal part of the strategy to modernize the NHS in Scotland. Information technology is the key that underpins the success of clinical networks.

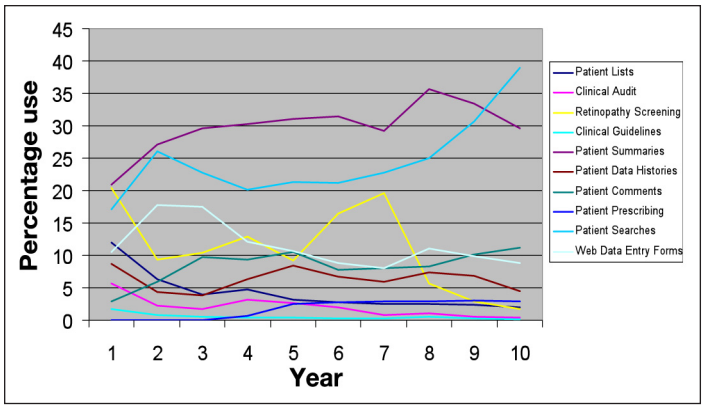

Figure 9. Utilization by functional area.

The aim of DARTS 2000 and subsequently the SCI-DC is to provide complete managed integrated care for diabetes. This ensures that clinical information can be collated and used efficiently, not only for individual patient care, but to inform practice, monitor outcomes, and clinical governance. Our study has demonstrated that the organized collaboration provided by a MCN can be underpinned by Web-based information technology to support comprehensive, seamless diabetes care across a geographical region. To the best of our knowledge, the Scotland-wide implementation of the SCI-DC is the first Web-based information system that supports care of all patients with diabetes in an entire national population.

The SCI-DC receives information from primary and secondary care clinicians relating to their findings at diabetes monitoring and assessment appointments. This promotes multidisciplinary team-working and sharing

Table 5.
Total Usage by Main System Functional Area per Year

Functional area	Year 1 2000–2001	Year 2 2001–2002	Year 3 2002–2003	Year 4 2003–2004	Year 5 2004–2005	Year 6 2005–2006	Year 7 2006–2007	Year 8 2007–2008	Year 9 2008–2009	Year 10 2009–2010
Patient lists	8546 (11.94%)	8922 (6.3%)	8246 (3.94%)	10,186 (4.75%)	7743 (3.22%)	8130 (2.78%)	8203 (2.51%)	7255 (2.49%)	10,209 (2.4%)	10,197 (1.95%)
Clinical audit	4093 (5.72%)	3199 (2.26%)	3623 (1.73%)	6880 (3.21%)	6212 (2.58%)	5773 (1.97%)	2677 (0.82%)	3106 (1.07%)	2330 (0.55%)	1954 (0.37%)
Retinopathy screening	14,619 (20.43%)	13,164 9.29%)	21,755 (10.41%)	27,578 (12.87%)	22,220 (9.23%)	48,090 (16.43%)	63,915 (19.57%)	16,670 (5.72%)	12,370 (2.91%)	9289 (1.77%)
Clinical guidelines	1188 (1.66%)	1141 (0.81%)	1157 (0.55%)	749 (0.35%)	923 (0.38%)	906 (0.31%)	971 (0.3%)	1465 (0.5%)	1058 (0.25%)	746 (0.14%)
Patient summaries	14,943 (20.88%)	38,457 (27.15%)	61,894 (29.61%)	64,840 (30.26%)	74,907 (31.11%)	91,860 (31.39%)	95,327 (29.19%)	104,009 (35.71%)	141,981 (33.39%)	154,998 (29.61%)
Patient data histories	6212 (8.68%)	6122 (4.32%)	7972 (3.81%)	13,407 (6.26%)	20,427 (8.48%)	19,660 (6.72%)	19,409 (5.94%)	21,285 (7.31%)	28,991 (6.82%)	23,339 (4.46%)
Patient comments	2114 (2.95%)	8457 (5.97%)	20,310 (9.72%)	20,030 (9.35%)	25,247 (10.48%)	22,740 (7.77%)	26,244 (8.04%)	23,985 (8.24%)	42,937 (10.1%)	58,306 (11.14%)
Patient prescribing	—	—	—	1407 (0.66%)	6070 (2.52%)	7945 (2.72%)	9293 (2.85%)	8556 (2.94%)	12,614 (2.97%)	14,817 (2.83%)
Patient searches	12,268 (17.14%)	36,970 (26.1%)	47,604 (22.77%)	43,100 (20.12%)	51,400 (21.35%)	61,815 (21.12%)	74,477 (22.81%)	72,863 (25.02%)	130,447 (30.68%)	203,788 (38.93%)
Web data entry forms	7575 (10.59%)	25,230 (17.81%)	36,467 (17.45%)	26,064 (12.17%)	25,645 (10.65%)	25,705 (8.78%)	26,036 (7.97%)	32,035 (11%)	42,220 (9.93%)	46,024 (8.79%)
Proportion of total usage	71,558 (62.44%)	141,662 (63.91%)	209,028 (61.59%)	214,241 (60.04%)	240,794 (55.45%)	292,624 (55.84%)	326,552 (56.69%)	291,229 (52.68%)	425,157 (56.99%)	523,458 (60.14%)

of information throughout the health care team. In support, it also has electronic links from the regional biochemistry database and the diabetic eye screening service. In turn, the SCI-DC provides up-to-date feedback showing detailed patient-specific data highlighting process, outcome, and reversible risk factor analyses.

Another benefit is the generation of clinical process and outcome indicators, essential for clinical audit and governance programs. Aggregate practice or clinic-specific data for various process and outcome variables are automated on a daily basis and compared with the regional benchmark. In Scotland, Quality Improvement Scotland performs peer-reviewed analyses of health board area performance.[26,27] Our study has shown that clinical governance information can be automated and gathered routinely and consistently.

Conclusions

Although computers are employed extensively in health care, the exchange of clinical data between systems has often been problematic. This commonly leads to poor communication and even duplication or omission of components of care. Our study clearly highlights the benefits and necessity of a nationally agreed "shared care" dataset for the automated exchange of clinical data, allowing computer systems to contribute to a shared clinical record. This agreed "currency of care" is critical if information is to be integrated as part of an electronic health record. This core dataset must support not only service delivery but also quality development. The Scottish Government has addressed this issue by publishing a diabetes dataset that is to be incorporated into all working clinical information systems used in the day-to-day care of people with diabetes.[19]

One potential problem with the current initiative is that MCNs have had a tendency to evolve with a "disease focus" such as diabetes or cancer. From the general practice perspective, it is essential that patients are viewed holistically and to recognize that multiple problems often coexist in the same individual. The challenge is to provide seamless communication that is patient focused, rather than disease focused. Information technology supporting clinical networks must therefore be fully integrated and seamless across diagnostic groups.

Web-based information technology can be used to support MCNs in providing comprehensive, seamless care of people with diabetes across a geographical region. We have shown that, while health care requirements evolve, technology can adapt, remain usable, and contribute significantly to quality improvement and daily working practice. It is recommended that a similar model is applied in countries where a similar health care environment and infrastructure are available.

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