Role of Information Technology in the Prevention, Control and Management of NCDs

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Key messages

- Non-communicable diseases (NCDs) are the leading cause of death worldwide and dominate healthcare needs and expenditure.
- Recent advances in information technology present unique opportunities for prevention, control and management of NCDs.
- Innovative approaches, including telemedicine, mobile technology, Internet and websites, can be adapted to prevent and manage NCDs in the community, particularly to reach out to remote and underserved communities at their doorstep.
- Electronic medical records and computerised clinical decision support systems have been shown to improve healthcare quality, safety and efficiency, and have been proposed as cost saving at the healthcare system level for chronic disease prevention and management.
- Innovative technological approaches offer great promise for enhancing the quality of care, improved access to care in remote areas, and prevention and detection of NCDs.
- Although models of care centred on electronic health (eHealth; information and communications technologies) may be replicable in both developed and developing countries, customisation of solutions would be needed for different needs.

Introduction

The global burden of non-communicable diseases (NCDs), including diabetes, cardiovascular disease (CVD), cancers, chronic respiratory diseases and mental illness, continues to increase. Indeed, NCDs present a global crisis and are a major barrier to development and achievement of the Millennium Development Goals (MDGs) [1]. Globally, two out of three deaths each year are attributable to NCDs and one-third of these are in people younger than 60 years [2]. NCDs are largely preventable and controllable through tackling common risk factors: tobacco use, unhealthy diet, physical inactivity and the harmful use of alcohol. There is robust evidence to show that targeting these
risk factors with effective lifestyle-related interventions can help in prevention and control of NCDs [3–7].

Although there is evidence to show that adherence to standards of care can prevent or delay the onset of chronic diseases and improve control, little more than one-third of patients achieve these targets [8]. Barriers to better management include 'system' factors such as inadequate record maintenance and patient education [9]. Recent advances in information technology (IT) present unique opportunities for prevention, control and management of NCDs [10]. IT has the potential to prevent and improve outcomes for patients in partnership with their healthcare providers and within the context of their families and communities and can be innovatively used to prevent chronic diseases. This chapter provides an overview of the role of IT in preventing and improving outcomes for NCDs, by citing evidence-based case studies (taking diabetes as an example) to show how strategic adoption of IT led to the improvement in delivery of preventive services in both the community and healthcare settings.

**Role of IT in prevention and management of NCDs**

**Prevention and management of NCDs in the community/individual**

There are several technological approaches to reach out to remote and underserved communities and monitor their health at their doorstep. The approaches include telemedicine, mobile technology, Internet and websites.

**Telemedicine**

Rural communities have less access to quality of care than cities [11,12]. Taking India as an example, although the prevalence of NCDs is lower in rural India, the total number of individuals with NCDs such as diabetes or hypertension in rural areas is much higher, because more than 70% of the population in India lives in rural areas [13]. In underserved rural areas, primary care providers may encounter difficulties in providing optimal healthcare and meeting quality of care standards. In rural populations, the main challenges for screening for NCDs and associated problems are inadequate healthcare resources, poor infrastructure, lack of awareness, illiteracy, limited availability of physicians and paramedical staff, limited access to healthcare due to problems with transport and unaffordability due to poverty. IT can help to link rural populations to healthcare professionals located in specialised centres in cities [14]. The emerging field of telemedicine, a tool that uses telecommunication to facilitate a beneficial interaction between the patient and the healthcare provider, has great potential to reduce geographical barriers. Through video conferencing, telemedicine facilitates real time visual interaction between the patient and the provider, almost mimicking face-to-face hospital visits. Having visible contact with the healthcare provider who has first hand knowledge of the patient's disease promotes treatment adherence and positive behaviour change, which is crucial in NCDs such as diabetes.

The use of telemedicine in chronic disease management has been shown to be successful in developed countries [15,16]. With its large medical and IT manpower and expertise in these areas, India has also emerged as one of the leaders in this field [17]. The Apollo Telemedicine Networking Foundation (ATNF) is the oldest (since 2000) and largest multispecialty telemedicine network [18]. The Ministry of External Affairs (MEA) has undertaken a global telemedicine initiative in Africa and South Asia to extend its telemedicine-enabled healthcare and educational services under a South Asian Association for Regional Cooperation (SAARC) and Pan-African e-Network Project [19]. In addition, telemedicine has been launched by several states of India, including Andhra Pradesh, Maharashtra and Tamil Nadu. In Tamil Nadu, under the National Blindness Control Programme, and with the support of Indian Space Research Organization (ISRO), Sankara Nethralaya at Chennai and Aravind Eye Hospital
at Madurai have launched mobile teleophthalmology service for diagnosis and treatment of eye diseases [20,21].

Telemedicine was initiated at the Madras Diabetes Research Foundation (MDRF) for screening of diabetes and its complications and to provide diabetes health care and prevention to a rural population in Tamil Nadu in collaboration with the World Diabetes Foundation, Denmark, and the ISRO, through the ‘Chunampet Rural Diabetes Prevention Project (CRDPP)’ (Fig. 14.1 and Case Study 1) [22,23]. The CRDPP telemedicine model, which has been recognised for screening and delivering diabetes care to rural areas in developing countries [24], can be scaled up and made available in other rural areas of India.

**Case Study 1: Public Health Intervention for Screening Diabetes and Its Complications in Rural India Using Telemedicine**

The “CRDPP” is a rural community outreach programme undertaken in a cluster of 42 villages in and around Chunampet in Kancheepuram district of Tamil Nadu, with the aim of implementing comprehensive diabetes screening, prevention and treatment using a combination of telemedicine and personalised care in rural India. A door-to-door survey was carried out; and more than 90% of the adult population (approximately 25,000 people) were screened for diabetes. Those confirmed to have diabetes by oral glucose tolerance test and all individuals with self-reported diabetes (>80% of diabetic individuals) undertook screening for diabetes-related complications in a fully equipped mobile telemedicine van using retinal photography,

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Doppler imaging, biothesiometry and electrocardiography. The photographs of the retinal and foot lesions were then sent by satellite network to the tertiary centre. Dr. Mohan’s Diabetes Specialities Centre (DMDCS) in Chennai. The ophthalmologists then graded the retinal photographs, and using video conferencing, the consultants were able to interact with patients, explain their present condition and provide the treatment and follow-up plans. All individuals who were diagnosed to have diabetes and early complications were followed up at the Sei Rural Diabetes Specialities Centre at Illedu near Chunampet. Those with more advanced diabetic eye, foot, heart or kidney complications requiring surgical treatment or hospitalisation were referred to the main diabetes centre at Chennai. Although all screening was done free of cost, subsequent treatment was provided either free of cost or at subsidised rates. This model has been successful in improving the level of diabetes control in this hitherto underserved rural area, as evidenced by a decrease in the mean HbA1c from 9.3 ± 2.8% at baseline to 8.5 ± 2.4% at 1 year follow-up [22]. Overall, CHPPV serves as a model for delivering affordable preventive and therapeutic diabetes healthcare to rural areas to reduce treatment gap.

In recent years, telemedicine has revolutionised the field of NCDs by removing traditional geographical barriers to care and communication, enabling bidirectional audio and video interaction between individuals and health providers. Although telemedicine clearly has a wide range of potential benefits (Box 14.1), it also has some disadvantages. First, there could potentially be a breakdown in the relationship between health professional and patient. Also, it is expensive and organisational and bureaucratic difficulties are likely to be present due to lack of personal contact. A systematic review that assessed 50 studies on telemedicine concluded that evidence regarding the effectiveness or cost-effectiveness of telemedicine is still limited and that only a few telemedicine applications can be recommended for broader use [25].

**Mobile technology**

Mobile health (mHealth), a component of electronic health (eHealth), most often refers to the use of mobile communication technologies to promote health by supporting health data collection, delivery of healthcare information or patient observation and provision of care [26] and disease prevention [27]. Although access to this technology has rapidly expanded in developing countries [28], its potential benefits to healthcare are still underutilised. Mobile phone messaging applications (text messaging or Short Messaging Service (SMS) and Multimedia Messaging Service (MMS)) could offer a convenient and cost-effective way to support desirable health behaviours for preventive health care, by providing educational and motivational advice [28].

SMS is suitable for behaviour change interventions because it allows for personally tailored health communication and reinforcement, helps communicate results of medical investigations, sends reminders for appointments and facilitates self-management [29].

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**Box 14.1 Benefits of the Telemedicine Service**

- Aids in implementation of prevention programmes for NCDs in rural areas
- Helps in early detection through screening and provides expertise and guidance for associated complications
- Improves access to information in NCDs for health professionals, for patients and for the population in general
- Helps in managing NCDs: with the help of existing healthcare providers, where specialised health care is not available
- Makes right expertise available anywhere and enhances decision making in clinical management
- Makes healthcare facilities available at doorstep
- Provides improved access, quality and continuity of care
- Reduces unnecessary patient transfers
- Reduces referrals to secondary care
- Saves costs to patient, provider and system
- Imports training to doctors in district hospitals and primary healthcare centres
- Overall, improves the quality of life of the people
include the following: it is available on almost every model of mobile phone, it can be accessed at any convenient time, cost is relatively low, its use is widespread, it does not require great technological expertise, and it is applicable to a variety of health behaviours and conditions [27,30].

A Cochrane review [31], which included 4 randomised controlled trials on primary prevention involving 1933 participants, reported that there was high-quality evidence that participants receiving SMS had a significantly higher likelihood of quitting smoking than those in a control group [32]. Another study reported moderate-quality evidence of higher self-reported adherence to medication by people receiving the messages [33]. However, there was very-low-quality evidence from one study that messaging interventions for self-monitoring of healthy behaviours related to childhood weight control did not have a statistically significant effect on physical activity, consumption of sugar-sweetened beverages or TV screen time [34]. Thus, although mobile phone messaging can be helpful for some aspects of preventive health care, we need data about the long-term benefits or even its potential negative consequences.

Several studies have been done to assess the feasibility of mobile technology to prevent and manage type 2 diabetes [35–40], CVD [41–43], cancer [44–46] and respiratory disease [32,47]. In asthma patients, daily text message alerts have been reported to improve adherence to inhaler medication – 18% higher in patients receiving a 12-week intervention with text message reminders [48]. A telemonitoring programme, via mobile phone messages (weight, heart rate and blood pressure (BP) sent weekly, and capillary plasma lipid profile and glucose sent monthly), conducted in 203 acute coronary syndrome (ACS) survivors, in Madrid, Spain, concluded that telemonitoring is very useful for improving the risk profile in ACS survivors and can be an effective tool for secondary prevention, especially for overweight patients. In this study, the cardiologist accessed the data received through mobile through a web interface and sent recommendations via SMS [49].

The prevention, awareness, counselling and evaluation (PACE) diabetes project, a large-scale community-based diabetes awareness and prevention programme, is an example of how prevention and management messages provided through direct public education and mass media campaigns to general population as well as to type 2 diabetic population increased the awareness of diabetes and its consequences in a whole city of Chennai [36,50]. With the help of popular networks, SMS messages on prevention and management of diabetes were sent to subscribers all over Tamil Nadu [36].

A prospective, parallel-group, randomised controlled trial done at 10 sites among Asian Indian men with impaired glucose tolerance assessed whether mobile phone messaging that encouraged lifestyle change could reduce incident type 2 diabetes [40]. The authors concluded that mobile phone messaging is an effective and acceptable method to deliver advice and support towards lifestyle modification to prevent type 2 diabetes in men at high risk.

This technology has also helped patients to manage their health conditions in a better manner [51,52]. A recent meta-review [53] on using mobile phones and SMS to deliver self-management interventions for chronic conditions reported that mobile phone text messaging significantly improved adherence to appointments and antiretroviral therapy, short-term smoking quit rates and other behavioural outcomes.

Some studies have assessed the utility of mobile phone–based applications in weight management and weight-related dietary and physical activity behaviour modification among youth and children [54,55]. The available evidence suggests that mobile phone–based and SMS-based programmes may support preventive health care, improve health status and health behaviour outcomes and thus improve outcomes of chronic care management. However, there are significant information gaps concerning the long-term effects, risks and limitations of, and user satisfaction with, such interventions.
Internet and informative websites

Internet-based counselling intervention with email reminders is being used to prevent and manage chronic diseases [56,57]. Static and interactive websites are being used to disseminate information on prevention and management of NCDs to a broad patient audience. IT platforms provide a forum to share and disseminate information between providers and patients and to deliver diabetes educational material to target populations. Some examples of websites that provide information on prevention and health promotion are the following: (i) a California state-sponsored website (www.opa.ca.gov), which posts medical practice results; (ii) the Indian NCD network (INN), which provides information, education, and communication (IEC) materials for NCDs (http://www.ncd.in/edu_materials.html); (iii) a web portal in Germany (http://praeventionatlas.de/); (iv) a website on monogenic diabetes, which has helped to provide genetic testing for neonatal diabetes and maturity-onset diabetes of the young (MODY) in India (http://neonataldiabetes.in/).

Role of IT in healthcare system for management of NCDs

Modern methods to improve chronic disease care include decision support for physicians and/or patients. These include electronic medical records (EMRs), disease registries, personal health records, and administrative data. EMRs provide an organised, quickly accessible structure for storing serial patient data to monitor progress [58], whereas the computerised clinical decision support system (CCDSS) has been shown to improve process and clinical outcomes for patients [59].

Electronic medical records

Several studies have employed advanced health information technologies and clinical decision support systems using functions enabled by EMR systems [60,61]. EMR systems can potentially lead to healthcare savings, reduction of medical errors, improved implementation of care guidelines and provision of data and decision support to improve the health of individuals with NCDs [58]. Outpatient EMR systems have been shown to improve the documentation of care, communication of clinical information across sites, and measurement of productivity and variations in the care provided, whereas inpatient EMR systems have led to improvements in care in some critical clinical domains [62,63].

The diabetes electronic medical record (DEMR) model at DMDSC in Chennai, in South India, provides an insight on how EMR plays a crucial role both in routine clinical care and for research in a developing country such as India (Case Study 2) [58,64]. Figures 14.2 and 14.3 show two of the illustrative screens viewable by our consultants in the DEMR module. The various biochemical parameters during the past visits can be viewed in a graphical manner, which makes clinical decision making easier. In our experience, DEMR offers improved medical follow-up of patients, with opportunities for screening, health promotion and control/prevention of diabetes and its complications. In addition, it has helped in large-scale data mining leading to valuable clinical research studies [65,66].

Case Study 2: The Diabetes Electronic Medical Record Model for Clinical and Research Applications in India

The main centre at Gopalganj and all branches of DMDSC in Chennai, in South India, are linked through EMRs and video conferencing facilities (www.dmdscdiabetes.com). Currently, the DEMR has details of approximately 3,00,000 patients with diabetes, registered across the various branches of DMDSC. The DEMR is designed to be manageable, maintainable, upgradable, maintainable and user-friendly. The modules in the DEMR system include registration, medical and personal history/anthropometry, test advice, diet advice, physical examination, billing, laboratory, special tests and inpatient. The DMDSC-DEM R provides clinicians with patient-specific assessments to help clinical decisions by flagging the patients who are at high-risk for complications and drug allergies and the patients who need preventive care. By effectively managing patients’ demographics, medical history, medications, test results, diet advice and physical activity, the DEMR plays a crucial role in providing (Continued)
comprehensive diabetes care, DEMR serves as a rich database for answering research questions. Using the DEMR database of DMDS, several retrospective, cross-sectional and follow-up studies have been published. It not only is a valuable tool for both clinical and research applications but also has helped the centre standardise various procedures and has enhanced the quality assurance programme leading to ISO 9001:2008 certification of the centre and accreditation of the laboratory by the National Accreditation Board for Testing and Calibration Laboratories (NABB) and College of American Pathologists (CAP). A strategy focused on financial support, multiple networking and training of technical support staff may be necessary to promote broader adoption of the DEMR system by medical service providers in India and other developing countries.

The major barriers to implement EMR in India include cost of implementation and maintenance, lack of knowledge to use computers and skilled technical staff. Multiple networking, training of technical support staff and financial support are some of the strategies to overcome these barriers to promote broader adoption of the EMR system in India [58].

**Computerised clinical decision support system**

CCDSSs are software systems that match characteristics of a patient with a knowledge base of information on recommended care in order to provide patient-specific recommendations as well as other information management.

*Figure 14.2* Blood glucose and glycated haemoglobin screen viewed by a consultant in electronic medical records at Dr. Mohan’s Diabetes Specialities Centre.
services [59,67]. There are reports that the use of CCDSS has improved physician adherence to guidelines, in addition to clinical performance for drug dosing, preventive care and other aspects of medical care [67,68].

To be successful, a CCDSS should first reflect the needs and preferences of the users (e.g., physicians) and the organisational system (e.g., ambulatory clinics) within which it works. Such a CCDSS should be introduced into clinical practice only after a ‘rigorous schedule of iterative usability testing and formative evaluation’ during which the CCDSS is modified to reflect the needs of the user and the demands of the clinical environment [69]. In India, an ongoing Cardiovascular Risk Reduction in South Asia (CARRS) translation trial is testing the feasibility, effectiveness and cost-effectiveness of a multifaceted intervention (physician-directed patient care) management facilitated by a non-physician care coordinator using eHealth records and decision support software) to reduce CVD risk among people with type 2 diabetes, compared with those receiving usual care among 1146 adults recruited from 10 urban clinic sites [70].

Role of IT in capacity building and medical education

Like any other field, medical system has also updated itself with IT and is widely used in all medical and surgical disciplines [71]. IT has the potential to transform the way medicine is
learned by students and healthcare professionals. It has the capacity to facilitate student learning and problem solving, in addition to many other benefits [72]. Two key developments in IT that provide new opportunities for medical education are multimedia and the Internet. Multimedia in medicine is primarily used in computer-based learning (CBL) programmes primarily for undergraduate medical students. The various CBL programmes for medicine that use multimedia to present and provide access to different types of information include information resources (reference/literature databases), electronic textbooks and digital video clips of surgical procedures.

Desktop video conferencing is another development in the IT sector that offers great promise for medical education and practice. Although video conferencing has been available for quite some time, it requires expensive equipment and satellite time. Recently, a range of desktop video conferencing packets that connect to standard multimedia computers have become available for which conventional telephone networks or the Internet can be used. Video conferencing has great potential for undergraduate, postgraduate and professional medical education in helping distance-based learners to communicate with their peers and tutors more effectively.

Conclusions

Innovative technological approaches offer great promise for enhancing the quality of care, improved access to care in remote areas, and prevention and detection of NCDs. A recent review on how IT has been used to improve self-management for adults with type 1 and type 2 diabetes reported that, overall, 74% of studies showed some form of added benefit, 13% of articles showed no significant value provided by IT and 13% of articles did not clearly define the added benefit due to IT [73]. The various limitations and research gaps identified by the authors include usability, real-time feedback, integration with provider EMR, and analytics and decision support capabilities. There is an urgent need for such technologies to be integrated into existing frameworks in order to manage chronic conditions in a cost-effective and scalable manner. Although models of care centred on eHealth (information and communications technologies) may be replicable in both developed and developing countries, appropriate customisation of solutions is needed to fit different needs and contexts. Further research is needed to apply these technologies to the chronic care model to control the escalating burden of NCDs, particularly in developing countries.

Summary

The prevalence of NCDs such as CVD, diabetes, cancers, chronic respiratory diseases and mental illness is increasing at an epidemic rate. Despite a wide range of effective lifestyle-related interventions to prevent and control NCDs, little more than one-third of patients achieve the targets. Recent advances in IT offer promise to improve outcomes for patients in partnership with their healthcare providers, within the context of their families and communities. IT-based approaches to prevent and manage NCDs include telemedicine, mobile technology, Internet and websites for the community/individuals, EMRs and CCDSS. Telemedicine model is found to be specifically useful because the patients need not travel long distances to visit a specialist to get a proper diagnosis and treatment. From a health provider perspective, such programmes are cost-effective because they do not need the full-time services of highly qualified specialists. Text messaging via mobile phone is a potentially powerful tool for behaviour change because it is widely available and inexpensive. Of the various types of decision support available for physicians, the EMR and CCDSS have emerged as effective information management tools with the potential to improve chronic disease care, but need to be customised and integrated into clinical frameworks in order to manage chronic conditions in a cost-effective and scalable manner.
Exercise

1. Visit a telemedicine facility in your institute and observe how it functions. Discuss the barriers for use of IT and how they could be tackled.

2. Discuss mHealth application in prevention and control of NCDs.

References


Suggested reading
