58 Models of Diabetes Care Across Different Resource Settings

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Keypoints

- A comprehensive approach to diabetes prevention and care includes policies and activities outside the formal health sector, particularly for primary prevention.
- Integrated care refers to the need to provide care for conditions coexisting with diabetes within the same primary health care service.
- Continuity of care, a cornerstone of effective health care organization, is associated with improved outcomes.
- Prerequisites for improving outcomes include ensuring that essential medications (including insulin) are either free or highly affordable and that tests for the diagnosis of diabetes, monitoring of control, and equipment to screen for complications are available.
- Living health systems should care for, empower and nurture their staff so that they are enabled to do the same for their patients.
- If no one is responsible for chronic care, the tendency is for it to be overlooked.
- A less qualified professional may offer lower quality care, but there is potential for effective substitution, with the right training and organization.
- A respectful, open and curious stance may help different professionals and people to understand each other better.
- Patient-centeredness improves quality of life, increases patient satisfaction, improves adherence to treatment, enhances the integration of preventive and promotive care, and improves the provider's job satisfaction.
- In low resource settings where large numbers of patients overwhelm facilities, it may make sense to extend care into the community.
- Ideally, a systematic process for reviewing the evidence and updating guidance accordingly should be in place in all countries.
- Advances in the usage of information technology and the internet are likely to provide increasingly important contributions to diabetes care both in well-resourced and less-well resourced settings.

Introduction

Almost no community worldwide remains unaffected by diabetes. Premature mortality and an array of complications, in particular the chronic complications, result in a considerable impact that is experienced by individuals, families and societies. This impact is predicted to increase, primarily in countries such as those in North Africa, sub-Saharan Africa, the Middle East and South Asia. In these countries, lifestyles are transitioning and the populations consume less healthy foods, and have rising levels of physical inactivity and obesity.

Enormous inequalities exist in the provision of health care for people with diabetes, in keeping with the widely disparate socio-economic status that prevails globally. These inequalities are not only found between countries, they occur within countries, for example in rural-versus-urban settings, private-versus-public sectors and hospital-versus-community-based services. Considerable challenges face health planners and providers, especially in less well resourced countries and areas countries, because of the traditional infectious diseases, such as tuberculosis and malaria, coexisting with HIV/AIDS, and the emerging scourge of chronic diseases, including diabetes, producing a multiple disease burden with competition for limited resources. Furthermore, most health care systems have evolved from the basis of dealing with acute medical problems and have been or, in most instances, remain ill-equipped to provide the kind of care that people with chronic diseases require.

That is not to say well-resourced countries do not face challenges with health care delivery. In these countries, there are also problems in ensuring that quality health care is delivered in a

Textbook of Diabetes, 4th edition. Edited by R. Holt, C. Cockram, A. Flyvbjerg and B. Goldstein. © 2010 Blackwell Publishing.

cost-effective manner. Notwithstanding these challenges, each person with diabetes, wherever they live, should have access to the best care that can be provided in their setting and consequently have the opportunity to achieve the outcomes they seek. Unfortunately, this is not the current situation, even in well-resourced countries and settings. The United Nations Resolution on Diabetes "Encourages member states to develop national policies for the prevention, treatment and care of diabetes in line with the sustainable development of the health-care systems, taking into account the internationally agreed upon development goals, including the Millennnium Development Goals" (Resolution 61/225, December 20, 2006). The resolve of the United Nations, together with the policies and influence of the International Diabetes Federation (IDF) and the World Health Organization (WHO), need to be harnessed in order to improve the suboptimal care and outcomes for people with diabetes. After all, it is not that a dearth of evidence exists for the effectiveness of a wide range of interventions to prevent complications associated with diabetes, but rather the reverse. Narayan *et al.* [1] have identified three interventions that are cost-saving and fully feasible in terms of penetration of the target population, technical complexity, amount of capital required and cultural acceptability, even in low and middle income countries and across all regions:

1 Improvement in glycemic control;
2 Blood pressure control; and
3 Foot care.

A fourth intervention, pre-conception care, was found to be cost-saving, but not fully feasible because of concerns of not being able to reach all women with diabetes.

The issue at hand is how to translate the evidence into practice and thus reality, acknowledging that, almost without exception, health services are in need of repair and the specific interventions to be introduced or implemented will undoubtedly vary depending on the health care structure and resources available. There is also the need to recognize that diabetes requires that people not only have access to sufficient resources, such as medication, but also the understanding, motivation and skills to self-manage their condition.

Health care cannot be seen in isolation, occurring as it does within a broad societal framework which places varying degrees of emphasis on ensuring that quality care is prioritized. Thus, in the first instance, for effective health care delivery, a positive policy environment needs to be in place, nationally and locally. The "macro" level of the WHO Innovative Care for Chronic Conditions (ICCC) framework focuses on this very issue (Figure 58.1), highlighting the components that can promote a positive policy environment [2]. Political will, building or strengthening partnerships (e.g. between community-based organizations, patient organizations, health care workers and government), and ensuring consistent funding are key aspects of the process. So too is the need for an inter-sectoral approach or collaboration to building a healthy society, encompassing, for example, urban

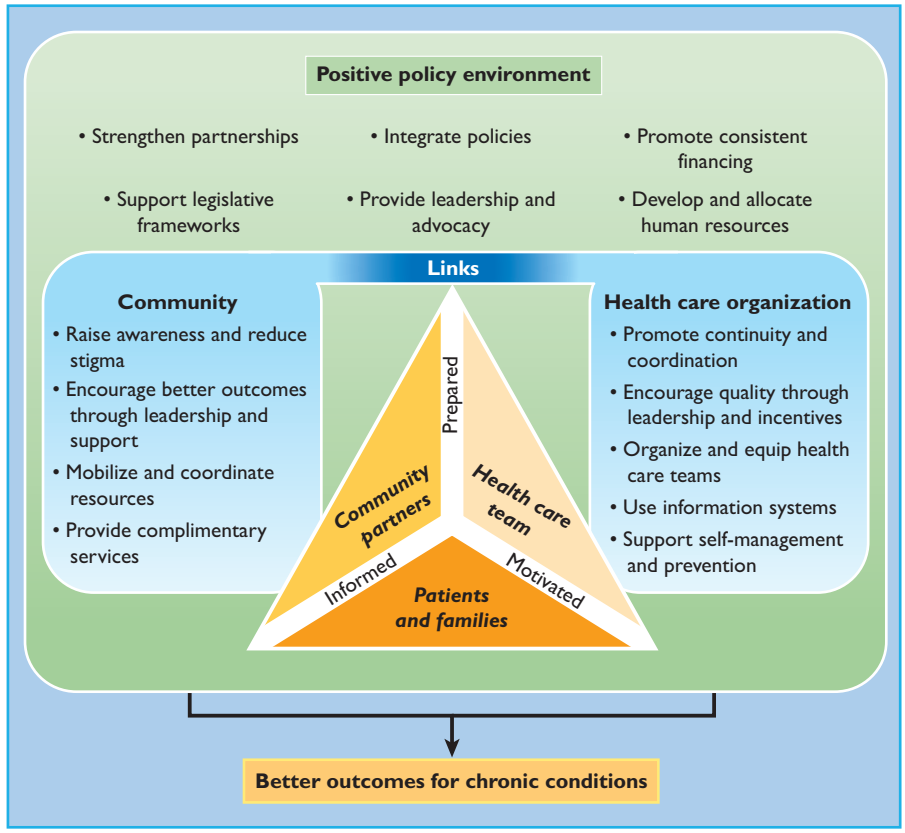

Figure 58.1 Innovative care for chronic conditions framework. Adapted from WHO [2].

planning (with the provision of green areas, easy public transport, access to sport and recreation facilities), the introduction of health promotion activities within schools and the food industry.

The "meso" level in the ICCC framework relates to health care organization and links to the community. It is at this level that the concept "model of care" comes into play. As coined by Davidson *et al.* [3], a health care model can be regarded as an overarching design for the provision of a service that is ideally underpinned by a theoretical framework, evidence base and clearly defined standards. The model has core principles and elements in addition to an agreed upon agenda for implementation and later evaluation. It is unlikely that a single health care model for diabetes exists that can be used effectively and efficiently in all settings – indeed, the model will take different forms or shapes in different settings. Health planners have to decide whether to pursue a diabetes-specific model of care or to incorporate multiple chronic diseases such as diabetes, hypertension and chronic lung diseases in a common chronic care model. There are salient reasons for pursuing the latter, given the commonality of aspects of care for these conditions, but factors such as the available resources are likely to guide this decision. Regardless of the model selected, changing the value system in which health care is delivered, with the aim of ensuring motivated affirmed health care workers, is perhaps key to equipping or enabling people living with diabetes with the information, motivation and skills to self-manage their diabetes. There is a real need to embrace the lessons that can be learned from the successful highly active antiretroviral therapy (HAART) programs for people with HIV/AIDS, which have yielded levels of adherence to therapy that most clinicians and public health specialists can only dream of in relation to diabetes [4].

There are certain core principles for diabetes care that could be applied across all resource settings [2]. These include establishing:

- A comprehensive approach that provides for health promotion to enable prevention and early diagnosis, management of diabetes and complications when they arise and rehabilitation when needed.
- Integrated health care, such that conditions coexisting with diabetes, can be readily managed within the same primary health care service.
- Continuity of care, which has a number of connotations: in terms of the relationship between health care worker and patient; in terms of management strategies and decision-making; and in terms of patient information.
- Access to care, which can be understood in a physical or geographic sense, but extends to access to appropriate equipment for monitoring, diagnosis and management as well as medication.
- Coordination of care from primary to secondary and tertiary levels, with appropriate referral strategies and role delineation. Where multiple professionals and organizations are involved in primary care, horizontal coordination of care is also important.
- Teamwork: diabetes care involves multiple health workers, professional categories and disciplines, even in low resource settings. Establishment of teams whose focus is on delivering and improving the quality of care permits the development of shared goals, defining and clarifying roles, reflecting on how care can be improved and holding each other accountable for decisions. The identification of a team leader may be a major factor in the success of this element.
- Person-centeredness implies a more collaborative approach and holistic understanding of the patient that elicits, acknowledges and addresses relevant beliefs, concerns and expectations. This is at least partly a paradigm shift in the mind of the health worker from the traditional biomedical, technical and sometimes authoritarian model to a biopsychosocial, holistic and participatory model.
- Family and community orientation are integral to provide support for the individual with diabetes as well as to raise awareness and to extend care from the health centers into the community.
- The use of evidence as far as it is available, accessible and relevant. The evidence base for diabetes is constantly expanding and all resource settings need to look at how they access the latest and ever-changing evidence base.

We now discuss how these principles are being incorporated into care for people with diabetes across different resource settings; low and middle income settings such as encountered in most low and middle income countries as well as in high income countries. Finally, how information technology can be embraced and harnessed appropriately in different settings with the goal of supporting these principles is explored.

A comprehensive approach

Taking a comprehensive approach to diabetes prevention and care implies that polices and activities are put in place to address primary prevention, early diagnosis (including screening if appropriate), management of diabetes and its complications, and rehabilitation for those affected by complications. A comprehensive approach will include policies and activities outside the formal health sector, particularly for the primary prevention of type 2 diabetes mellitus (T2DM). For example, promoting healthier diets and greater physical activity could involve policies on food production, marketing and taxation, and policies on design of local environments and public transport. The WHO's strategy on diet and physical activity provides a framework for developing national and international policy that is relevant to countries at all levels of development [5]. The best indication of a comprehensive approach is a national government-led strategy that covers primary prevention through to rehabilitation, with the caveat that the presence of a strategy does not guarantee that it has been implemented. A recent survey carried out through IDF member organizations [6] found that of the 98 countries from which responses were received, just over 70% claimed that their country had implemented a national diabetes program. The region with the lowest proportion of countries (30%) with a

national diabetes program was sub-Saharan Africa, but even in richer regions, such as Europe, over 20% of responding countries did not have a national diabetes program. Examples of national diabetes programs in countries at opposite ends of the economic spectrum include the program in Cameroon [7] and the National Service Framework for Diabetes in England [8].

Integrated health care

Integrated care for people with diabetes refers to the need to provide care for conditions coexisting with diabetes within the same primary health care service. Within most high income countries, primary health care has been developed to provide a range of services covering most of the needs with people with diabetes, and indeed with other chronic conditions. In low and middle income countries, however, integration of care is often a challenge, as donor funding is most often given to specific disease programs such as HIV/AIDS, tuberculosis or malaria, or large-scale government funding is allocated for specific vertical programs, such as HIV/AIDS. For example, in Zambia the donor funding for HIV/AIDS is larger than the total health care budget. While this funding enables higher quality care for a specific disease it can weaken the health care system as a whole. Further, disease-centered programs, through higher salaries and better working conditions, may draw professional staff away from primary care. Therefore, initiatives aimed at strengthening an approach to diabetes should do this with an integrated model of care and with the goal of strengthening the whole approach to chronic care [9,10]. An example of an integrated chronic care clinic for HIV/AIDS, diabetes and hypertension at provincial hospitals in Cambodia has recently been reported (Box 58.1) [11]. There is no reason why such an approach could not be used in primary health care [12].

Box 58.1 Cambodia: integrated chronic disease clinics

Chronic disease clinics for the combined care of HIV/AIDS, diabetes and hypertension were set up in two provincial referral hospitals in Cambodia based on a number of assumptions: a common approach is needed to respond to the needs of chronic disease patients, with the widespread acceptance that HIV/AIDS has become a chronic disease following increasing availability of antiretroviral therapy; attending a combined clinic would minimize the stigma that a specific HIV/AIDS clinic induces; and that the care model should reflect estimates of disease burden. All patients were managed according to standard treatment protocols. A team of counselors promoted adherence and lifestyle changes to complement medical consultations, and peer support groups extended the efforts of the doctors and counselors.

After 2 years

- 70.7% of patients with diabetes (90% of those who attended for >3 months) and 87.7% of patients on highly active retroviral therapy (HAART) remained in active follow-up
- Median HbA_{1c} was 8.6% (70 mmol/mol), but the degree of improvement could not be assessed in the absence of a baseline measurement
- Median CD4 count doubled in patients on HAART

Thus, integrated chronic care is not only feasible, but can produce good patient outcomes

Continuity, access, coordination and teamwork

These four core principles – continuity of care, access to care, coordination between different levels of care and multidisciplinary team work – really belong together, as they concern providing good quality health care for managing diabetes and preventing its complications. A particular challenge in low resource settings is that of moving away from a focus on episodic curative care. High patient numbers, with acute infectious illness and low numbers of trained professionals have nurtured this approach, which will tend to wait for the patient to present with gangrene of the foot rather than invest energy in identifying the patients at risk. Likewise, there is more focus on treating the problem than empowering the person. For example, a patient with elevated blood glucose levels is more likely to receive a change in prescription than a useful exchange of information about diet or exercise and advice about overcoming barriers to adherence.

Continuity of care

Continuity of care in chronic diseases is a cornerstone of effective health care organization and has been associated with lower mortality, better access to care, less hospitalization and referral, fewer emergencies and better detection of adverse medical events [13,14]. Continuity is easier to achieve when services are offered close to communities where access is easier. Care that requires visits to a distant referral hospital is unlikely to support continuity because of the costs and time taken to travel. In many less well resourced countries and areas, diabetes care has not been part of primary health care offered in the community although there is a clear drive by the WHO to change this.

Central to providing continuity of care is continuity of information, such that the status of individuals is known, in terms of when they attended their last appointment, the next appointment due, and what was found, discussed and prescribed at previous appointments. A diabetes register is therefore essential, providing a list of patients with diabetes being treated at that facility, a record of their appointments, linked to a system to follow-up those who fail to attend for an appointment. In higher income situations, electronic diabetes registers are now the norm, and in some situations registers are maintained across more than one level of care, such as primary and secondary care. In low income situations, an adequate register can be kept using "pencil and paper" at the level of the facility at which most diabetes care is delivered. In addition to keeping a register of patients and their

appointments, there is the need to provide continuity of relevant information between visits. In high-resource settings, electronic records linked between different levels of care provide a state of the art approach. In low-resource settings, a range of approaches have been tried (e.g. color coding of patient records, the use of annual summary sheets and patient-retained records) [15]. A simple but effective approach in some settings can be a combined "paper and pencil" register and record, recording a small number of core items such as blood pressure, a measure of blood glucose control, whether feet were examined, advice given and current medication.

Continuity of management aims to provide continuity with a specific group of health care providers. The challenge here is to maintain the same team of people for a reasonable period of time. Relational continuity with the same health care provider over time is occasionally possible and would be an ideal [16].

Access to all

Access to care, of any type at all, is still an issue in many low and middle income countries, particularly in more remote areas. A specific example is the lack of availability or access to insulin leading to unnecessary mortality in people with type 1 diabetes (T1DM) [17,18]. Even when available, the cost of purchasing insulin is substantial and can be the equivalent of up to 20 days wages for a 1-month supply of insulin. Thus, addressing the supply chain for medication and ensuring that essential medication is either free or highly affordable is a prerequisite for improving outcomes, but that is not all that is required. Availability of tests for the diagnosis of diabetes, monitoring of control and equipment to screen for complications are also essential.

A shortage of human resources is a serious barrier to providing access to care in many low and middle income countries, the irony being that these countries are often recruiting grounds for high income countries seeking to staff their own health care systems. Given their shortage, health workers in low resource settings often develop a broader scope of practice than their equivalents in high resource settings and as a result need to have a wide range of skills. This is often necessitated by the absence of more highly trained professionals, particularly in rural and remote areas. Although a less qualified professional may offer lower quality care, there is also the potential for effective substitution, with the right training and organization. This has been well demonstrated by Gill *et al.* [19] in rural Africa. Using a wholly primary care level nurse-led program, with key elements of education and drug titration by clinical algorithm and using drugs on the essential drug list, significant improvements in glycemic control were noted and maintained over an 18-month period (HbA_{1c} 11.6 ± 4.5%, 103 ± 49 mmol/mol [SD] at baseline, and 7.7 ± 2.0%, 61 ± 22 mmol/mol at 18 months). The impact of education alone was remarkable, as without any change in drug therapy the HbA_{1c} dropped from 10.6 ± 4.2% (92 ± 46 mmol/mol) baseline to 7.6 ± 2.3% (60 ± 25 mmol/mol) at 18 months.

In primary care, well-trained nurses can offer equivalent care to doctors for routine follow-up of chronic conditions, minor illness and preventative interventions [20]. In diabetes, this may mean the nurse conducting the consultation and reviewing results such as urinalysis, HbA_{1c}, glucose and cholesterol levels. The nurse may also screen the feet, take blood pressure and calculate the body mass index. Nurses will then refer to the generalist doctor for complicated or uncontrolled patients. Patient satisfaction may even be higher as consultations are longer and contain more information. Nurses, however, may not necessarily be cheaper as they are less productive [20]. Similarly, in low resource settings the generalist doctor may need a broader range of procedural and surgical skills at the district hospital and the ability to act as a supportive consultant to nurses. A range of mid-level workers such as health promoters and clinical associates/assistants may also provide effective substitution [21].

Management of diabetes and other chronic diseases involves providing access to screening and early intervention to prevent or at least limit the impact of complications [2]. In low resource settings, some complications are easy to screen for (e.g. using a testing strip dipstick to assess for proteinuria or identifying the at-risk foot with a monofilament) provided the necessary tools are available; however, screening for retinopathy is problematic as health providers seldom succeed in overcoming the many obstacles to effective ophthalmoscopy. Nevertheless, even in low resource settings, appropriate technology using a fundal camera may be possible [22,23].

Further decisions need to be made regarding the relative costs and benefits in different resource settings of macro vs micro albuminuria screening; use (and frequency) of glycated hemoglobin vs random/fasting blood glucose as well as total cholesterol vs high density lipoprotein (HDL) cholesterol and low density lipoprotein (LDL) cholesterol measurements. Effective screening requires a structured and systematic approach by the health care team.

Coordination of care

Coordination of care from primary to secondary and tertiary levels is needed to provide the full range of diabetes care, if resources allow. In well financed and organized systems, this coordination includes well-developed referral pathways within health districts and regions, and well-developed systems of information exchange between the levels, in order to preserve continuity of care. Specialist services likely to be available at a secondary level include the treatment of foot ulcers, retinal laser therapy, and the investigation and medical treatment of renal impairment. Renal dialysis and replacement is an example of services often provided at the tertiary level. In low and middle income settings, and even in some high income countries where universal health insurance does not exist, access to secondary and tertiary care tends to be highly dependent on the ability to pay.

Teamwork

Teamwork is an essential feature of providing diabetes care. Even at primary health care level, particularly in high income situations, several professionals and disciplines can be involved in the routine care people with diabetes – including, for example,

doctor, nurse, podiatrist and optometrist. In order to develop chronic care, the people involved in managing chronic conditions need to develop a team that meets regularly to focus on improving the quality of care [2], and one of the team should be appointed as the chronic care coordinator. If no one is responsible for chronic care, the tendency is for it to be overlooked. For example, basic equipment, such as glucometers, monofilaments or obese cuffs for blood pressure measurement, is not provided [15]. In addition, new ideas, initiatives and procedures are not sustained in the absence of a leader who is present over a sufficient time period. Continuously rotating staff, such as nurses, erodes the ability to create effective teams and sustain changes. When teams meet they should develop shared goals, clarify their complementary roles, reflect on how to improve care and hold each other accountable for decisions. Health professionals need to be clearly aligned with the purpose of improving chronic care and not with defending professional identities. A respectful, open and curious stance helps professionals and others to understand each other better [24].

When nurses working in a large informal settlement in Cape Town were asked what would help improve diabetes care they replied "caring for the carers," reminding us that building good teams begins by caring for its members. The nature of the relationship between health workers and managers, and the values embedded in the organizational culture may be reflected in the nature of the relationship between health worker and patient and the culture of caring [25]. Organizations that operate too heavily in a mechanistic and bureaucratic model tend to treat health workers as human resources that can be used and replaced like parts in a machine [26]. Organizations should strive for congruence between individual values and behavior and organizational culture and structures [27]. It is difficult for health workers to empower people for healthy living, motivate change and care for patients when the organization is not congruent with the same values. Wheatley [28] expresses this well when she says, "After years of being bossed around, of being told they're inferior, of power plays that destroy lives, most people are exhausted, cynical and focused only on self-protection … when obedience and compliance are the primary values, then creativity, commitment and generosity are destroyed." Living health systems should care for, empower and nurture their staff so that they are enabled to do the same for their patients.

Patient-centered care

In low resource settings the need to be patient-centered is often dismissed as a luxury in the face of high workloads and sometimes broad differences in education, language and culture between health providers and patients. Nevertheless, patient-centeredness has been found to improve quality of life, increase patient satisfaction, improve adherence to treatment, enhance the integration of preventive and promotive care, and improve the provider's job satisfaction. It does not necessarily imply a longer consultation. Patient-centeredness implies a more collaborative approach and holistic understanding of the patient that elicits, acknowledges and addresses relevant beliefs, concerns, ideas and fears [14].

Patient-centeredness is in part a paradigm shift in the mind of the health worker from a bio-medical, technical and sometimes authoritarian model to a biopsychosocial, holistic and participatory model [14]. It is fundamentally a way of being with the patient. Nevertheless, a range of specific communication skills can be learnt such as the ability to ask open as well as closed questions, to make reflective listening statements, exchange information or invite mutual decision-making [29]. While training of doctors has begun to include these communication skills, even in low resource settings, the training of nurses and mid-level health workers often has not.

Motivational interviewing builds on a patient-centered approach and can best be described as a guiding style. Diabetes, which involves multiple changes in behavior (diet, exercise, smoking, alcohol, medication), particularly lends itself to adaptations of motivational interviewing. A challenge in low resource settings is to see how a range of health workers can incorporate a guiding style into their consultations.

In a model of care that emphasizes patient empowerment and self-care as key components [2], every consultation needs to be seen as an opportunity for this. Health providers need to have the necessary expertise in the relevant topics, useful communication skills and a range of educational materials appropriate to the literacy level of the community. In some settings, group as well as individual approaches may be effective [30].

A family and community orientation

Beyond the individual patient is their family and community context. Clearly, family beliefs and customs and degree of social support will have an impact on the ability of an individual within that family to make lifestyle changes and cope with their diabetes. Involving family members in the consultation or educational program can strengthen the overall response to diabetes [31]. Likewise, an understanding of the patient's environment will inform discussions about appropriate changes and likely constraints.

In low resource settings, where facilities are overwhelmed with large numbers of patients it may make sense to extend care into the community [2]. For example community-based support groups can be run by health promoters or local non-government organizations to offer some aspects of routine chronic care. Patients can then return to the local clinic for periodic or annual review and help with complications. Support groups can also encourage lifestyle change and adherence to medication. Expert patients, an increasingly developed resource in both low and high income situations, may also be useful to enhance self-care, although further evaluation is required [32]. Community health workers have the potential to promote healthy lifestyle, provide home-based care and link selected patients with the local facilities [33].

Communities should not just be seen as additional platforms for care or targets for interventions but representative structures or key leaders should be engaged with in order to understand how local health priorities are perceived and to elicit feedback and involvement in the planning and delivery of services [14].

Primary care workers usually have a responsibility not just for individual patients but for people living within specific communities or health districts [14]. Concern for the growing number of people with diabetes should lead to interventions that address the underlying determinants of obesity and reduced physical activity: for example, school-based healthy lifestyle programs, provision of green spaces in inner cities, marketing of food to children, sale of junk food on public premises and labeling of food. Many of these require health workers to contribute to interventions in other sectors [34].

Making use of evidence

The evidence base for diabetes is constantly expanding and all the above areas need to be informed by the latest evidence base that is relevant to the resource setting in which it is to be applied. Ideally, a systematic process for reviewing the evidence and updating guidance accordingly should be in place in all countries. An example of such a system from a high income setting is the National Institute for Health and Clinical Excellence (NICE) in the UK. This may be beyond the resources of lower income countries but through regional cooperation, such as coordinated by WHO, the IDF and the World Bank, regular reviews of the evidence appropriate to different resource settings do take place. The availability of evidence does not guarantee that it will be used, and there is a strong and growing literature on how to build local ownership and influence local practice, such as through the development of local treatment guidelines.

Information technology – how to embrace it?

Information technology (IT) is a rapidly growing field that has the capacity to strengthen the model of care for diabetes across different resource settings. The potential targets for IT range from people with diabetes to people at risk for diabetes, health workers and managers. Some of the ways in which IT can strengthen the model for diabetes care are improving continuity of information, assisting in running referral systems between different levels of care, and providing tools for education and empowerment.

Numerous IT modalities or systems exist, although these need to be tailored according to the target population and desired outcome. Thus, real-time imaging and audio contact via equipment such as digital cameras, video phones and computers can permit interaction between health workers and individual patients or groups of patients for education sessions. Dietary management and medication adherence support may be provided by mobile phone messaging; self-care may be enabled by technology-mediated feedback on blood glucose levels on a daily basis. Quality of care may be enhanced by access to the latest evidence or decision-support tools; auditing may be supported by software that automates the analysis of raw data and integrates it with district health information systems.

Innovative strategies for clinical management, especially those which address monitoring of patients by technology-mediated communication with the diabetes care team, are being introduced in high resource settings. One of the key issues to be addressed is the cost-effectiveness of such IT-based systems [35] and the amount that an individual is willing to pay may well depend on their perception of risk. Furthermore, even in high resource settings, a patient's age and educational background may place limits on their ability to utilize IT [36]. In contrast, at present IT has limited applicability in low resource settings as these are characterized by no or very limited access to the Internet and a lack of familiarity with computers amongst health care workers. Even when a large health center or hospital has computers and Internet access, these are likely to be available to the managers or possibly large clinical areas, certainly not in individual consulting rooms, while such access in primary care settings is simply not to be had for the most part. Furthermore, patients coming from poor backgrounds are very unlikely to have access to the Internet.

Mobile phone-based telecommunication system to enhance patient self-care

Mobile phones, of all the currently available technologies directed at the patient, are likely to have the greatest potential use in low resource settings. This is because the digital divide along the socioeconomic gradient appears to be less evident with mobile phones than other forms of IT, such as the Internet [37,38]. Mobile phones are even to be found in remote villages, indicating the extent of their penetration in contrast to the lack of access to land lines in many rural areas; however, unlike the situation in well-resourced countries where the majority of mobile phone owners have a contract for a year or so, the usual practice in low income countries is one using prepaid phone cards and sharing of phones. If the IT involvement is simply related to the patient's receipt of messages to support their care, this may not have a negative impact, since even when phone use exceeds the amount paid, the phone may still receive messages, but may not be able to send outgoing comunications.

In countries with better resources, mobile phones have been put to additional uses in diabetes care. A real-time telemedicine transmission system has been developed and tested. One system uses a blood glucose monitor connected to a general packet radio system mobile phone to enable transmission of patients' blood glucose levels [39] with subsequent feedback. Farmer *et al.* [40] demonstrated that real-time telemedicine was feasible and realistic in a randomized controlled trial. Further, the idea of measuring the blood glucose level directly from the mobile phone has also been introduced (Figure 58.2). Cho *et al.* [41] reported that the effect of the mobile communication system using the "diabetes phone" (Figure 58.3b) was not inferior to that of an Internet-

Figure 58.2 Glucometer with telecommunication. Adapted from Cho *et al.* [41]. (a) The Diabetes Phone (Healthpia, Korea) has a glucometer in a battery pack (phone embedded type). (b) The glucometer can be directly connected to a cellular phone (Dongle type). (Gluco plus, Healthpia, Korea.)

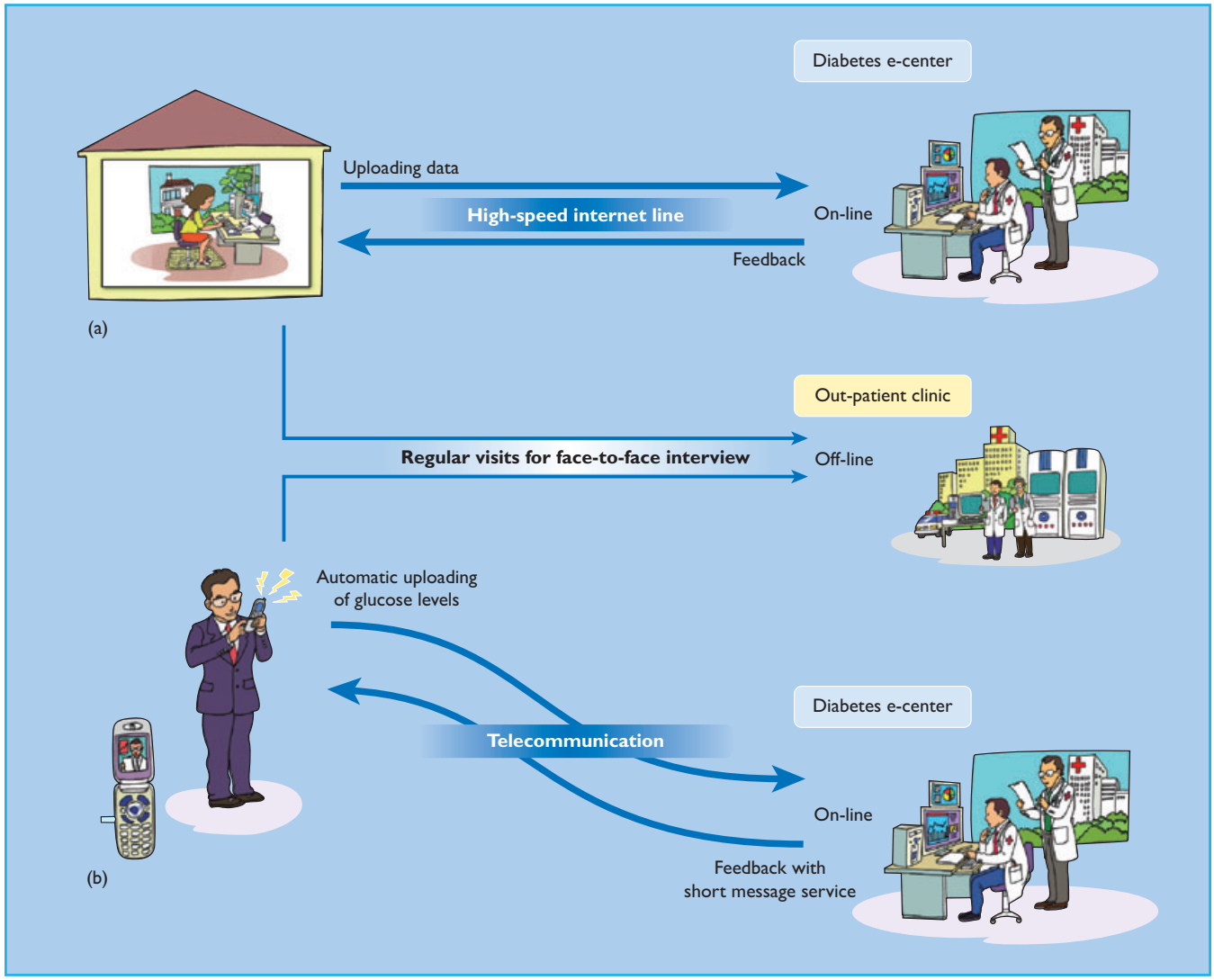

Figure 58.3 (a) The Internet-based glucose monitoring system (IBGMS). Patients logged on to the website from their homes or offices at a time they found convenient and uploaded their glucose data, together with additional information such as current drug information (type and dosage of oral hypoglycemic medications or insulin), lifestyle modifications and hypoglycemic events. In addition, patients recorded any changes in their blood pressure or weight, and any questions or detailed information that they wished to discuss, such as changes in diet, exercise, hypoglycemic events, and other factors that might influence their blood glucose level. (b) The telecommunication-based glucose control system in which mobile devices such as a mobile phone with the capacity to measure blood glucose were adopted. Patients could upload their information through telecommunication automatically and the patient–doctor communication could be achieved practically in real-time by the short message service. Adapted from Yoon *et al.* [42].

based glucose monitoring systems in terms of supervision, care and patient's satisfaction. The fact that text messaging on mobile phones is very limited represents a possible disadvantage for utilizing real-time telemedicine in providing information regarding blood glucose status. It is probable that the integration of medical equipment and mobile phones will be developed within the not-too-distant future.

Technology-based access to the latest evidence and guidelines for health workers

IT can enhance interaction with and use of evidence-based guidelines by health workers even in low resource settings. This can take the form of palm-held stand-alone personal digital assistant (PDA) devices or stand-alone tablets with periodic updating via Internet or CD ROM. The latter has been used sucessfully even in remote areas. Devices can contain reference material, evidence-based guidelines or automated decision trees. If Internet access is available, these devices can be used to access electronic databases from the consulting room. Such technologies need to provide information without interrupting the consultation process for health care workers facing serious time constraints. Additionally, the technology must not have a negative effect on the interaction between the patient and health worker.

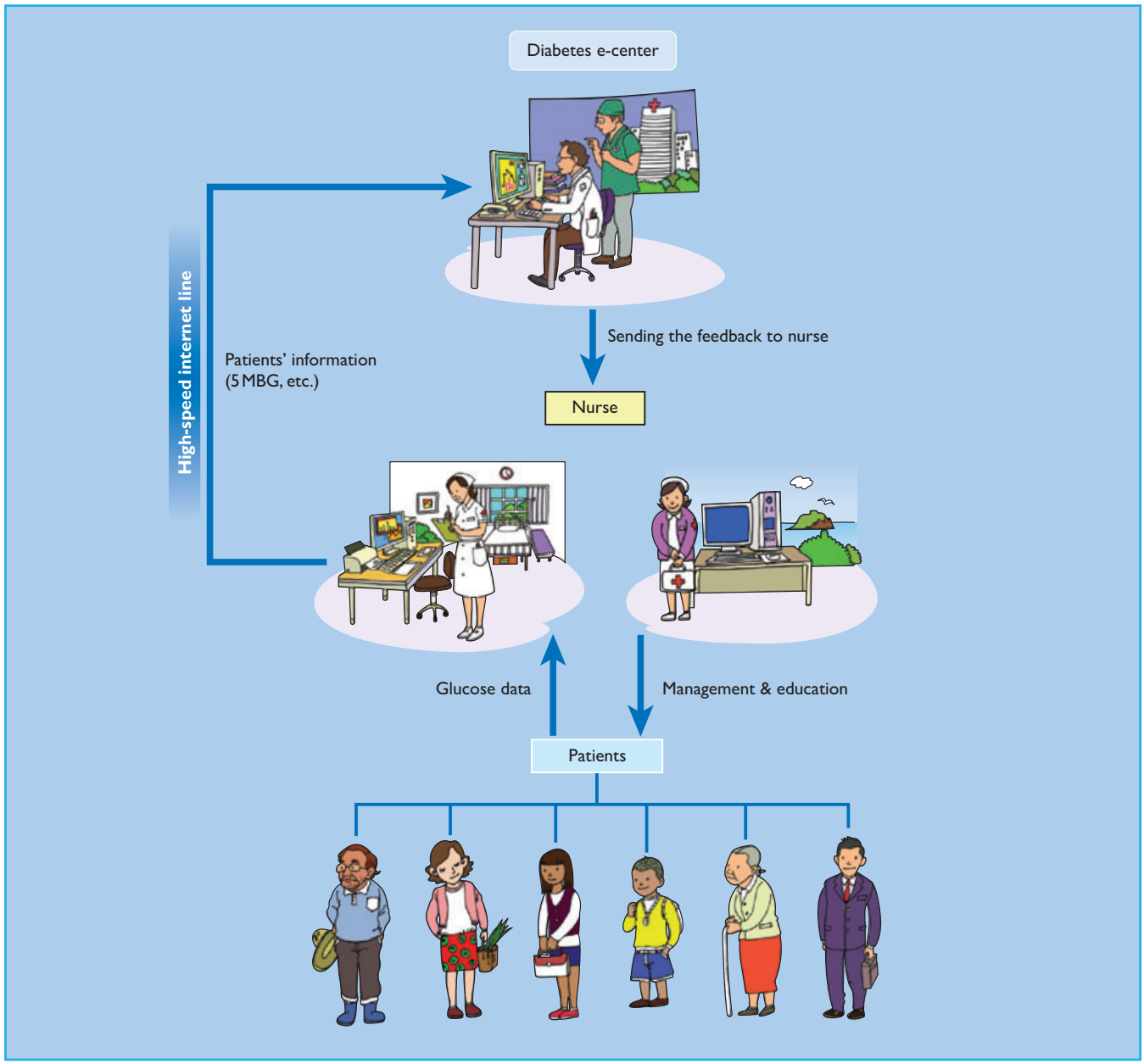

Figure 58.4 Technology-based clinical support. First, a nurse checks the self-monitoring of blood glucose (SMBG) data of patients and sends the patients' data, including SMBG data, to the endocrinologist. The endocrinologist reviews the patients' uploaded information and sends messages to the nurse. The nurse educates and manages the patients according to the endocrinologist's recommendations. Adapted from Yoon *et al.* [42].

Technology-based clinical support

Certain aspects of diabetes care, such as retinal screening, lend themselves to mobile digital photography by fundal camera with transmission of photographs and reports via satellite or Internet between the peripheral and a central reporting site. Examples have been reported from relatively low resource settings in Africa and India [22,23]. Primary care providers can also be supported from referral centers via IT to improve the quality of clinical advice and decision-making. For example, in South Korea a nurse can send information regarding specific patients' glucose readings to an endocrinologist. The specialist can review the data uploaded and send advice on patient management (Figure 58.4) [42]. It is anticipated that the indirect communication system could eventually be applied to health workers living in low resource settings, thereby contributing to the gradual but definite development of universal IT-based diabetes management systems.

Automated feedback systems to enhance patient self-care

People with diabetes can use their own personal computer to receive automated feedback on self-management (Figure 58.5a) [43]. Similar automated feedback on glucose levels can be obtained via the Internet (Figure 58.5b). In this situation, it is imperative to have software or a decision support system that can make an appropriate recommendation on glycemic status. Meigs *et al.* [44] have developed and reported on the clinical applicability of a web-based decision support tool, the diabetes Disease Management Application. Although this system could be highly cost-efficient, long-term compliance and satisfaction could be limited because of lack of flexibility and human contact.

Interactive feedback systems to enhance patient self-care

Internet-based interactive communication systems enable two-way communication between patients and their physicians via the Internet (Figure 58.3a). Systems are still cost-efficient and yet are more personalized [45]. Options range from utilizing e-mail to developing a private homepage to share clinical information [46]. For instance, Kwon *et al.* [47] reported a short-term reduction in HbA_{1c} through the effect of an Internet-based glucose monitoring system (IBGMS), in which patients and doctors shared a web-chart (Figure 58.6). Patients uploaded their glucose data to the remote web server and their doctors provided advice after interpreting the data [47]. The idea of integrating web-based communication with the hospital's own electronic medical record charting system was also introduced [48]. Cho *et al.* [49] reported that the longest prospective study (30 months) of an IBGMS in

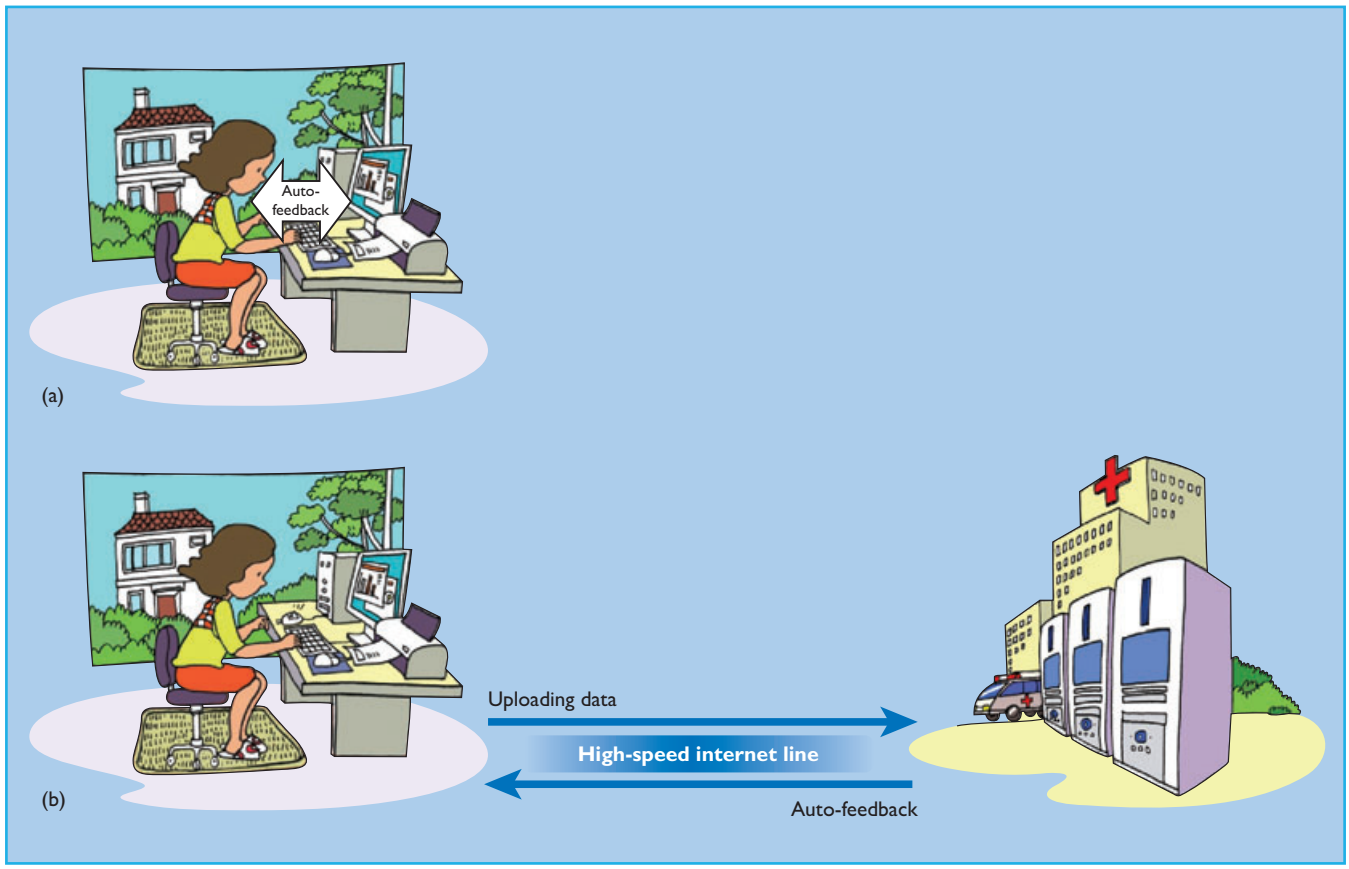

Figure 58.5 (a) Personal computer-based self-management (automated) system. (b) Internet-based auto-feedback system. Adapted from Lehmann [43].

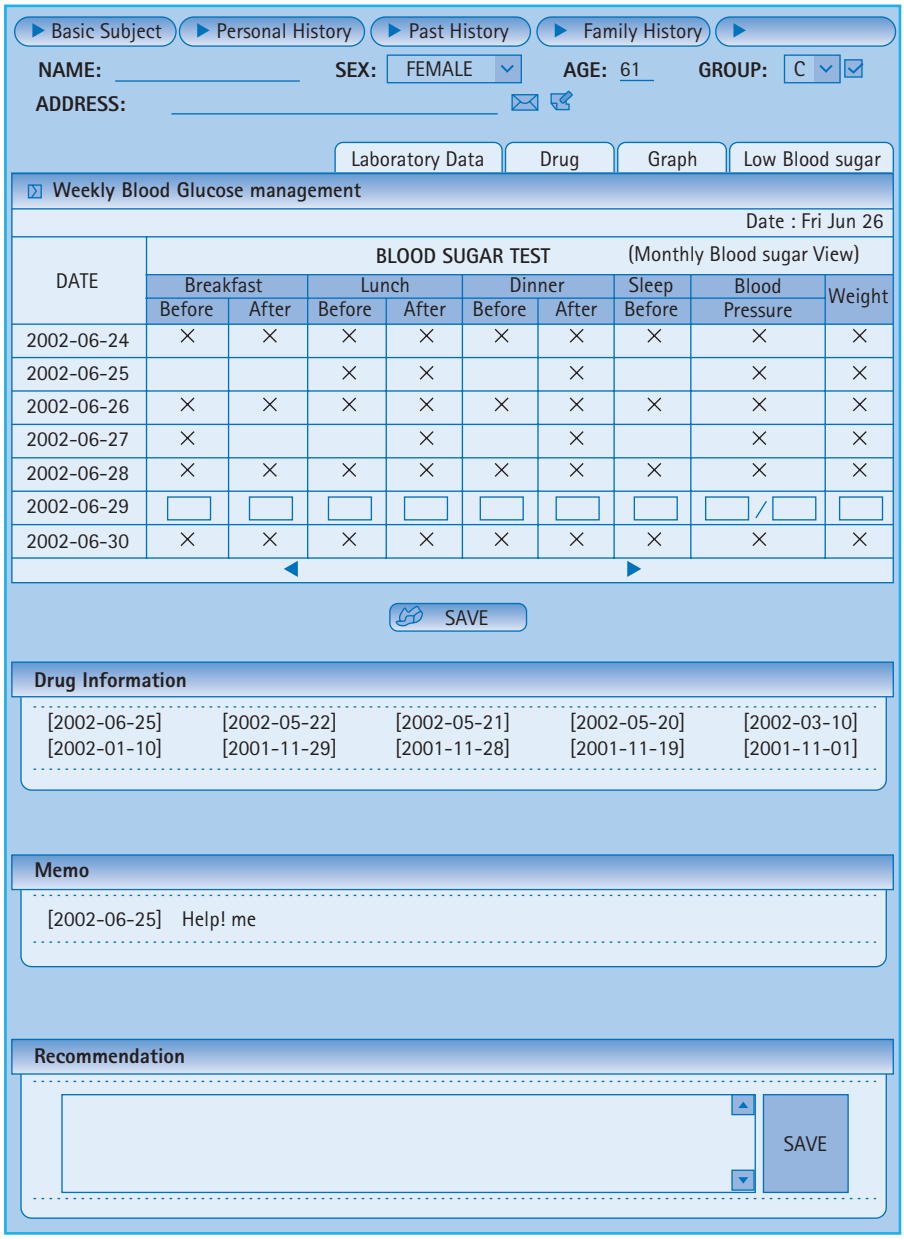

Figure 58.6 Screen viewed by patients and physicians on the website for diabetes management (www.biodang.com). Basic profile, past history, family history and laboratory data are shown on the top. Self-monitored blood glucose levels are shown (middle), which are recorded as fasting or post-prandial (breakfast, lunch and dinner). Drug information, notes from the patients and recommendations from the physicians are shown at the bottom. Reproduced from Kwon *et al.* [47] with permission from the American Diabetes Association.

diabetes was effective in reducing HbA_{1c} (Figure 58.7). Uniquely, this system not only provides periodic advice and feedback, but also allows continuous support for glucose control, frequent encouragement, problem assessment and individualized education about diet, exercise and drug modification, thereby providing a comprehensive caring system for patients with diabetes. Montori *et al.* [50] used a telecare system using a modem for patients with T1DM receiving intensive insulin therapy. When the patient deviated from the desired glycemic control, the glucose analysis software assisted nurses to interpret the patient's status and provide feedback to the patient. Even more specialized systems have been developed for women with gestational diabetes [51].

Merged feedback systems to enhance patient self-care

In order to develop a more efficient system, the time required from health care providers should be minimized, while preserving some communication between patients and health care providers when absolutely necessary. Recently, a system was piloted that will respond automatically when the glucose level is accept-

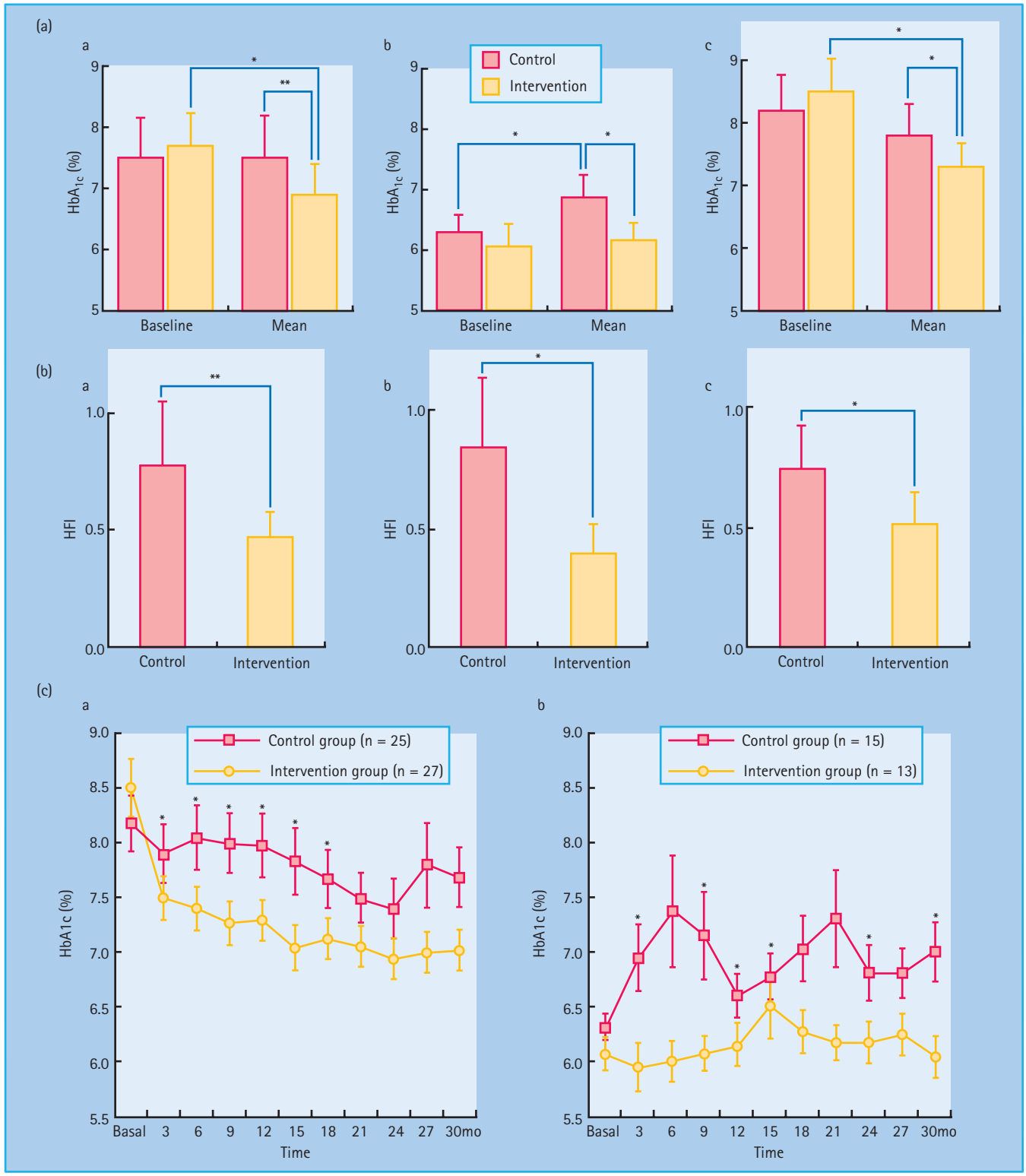

Figure 58.7 The effects of intervention (Internet-based glucose monitoring system [IBGMS]) on changes of HbA_{1c} and glucose stability. A: Baseline HbA_{1c} and mean HbA_{1c} during the study 30-month period. (a) All subjects, control (n = 40) vs intervention (n = 40). (b) Subjects with a basal HbA_{1c} < 7%, control (n = 15) vs intervention (n = 13). (c) Subjects with a basal HbA_{1c} ≥7%, control (n = 25) vs intervention (n = 27). B: Difference of HbA_{1c} fluctuation index (HFI) between the control and intervention groups. (a) All subjects. (b) Subjects with a basal HbA_{1c} < 7.%. (c) Subjects with a basal HbA_{1c} ≥7%. C: Fluctuating line of HbA_{1c} for the 30 months. (a) Subjects with a basal HbA_{1c} ≥7%. (b) Subjects with a basal HbA_{1c} < 7%. At each follow-up point, ≥90% of patients took the test. $^{*}P < 0.05$; $^{**}P < 0.01$. DCCT aligned HbA_{1c} of 7% is equivalent to IFCC HbA_{1c} of 53 mmol/mol. Reproduced from Cho *et al.* [49] with permission from the American Diabetes Association.

able, but which will involve a health care provider for further evaluation when the result is abnormal. Cho *et al.* [52] reported the effect on labor savings of a semi-automatic response system for glucose control. The system, which had an algorithm-based glucose decision engine, reduced physicians' labor time by nearly 50% while preserving interactive communication between patients and physicians. Simple algorithm-based programs are inadequate to meet the complexity of clinical decision-making, however, and in the future artificial intelligence-based programs may be developed to handle more complex data.

Internet-based health education and primary prevention

The Internet has been used as a medium for a weight loss program to prevent diabetes [53] and as part of a walking program for patients with T2DM. The latter had a more significant effect on patients' physical activity and reduction of depressive symptoms, compared with the conventional method of sharing physical activity information [54]. An Internet and mobile phone intervention was found to improve cardiovascular risk factors for both T1DM and T2DM groups [55]. Additionally, a mobile diabetes education and care system brought beneficial effects in children and young people with T1DM in a rural area [56].

Automatic data uploading system for more convenience

An automatic data uploading system has been introduced in South Korea to achieve more convenient IT-based communication system. This system allows for self-monitored glucose data measured with a home glucometer (OneTouchUltra, Lifescan, USA) to be sent to the patient's web chart via Internet by simply connecting it to a personal computer. Physicians can view the automatically uploaded glucose data on the web chart and send messages to the patient.

Electronic patient records and decision support

The electronic health record is a longitudinal electronic document of a patient's health information generated by one or more encounters in any care delivery setting. This information may include patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, radiology reports, etc. The electronic health record automates and streamlines the clinician's workflow, it has the ability to generate a complete record of a clinical patient encounter – as well as supporting other care-related activities directly or indirectly via interface – including evidence-based decision support, quality management and outcomes reporting [57].

Various clinical decision supporting systems have been developed, which are able to provide diagnostic and therapeutic services to both clinicians and patients by using electronically recorded health data. Advanced development in IT not only guarantees efficient communication between an individual and a medical institution, but also makes possible for the medical institutions themselves to share information efficiently. Massin *et al.* [58] sent retinal images (non-mydriatic photography) of people with diabetes to a reading center for diagnosis and follow-up of diabetic retinopathy. Recently, efforts to standardize medical terminology and interfaces among devices and communication systems have been made.

Management and health information systems

A variety of personal health information systems have been developed and some are currently used for disease management, including diabetes. Several countries with good IT infrastructure already have commercialized various diabetes management systems. Mycareteam uses web-based software to facilitate diabetes management by allowing interactive communication between patients and their physicians or family members (www.mycareteam.com, Mycareteam Inc, USA). A similar web-based service system in which patients can communicate with the diabetes-specialist care team consisting of a nurse, nutritionist and exercise therapist was introduced to improve glycemic control of women with pregnancy-associated diabetes (www.cared.co.kr, C&I Healthcare Co., Republic of Korea). Growing numbers of health care companies in the USA are using IT tools for their care solutions instead of traditional telephone-based services. Alere provides a diabetes management program mainly focusing on education and ensuring that patients adhere to the physician's directions and clinical guidelines using web-based tool and telephone interactions (www.alere.com, USA). By establishing evidence showing an improvement in the quality of disease care, eventual medical cost reduction and improvement in patients' satisfaction, the IT-based health care market could increase.

Addressing economic hurdles

In the first instance, it is essential to determine the cost-effectiveness of IT. Cho *et al.* [59] reported a simulation study indicating that the IBGMS could save $27 666 of direct cost per person for 35 years compared to a conventional face-to-face interview system in an outpatient clinic. Johnson *et al.* [60] reported that individuals were willing to pay $1500 over 3 years to participate in a lifestyle intervention program similar to the diabetes prevention program. This indicates that individuals with a high risk of diabetes are willing to pay more than individuals with lower perceived risk. An IT-based patient care system sounds tempting but, once again, the key to its feasibility lies in cost-effectiveness even in high resource settings.

Addressing difficulties in IT use

Although Internet access is increasing worldwide, there is still a limited pool of people who can use IT without difficulties. Thus, an Internet-based diabetes care system must address and overcome its limitations before application. Watson *et al.* [61] reported that patients with diabetes with no experience of the Internet or media communication are enthusiastic about adopting future health information technology for their diabetes care. Furthermore, Jackson *et al.* [62] showed that among African-Americans with a lack of computer skills, 66% were willing to learn and 89% were willing to use a computer program to manage their diabetes, if it were offered free of charge. From this evidence,

the potential users for IT-based diabetic care should not be underestimated [61].

Advances in the near future

It is believed that the dramatic development of IT and its application to health management systems will have a crucial role. Simple IT management models for controlling blood glucose levels for patients with diabetes will definitely evolve into much more complex models, in which various technologies are integrated in order to provide the complex management required. Technologic gadgets may be directly connected to a communication system to transmit a patient's current status and past data. For example, a physical activity monitor (Lifecoder, Suzuken, Japan; Actical, Philips, USA) could be integrated into the health information system for monitoring real-time physical activity.

These innovative technologies can also be applied to other chronic diseases such as hypertension and rheumatoid arthritis. It is important to develop software that can integrate efficiently and process the constant flow of incoming data. To achieve this, we must keep in mind that simple algorithm-based programs are not enough to meet the challenges of medicine; rather, artificial intelligence-based programs will be necessary to handle the complex data and to provide economic benefits by lowering the human labor and costs. Communication systems that are not hindered by time and space are also needed. Information technology should never be seen as an end in itself, but as a tool to complement other aspects of holistic patient-centered diabetes care.

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